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Quarries, Caravans, and Routes to Complexity: Prehispanic Obsidian in the South-Central Andes

A Dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Anthropology

by

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Publications

In Review **Spatial and Temporal Variation in Stone Raw Material Provisioning in the Chivay Obsidian Source area.** By N. Tripcevich and A. Mackay submitted to Advances in Titicaca Basin Archaeology, vol. 2, C. Stanish and E. Klarich, eds., Cotsen Institute of Archaeology, Los Angeles, CA.

2007 **La fuente de obsidiana "Chivay" y su posición en los Andes Sur Centrales.** By N. Tripcevich and W. Yepez Alvarez. In *Actas del Simposio Internacional de Arqueología del Area Centro Sur Andina*, edited by Augusto Belén Franco, Mariusz Ziolkowski, and Justin Jennings, Instituto Francés de Estudios Andinos, Lima (in press).

2004 **Flexibility by Design: How mobile GIS meets the needs of archaeological survey.** *Cartography and Geographical Information Science*, Vol. 31, No. 3, pp. 137-151.

2004 ***Interfaces:*** **Mobile GIS in archaeological survey.** *The SAA Archaeological Record*, May 2004. Vol. 4, No. 3, pp 17-22.

Professional Presentations

2006 **Mobility and Exchange in the Andean Preceramic: Insights from obsidian studies.** Paper presented at the 71th Annual Meeting of the *Society for American Archaeology*, San Juan, Puerto Rico.

2006 **Production and Exchange of Obsidian from the Colca Valley, Arequipa, Peru.** Paper presented at the 46th Annual Meeting of the *Institute for Andean Studies*, Berkeley, CA.

2005 **Tripcevich, Nicholas and Willy Yepez Alvarez. Fuente de Obsidiana "Chivay" y su posición en los Andes Sur Centrales.** Por "Simposio Internacional sobre Arequeologia del Area Centro Sur Andina", Arequipa, Perú.

2005 **Tripcevich, Nicholas and Alex Mackay. Spatial and Temporal Variation in Stone Raw Material Provisioning Around the Chivay Obsidian Source.** Paper presented at the 70th Annual Meeting of the *Society for American Archaeology*, Salt Lake City, UT.

2004 **Mobile GIS on Archaeological Survey.** Paper presented at the *Archaeological Sciences of the Americas* conference, University of Arizona, Tucson.

2004 **Chivay obsidian source and south-central Andean prehistory.** Paper presented at the 69th Annual Meeting of the *Society for American Archaeology*, Montreal Canada.

2003 **Viewshed analysis in archaeology.** Poster presented at the 68th Annual Meeting of the *Society for American Archaeology*, Milwaukee Wisconsin.

Teaching Experience

2007 **Lecturer, *Origins of Complex Societies*, UC Santa Barbara.**
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2000 – 2004 **Instructor, archaeological fieldwork and use of GIS technology.**
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Professional Experience

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Grants and Awards

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2003	**Proyecto Ch'amak Pacha,** ESRI Special Achievement in GIS award.
2002	**Dissertation Proposal Writing Fellowship, UCSB Graduate Division.** Support for proposal writing in order to facilitate advancing to candidacy.
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Professional Memberships

1998 – **Society for American Archaeology**

2000 – **Professional Archaeologists of Peru, number DT-0176.**
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ABSTRACT

Quarries, Caravans, and Routes to Complexity:

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Regional studies of obsidian artifacts in the south-central Andes have shown that over 90% of the analyzed artifacts from the Lake Titicaca Basin belong to a single geochemical obsidian type. A decade ago researchers identified the geological origin of this obsidian type as the Chivay / Cotallalli source, located 180km west of Lake Titicaca above the Colca valley in Arequipa at 71.5355° S, 15.6423° W (WGS84), and at 4972 meters above sea level. This research project focused on the obsidian source and adjacent lands within one day's travel from the source. The project included a 33 km^2 survey, 8 test units, and in-depth lithic attribute analysis. Mobile GIS (Arcpad) was used extensively during survey. A substantial quarry pit and an obsidian workshop were examined closely, as were consumption sites in nearby areas. The results of this study found that the earliest diagnostic materials at the source date to the Middle Archaic (8000 – 6000 BCE) and that intensification of obsidian production occurred earlier than previously recognized, at circa 3300 BCE Increased obsidian production appears to have been focused on the acquisition of

large (> 20cm) and homogeneous obsidian nodules, although the formal tools produced with obsidian were predominantly small projectile points. It is argued that the acquisition of large, homogenous nodules was prioritized because the production potential of large nodules was highest, and because obsidian was associated with competitive display among early aggrandizers. The timing and economic associations of obsidian production and circulation suggest that the possession of large obsidian pieces in the Titicaca Basin was a demonstration of social connections to distant resources, and to regional trade networks that emerged with regularized camelid caravan transport networks. Obsidian artifacts were not inherently “prestige goods”; rather, it is suggested here that obsidian was the least-perishable of a number of cultural goods distributed by an expanding network of caravans that linked communities in the region. The acquisition and consumption of these cultural goods was a demonstration of economic connections and cultural influence during the dynamic period of incipient social inequality between the Terminal Archaic (3300–2000 BCE) through the Middle Formative (1300–500 BCE).

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Like Salt or Like Gold?

Patterns in Obsidian Circulation in the South-Central Andes

1.1. Overview

Archaeologists have long recognized the central importance of interregional relationships in much of Andean prehistory, but consistent forms of evidence that can be used to gauge long-distance interaction are relatively few. Over the past century, systematic studies on a regional scale have provided evidence of interaction based on stylistic attributes, such as the presence of non-local ceramics, design elements, and architectural styles. More recently, geochemical evidence has taken a more prominent role in documenting long-distance interaction and exchange because evidence from a variety of chemically unique materials – such as obsidian – have been accumulating in databases as chemical identification techniques are refined. This project aims to apply geochemical evidence of long-distance interaction from an obsidian source in the south-central Andes to an interpretation of regional developments.

Obsidian is among the least-perishable of a number of materials that were widely transported in the prehispanic Andes. On one level, obsidian should be understood as just another one of the widely circulated items, such as nuts, gourds, wood, shell, metal, coca, sebil, and basalt, in a long list. As a regionally distributed material, however, obsidian has a number of characteristics that are distinct from some other goods that circulated in local and regional trade. As a lithic raw material, obsidian is a reductive technology and therefore distance decay effects are prominent in its regional distribution. Obsidian implements can have extremely sharp edges, and by far the most common formal obsidian tools produced in the south-central Andes were the projectile points. Obsidian artifacts are sometimes found in contexts – such as monuments or burials – that suggest that obsidian had ritual importance; however, throughout the region obsidian artifacts are frequently encountered in domestic contexts and middens with little compelling evidence of ritual or symbolic importance. A central concern of this research project is to avoid the simplistic, dichotomous archaeological construction of a "utilitarian" artifact group versus a "prestige" and/or "ritual" associated artifact group. As a highly visible material that was often made into projectile tips, "utilitarian" obsidian tipped implements themselves may have had a role in social influence or coercion, and were perhaps used in status competition displays. Obsidian made into a sharp weapon simultaneously represents access to non-local goods and, in the case of non-local obsidian, may reflect regional scale alliances. Thus, the circulation of obsidian may have been akin to that of utilitarian products, a such as salt, or along the lines of a precious commodity like gold or turquoise where value is related to production costs and reflects scarcity or exclusivity.

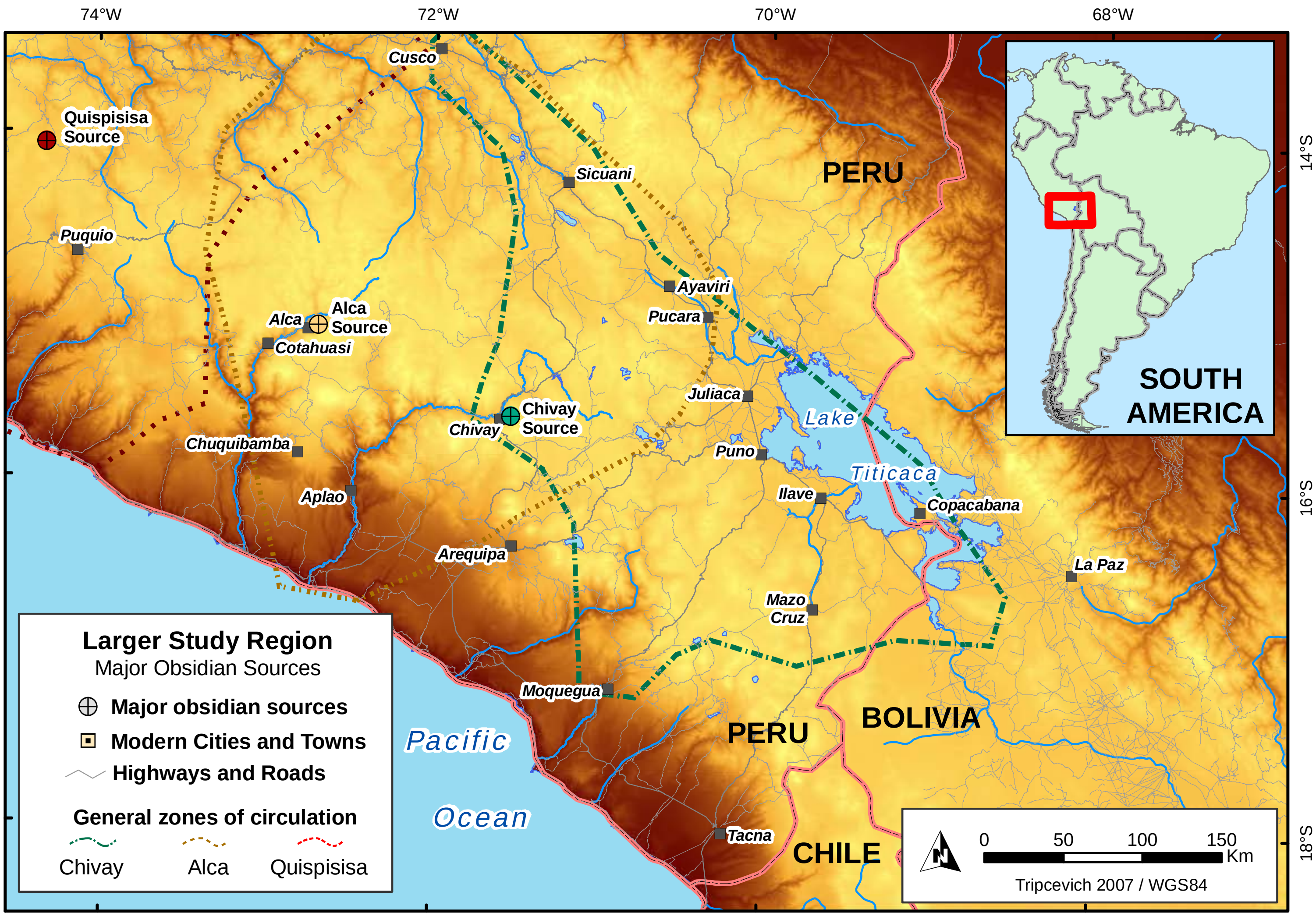

Figure 1-1. Larger study region with modern towns and roads. General obsidian distribution areas are depicted, showing largely a Formative Period extent.

Archaeologists identify these materials as non-local when they are encountered in archaeological sites far from their source areas, and in these contexts archaeologists interpret non-local materials as providing evidence of the long distance movement of goods. The dramatic altitudinal zonation on the flanks of the Andes contributes to the archaeological identification of non-local materials because a number of these products are zone-specific. The major environmental and geological zones with distinctive products include the Amazonian lowlands to the east, the mineral rich western Cordillera, and the Pacific littoral.

This project focuses on the source region of an obsidian type that was widely circulated in the prehispanic Andes. This chemical group, first referenced in the 1970s as the “Titicaca Basin Type” (Burger and Asaro 1977), was finally traced to its geological source in the Colca valley of Arequipa, Peru in the 1990s. In the Colca, the geochemical type was documented under two names, the Chivay Source (Burger et al. 1998a) and the Cotallalli Source (Brooks et al. 1997). The source lies in volcanic terrain that is relatively difficult to access by the modern road network, a situation which has hampered research in this zone but has also resulted in relatively little disturbance to archaeological sites in the obsidian source area. This project sought to comprehensively research this zone in order to address a number of long-standing theoretical questions concerning the human use of obsidian in the larger region. Obsidian from the Chivay source is found in a variety of archaeological contexts in the region ranging from common residential middens to ceremonial structures and burials. Unlike other regions of the world where a variety of artifact forms are produced from obsidian, in the south-central Andes the formal implements made from obsidian are largely restricted to projectile points. Simple obsidian flakes are seen as valuable as well, as the shearing and butchering requirements of dedicated pastoralists are significant, and these sharp obsidian flakes filled a functional category akin to razor blades in modern life.

On a theoretical level, this research can contribute to anthropological models concerning the emergence of social hierarchy, the influence of regularized caravan-based trade, and the role of exchange in non-local goods that were widely-circulated in prehistory. Obsidian escapes easy classification as a “prestige item” or an “ordinary good” because the cultural meaning of the material appears to have been highly variable. Obsidian is typically abundant at archaeological sites close to a geological source and scarce in areas more distant from geological sources, and obsidian flakes are plentiful at pastoralist rock shelter sites in the *altiplano* that appear to be relatively lacking in other material goods. Together with coca leaf and other widely circulated goods of cultural value in the Andes, obsidian appears at times in ritual contexts; for example, obsidian may be used as a knife in a llama sacrifice, as flakes placed in a burial, or as projectile point tips represented on Tiwanaku and Nasca ceramics. However, obsidian appears to not have been a “preciosity” in the sense that large and recognizable quantities of labor were necessarily invested in the production of the material, and indeed obsidian is often found in commonplace, utilitarian contexts. As a household level enterprise, the acquisition of obsidian may constitute evidence of regional interaction, which contributes to an archaeological understanding of the prehistoric emergence of regularized exchange over distance, perhaps scheduled around festivals, seasonal harvests, and other regional scale events that integrated distant communities across the Andean highlands. In sum, while it is difficult to place of obsidian on a scale from ordinary to prestige good, it appears that the mere possession obsidian may have had some value as a symbol of participation in the long-distance exchange of a variety of goods of cultural value.

This project investigates the economy of Chivay obsidian in prehistory at three levels. First, fieldwork was conducted at the Chivay source in order to examine production at the obsidian source area itself. This work documented the geological exposures of the material, the archaeological sites in association with the source area, and the physical geography and trail system around the source. Second, the project area included obsidian consumption zones within a day's walk of the source in two adjacent residential areas in order to evaluate the local use of obsidian within the larger archaeological context of the Upper Colca. Third, the regional consumption patterns of Chivay obsidian in the south-central Andes were explored using existing studies from the published sources for a more complete picture of production, distribution, and consumption of the material through prehistory. This dissertation represents the integration of these three perspectives on Chivay obsidian in light of anthropological theories of exchange and Andean culture history.

Archaeological evidence for interpreting obsidian production at Chivay takes the form of differences in diagnostic materials and artifact morphology across space from a surface survey, and from measurable change in stratified deposits from test excavations. Four models of procurement and circulation are proposed here, and the material correlates for these models are evaluated based on expectations and measurable changes in artifacts that primarily consist of flakes and cores. The information potential from surface scatters is limited by the non-diagnostic nature of most artifacts at raw material quarries. Nevertheless, this research has found that a strong correlation exists between obsidian intensification and early pastoralism, and perhaps camelid caravan transport; and the research contributes to answering long-standing questions about the relationship between the Colca valley and prehispanic Titicaca Basin polities. This study explores obsidian production and circulation as a unifying theme that can be studied at a regional scale in order to examine long-term processes that led to social changes manifested in the emergence of chiefdoms and states in the Andes.

1.1.1. Prehispanic Economy

As an investigation of non-western exchange, this research relies on categories and approaches developed in economic anthropology. The analysis and interpretation applied in the Upper Colca project is rooted in the substantivist tradition, but the weaker elements of the original substantivist approach will be avoided. These weaker elements include an attempt at an explicit delimiting of culture areas (where values are assumed to be shared), and implicit evolutionary links between volume of exchange and social complexity. Concepts from economic anthropology based on the work of Polanyi (1957) that include the idea of social distance as developed by Sahlins (1972) will be used to explore diachronic change in the circulation of obsidian in the prehispanic Andes. More recent discussions of the importance of “ordinary goods” (M. L. Smith 1999), in contrast to the usual focus on prestige items, will be considered in light of the cultural importance of coca, herbs, obsidian, and other non-exclusive but widely valued items in the Andes.

A principal theoretical question addressed in this dissertation concerns the circumstances of a large shift in obsidian production during the Early Formative, around 2000–1300 BCE. It is argued here that the links between prestige goods circulation with models of competitive display are evident, but that influence is also accrued by individuals, perhaps certain organizers of llama caravans, who generate consistent traffic between areas by circulating both information and non-local goods on a seasonal or an annual basis. The underlying assumption is not that the act of exchange inherently “creates value” (Appadurai 1986), but rather that the circulation of material goods was a pragmatic incentive for maintaining a range of important social and ideological relationships across space (Browman 1981a; Nuñez and Dillehay 1995 [1979]). The caravan model described here is not adaptationalist, however, as it is not proposed that greater efficiency or social harmony led to the emergence of social complexity in the Andean highlands. Rather, the successful manipulation by aggrandizing individuals of the institutions that developed around these regional relationships was one early basis for the incipient concentration of power and the establishment of inequalities that are most apparent at early regional centers in the Andean highlands (Hayden 1998; Stanish 2003). The social and economic foundations for the emergence of these early centers clearly predate the ascendancy of these centers during the Middle and Late Formative in the Titicaca Basin, and obsidian is one class of artifact that was circulating consistently since the preceramic period that may reflect the changing socio-political role of exchange over the long term.

A study of obsidian production and circulation among Andean peoples across a time span of nearly 10,000 years demands the consideration of a wide variety of cultural contexts, economic systems, and socio-political structures. A major question about obsidian circulation through time concerns the nature of obsidian exchange and perceptions of value with increased distance from the geological source.

> Obsidian was a raw material essential to the daily existence of common people. In one sense, the distribution of obsidian may have had more in common with the exchange of agricultural commodities or salt, than it did with either long distance trade in prestige goods such as lapis lazuli, turquoise, or exotic pottery, or with commodities traded long distances for ritual purposes, such as spondylus and strombus shells. Thus, one should expect the patterns of obsidian exchange to differ from exchange patterns of these other trade goods and reflect different kinds of social and economic interactions (Burger and Asaro 1977: 18).

Expanding on Burger and Asaro's (1977: 18) observation, this dissertation examines the possibility that archeologically perceptible strategies of quarrying and production at the source, considered in tandem with consumption patterns, can help to describe what these "different kinds of social and economic interactions" may have been.

How did the contexts of exchange and value change as obsidian was conveyed away from the source area geographically and with greater social distance? The expression "regimes of value" (Appadurai 1986: 5, 14-15) has been used to describe arenas where shared perceptions of value are used in the construction of worth and equivalencies for circulating goods. What was the role of frontiers, either between cultural or environmental zones, in the transmission and value ascribed to these goods? While there is no simple answer to these questions, obsidian appears to have fallen somewhere between the probable regional circulation patterns of salt on one hand, and gold or turquoise on the other. The production and circulation represented by salt and gold serve as types on a continuum in this discussion, and the given changing patterns in obsidian circulation in the south-central Andes, the pattern falls at different points along this continuum in different prehispanic time periods.

A second major theme in this research is the association between a camelid-focused economy and obsidian circulation. High altitude pastoralists had easiest access to obsidian sources as obsidian was found on geologically young volcanoes high in the puna ecological zone; and additionally, pastoralists had burden-bearing animals capable of carrying heavy loads (Burger and Asaro 1977: 41). The sharp edges of obsidian flakes have great utility for pastoralist functions including shearing, butchery, and castration, although it is important to note that these characteristics are not unique to obsidian. Alternative local materials, such as high quality cherts, are found in a number of regions in the south-central Andes where exotic obsidian was used. Obsidian appears to have been circulated largely by pastoralists following the advent of a pastoral economy; however a simple utilitarian explanation for obsidian use among pastoralists is incomplete given the regional data from consumption sites.

There is key countermanding evidence to a simple utilitarian association between obsidian consumption and the functional needs of pastoralists. First, the obsidian flakes observed at pastoralist sites, even in excavated contexts, are overwhelmingly small and apparently of insufficient size for use as shearing or butchery tools. These flakes appear to be debris from advanced stages of reduction, perhaps from projectile point production and resharpening, and utilized flakes as one would expect among pastoralists are rarely reported in the literature. Second, the trends in obsidian procurement, as will be described in this document, suggest that the focus was on acquiring large nodules, a fact that that is discordant with the predominantly small sizes of the formal obsidian points and tools found both in the vicinity of the Chivay source and in the larger region, even when accounting for distance-decay issues. If obsidian was principally utilitarian because it was used for projectile points for subsistence hunting, why did obsidian use in projectile points expand dramatically only *after* the food producing economy became well-established (from 3300 BCE onwards)? Finally, pastoralist sites are often found without obsidian. During the Late Intermediate Period and Late Horizon the evidence shows that camelid herds expanded markedly, yet obsidian circulation seems to have relatively declined. If obsidian was primarily for utilitarian pastoralist activities, why did it decline as the herds expanded? It appears that the distribution of Chivay obsidian was heavily influenced by the interaction of complex phenomena that included demand in a network of exchange and caravan-based links between the western margins of the altiplano and the Titicaca Basin, the enduring social network that connected communities in these different regions.

This research at the Chivay source supports earlier observations by Burger et al. (2000: 348) where the strongest correlation with widely distributed obsidian types appears to have been the availability of large nodules of homogeneous obsidian. Given the diminutive size of the formal obsidian tools found in the archaeological record, and despite the issue of resharpening, there is an important display aspect to large obsidian nodules that is lost in utilitarian explanations linking obsidian with pastoralism. The link between camelid pastoralism and increased obsidian consumption in the south-central Andes is not causal, as pastoralists also make wide use of other materials, yet the appearance of pastoralism followed by the traffic of regularized long distance caravans appears to have been largely responsible for disseminating the material.

In light of the patterns of obsidian production and circulation, the anthropological relevance of obsidian appears to go beyond the fact that the material was used to produce sharp-edged tools of use to pastoralists. The analysis in this dissertation, therefore, focuses on the large-scale social and economic changes that occurred in the south-central Andes and on the possible role of obsidian as a material used by early leaders to represent contact with sustained regional networks and to signal social differentiation.

1.1.2. Chemical characterization work in the Andes

This study benefits from the work of the many archaeologists who have documented obsidian in archaeological contexts throughout the south-central Andes and who have conducted chemical characterization studies of Andean obsidian. The basis for research at the Chivay obsidian source returns largely to obsidian sourcing efforts by Richard Burger and by Karen Mohr-Chavez in the 1970s because it was these early studies that established the regional significance of this obsidian type. These studies further served to demonstrate the utility of obsidian for examining regional relationships in the Andes and for catalyzing greater interest in the context and form of obsidian artifacts among archaeologists working in the region. The first chemical analysis of obsidian from the region was Mohr-Chavez and Gordus in 1971 at the University of Michigan (Burger et al. 2000:271; Karen Lynne Mohr Chávez 1977). In the 1974-1975 study at Lawrence Berkeley Labs the analysis conducted by Burger and Asaro (1977) analyzed 800 artifacts from 141 archaeological sites in Peru and Bolivia (Burger et al. 2000:273). They isolated eight major chemical groups from this study, however twelve artifacts did not belong to any of these twelve groups and they were designated "rare" types.

A number of important chemical characterization studies have taken place in the region, though none as sweeping as Burger and Asaro's early work. The most significant work with respect to this study was the sampling conducted by Sarah O. Brooks in the Colca valley during the mid-1990s. Additional samples were collected by Steven Wernke during his 1999 Colca survey work. In the course of the present research, samples were collected throughout the study region. New developments in sourcing technology, in particular the portable XRF machine, promise to expand greatly on the insights provided by the chemical characterization studies of the twentieth century.

1.2. Structure of the Dissertation

1.2.1. Organization of presentation

Following this introduction, chapter 2 provides an overview of theoretical approaches to exchange and to raw material procurement areas from anthropological studies worldwide. Chapter 3 shifts the focus to the Andes with a review of the existing research that informs this investigation. In chapter 3 a discussion of economy, exchange, and long-distance interaction in the region is presented, as well as a summary of the evidence of Chivay obsidian consumption through time. Chapter 4 is a geographically oriented chapter with a discussion of the region in terms of climate, economy, geology, obsidian deposits, and finally the original chemical sourcing work that accompanied this research project. Chapter 5 describes the methods used in this dissertation with a focus on the novel methods employed by this project. Chapter 6 presents the results and analysis of a 33 km^2 archaeological surface survey in six blocks throughout the Upper Colca study area. Chapter 7 describes the results of the testing program that included eight 1x1m test units, five of which are analyzed in detail here. Finally, chapter 8 is the summary of significant findings from this research and chapter 8 strives to reconcile the results of this research with the theoretical objects of the study.

1.2.2. Digital data availability

While a major methodological goal of this project was to exploit new technologies for spatial data and the organization of information, the presentation in this Ph.D. dissertation is largely confined by the traditional format of the library monograph. Large segments of data from this project are available online at

http://www.MapAspects.org/colca/

where additional maps, photos of features and artifacts, and searchable GIS datasets are available permanently. Links to online materials are provided, as well, in the Appendices at the end of this document.

1.2.3. Dates

Throughout this dissertation chronology will be discussed in calibrated years Before the Common Era (BCE). Where possible, ^{14}C dates will be completely reported using the form that follows. The actual radiocarbon years before present will be presented with a lowercase "bp", the laboratory identification will follow, and then the range of 2σ (95.4%) calibrated Before Common Era dates are shown as reported by OxCal v3.9 (Ramsey 1995, 2003) using data presented in Stuiver, et al. (1998). Calibrated Before Common Era dates are shown with the uppercase letters "BCE".

1.2.4. Spatial data

Most spatial data from the Andes is in coordinate systems referenced to the Provisional South American Datum of 1956 (La Canoa) based on the International 1924 ellipsoid. In order to be compatible with topographic data, imagery, and the datum native to the GPS system the coordinates have all been converted to the modern WGS1984 datum using the ArcGIS three parameter transformation function "1208: PSAD_1956_To_WGS_1984_8". The 1991 three parameter transformation to WGS1984 for metric UTM data for Peru is as follows $\Delta X = -279$ m ± 6 m, $\Delta Y = +175$ m ± 8 m, $\Delta Z = -379$ m ± 12 m, and was based on 6 collocated points (Mugnier 2006).

A GIS database of chemically-sourced obsidian samples has been compiled from the central and south-central Andes based almost entirely on published materials. In the text that follows travel times are been reported between the source and the consumption locale as calculated using Tobler's (1993) Hiking Function. This function models travel velocity as a function of slope.

Walking velocity (km/hr) = 6 exp (-3.5 * abs (S + 0.05))

Where S = slope in degrees ($\Delta Z/\Delta X$)

Figure 1-2. Tobler's (1993) Hiking Function models foot travel velocity as a function of slope.

Tobler's function follows Imhof (1950) in deriving travel speeds of 5 km/hr on flat terrain and an optimum travel speed of just over 6 km/hr on a -3.5° downslope. Further elaboration of this hiking speed function, such as on or off path travel and llama caravan versus hiking speed was not attempted as there are too many unknowns to reliably model such differences. While the absolute travel velocity may be unreliable, the relative speeds for comparing one consumption site to the next are informative and correctly factor in the effects of travel over steep terrain versus travel across the gentle slopes of the altiplano. The function has been used elsewhere in archaeological contexts (Gorenflo and Gale 1990; Jennings and Craig 2001; Kantner 1996; Van Leusen 2002).

Topographic data used in this project derive from GPS and from Digital Elevation Models (DEM) generated from two space-borne remote sensing platforms. Three dimensional GPS data was gathered throughout the project using Trimble GPS units and post-processed using the Arequipa IGS base station. Local topographic relief was acquired from the ASTERDEM dataset (30m), and regional scale topographic data was acquired from the SRTM (90m) dataset. As will be described in more detail in Chapter 5, ASTER imagery and DEM data proved to be extremely useful in designing and executing this work in the mountainous terrain of the Chivay source area.

Quickbird satellite imagery for portions of the study region were made available in 2006 as a part of GoogleEarth v4. These data are distributed by DigitalGlobe and they are 2.4m per pixel multi-spectral imagery pan-sharpened with 0.68m per pixel panchromatic imagery for natural color imagery, and GoogleEarth topographic relief is blended into the imagery from the SRTM 90m layer.

1.2.5. Photographs and scale

Linear units used in this project are exclusively metric. A tape measure was extended to exactly 1m in landscape photographs to provide scale. Despite the tape not being legible, the total length of the exposed tape is always 1m unless otherwise noted. In some instances the tape is not perpendicular to the photographer position, a situation that could lead to foreshortening and in such cases the 1m scale would become invalid. Laboratory photos were taken on a matte grey background with a 1cm grid in the background. Additional notes regarding the methodology are provided in Chapter 5.

1.3. Conclusion

This dissertation combines a theoretical discussion of economy in anthropology and a review of existing knowledge regarding Chivay obsidian in the south-central

Andes with new data from the Upper Colca research project. The significance and implications of the data presented here will be need to be reassessed in the future when investigators are provided with additional chemical sourcing studies, new archaeological research in the south-central Andes, and further studies of the Colca area itself.

– Chapter 2 –

Theoretical Approaches to

Economy, Exchange, and Raw Material Sources

2.1. Introduction

This study seeks to investigate long-term social and economic change from the perspective of production and exchange in a region with marked developmental changes in prehistory. First, major stages in south-central Andean prehistory have been widely discussed in the literature, including the transitions from foraging to food production, mobility to sedentism, egalitarianism to social ranking, and from low-level exchange to sustained interregional exchange. Should one not expect marked changes in the acquisition and production of obsidian that are correlated with these large scale prehistoric developments? For example, with the domestication of camelids and the emergence of llama caravans the costs in both time and labor in transporting weighty cargo, including obsidian nodules, must have dramatically decreased. Furthermore, with increased specialization one might expect merchant caravans or state-controlled interests to have emerged that benefit from the regional demand for obsidian. Complexities lurk behind each of these assumptions as these changes are largely co-evolutionary. Problems also lie in the very measures that are used to quantify changes in obsidian production, circulation, and consumption in the region.

Theoretical complications rest largely in three major issues; (1) the cross-cultural study of labor and value in economic anthropology, (2) associations between exchange and socio-political complexity, and (3) measures of prehistoric production that are both valid and practicable in the study of quarry areas. Each of these general issues will be addressed in turn below, and in the subsequent chapter (Ch. 3) the focus will be shifted to the south-central Andes.

Investigations using a close adherence to individual high-level theoretical approaches, particularly formal models of exchange and efficiency in production, were explored during the 1970s and 1980s in a number of obsidian quarry studies, most notably in the Mediterranean and in Mesoamerica. In these areas the regional trajectory benefits from distinct evolutionary changes like the development of highly efficient prismatic blades and well-documented mercantile traditions that perhaps conformed more closely to neoclassical economic cost-efficiency. Yet even in these areas, formal models encountered substantial difficulties in linking theoretical expectations with the breadth of regional exchange and in establishing empirical measures of control and efficiency beyond technical attributes of blade production. This study assumes a broader theoretical approach based primarily in finding correlates between evidence for prehispanic obsidian production and circulation and regional developments in economic organization and socio-political ranking. The theoretical issues presented here are linked to (1) evaluating the structure and level of independence of exchange networks and caravans, and (2) the degree of control exerted by household economies, aggrandizing individuals, and population centers prior to, and during, the Formative in the Lake Titicaca Region.

2.2. Anthropological approaches to economy and exchange

> It is a critical limitation of archaeology, particularly when not given powerful assistance from historical sources, that it remains tied to the spatial distribution of imperishable objects or non-artifactual materials whose temporal sequence is seldom more than very roughly defined. Questions normally asked by archaeologists about trade and diffusion have been those which they can (or think they might be able to) answer directly and incontrovertibly from their data. But we must ask whether such questions are the important ones for an understanding of human society (Adams 1974: 139-140).

2.2.1. Economies

The study of ancient economies has long been a central theme in archaeological research. Lying at the intersection of human behavior and material goods, economy can often provide a theoretical basis for connecting features and artifacts with larger scale traits in prehistoric societies. Economic approaches to prehistory have the promise of bridging the premodern individuals and institutions of anthropological study with their material remains in a quantifiable way in order to examine processes such as change in subsistence, intensification, and exchange.

A fundamental question in economic anthropology concerns the cross-cultural applicability of economic models developed primarily for explaining behavior in Western, market-oriented societies. In the past 50 years economic anthropology has witnessed protracted debates between advocates of formal and substantive approaches to economy (Plattner 1989: 10-15). The perspective put forward by formalists is that ancient and non-western societies differ from those of modern capitalist societies in degree but not in kind (Wilk 1996). In contrast, substantivists recognize fundamental differences between ancient or non-capitalist societies and modern economies. These debates have been reconciled to a certain extent with the recognition that the two approaches largely complement each other. The distinct assumptions associated with formal and substantive economics, however, are critical to framing research questions about ancient economy, commodities, and exchange.

Formal approaches

Formal approaches explore the outcome of rational decision-making with regard to choices faced by prehistoric populations. By conceiving of economic behavior in terms of universal rationality, these approaches are analytically useful because they allow for the isolation of variables and for cross-cultural comparisons. Formal economic analyses are built on studies of modern markets by human geographers and involve reducing labor, land, and capital to the price as the unit of cost. Anthropologists using formal approaches may apply energy or time as value units to studies of food procurement, raw material provisioning, and settlement choice as in studies by behavioral ecologists (Winterhalder and Smith 2000) and archaeologists (Earle and Christenson 1980; Jochim 1976; Kennett and Winterhalder 2006).

Formal approaches to prehistoric exchange have been used by archaeologists to study the evolution in exchange systems both organizationally and from the perspective of individual behavior (Earle 1982: 2). On the larger scale, regression analysis (Hodder 1978; Renfrew et al. 1968; Renfrew 1977a; Sidrys 1977) and gravity models (Hodder 1974) use assumptions of cost minimization to differentiate between possible exchange systems in prehistory. “The sociopolitical institutions establish constraints in terms of the distribution and value of items. Then, individuals, acting within these institutional constraints, procure and distribute materials in a cost-conscious manner" (Earle 1982: 2). Neoclassical assumptions on the scale of individual behavior have also been used to examine the evolution of market based exchange (Alden 1982) and subsistence goods exchange by territorial groups exploiting high-yielding yet unpredictable resources (Bettinger 1982). A synthesis by Winterhalder (1997) investigates the way in which complex exchange behaviors that have been documented ethnographically can result from *models of circumstance* such as tolerated theft, trade and risk reduction, and *models of mechanism* such as kin selection and dual inheritance.

Critiques of formal approaches have been various, with strong methodological criticism coming from influential ex-formalists like Ian Hodder. On the subject of exchange, Hodder (1982: 202) observes that the explanatory power of formal approaches to prehistoric exchange are significantly weakened by the problem of equifinality in the empirical evidence, an issue discussed below. Hodder further argues that middle range links between social contexts, political strategies, and the empirical evidence provided by distributions of archaeological data are insufficiently accounted for with formal approaches such as regression analysis.

Substantive approaches

Substantivism arose in anthropology largely in response to what was perceived as the inapplicability of formal approaches and the assumptions of neoclassical economics to ethnographic case studies (Wilk 1996: 1-26). Substantive approaches emphasize that economy and exchange are fundamentally linked to other aspects of human behavior. To substantivists, economic institutions are effectively cultural traits, therefore techniques designed around "modern" or "western" conceptions of rational individualism are inadequate for application in non-western cultural contexts (Bohannan and Dalton 1962; Dalton 1969). The position was first articulated by Karl Polanyi (1957) that the economy is "embedded" in sociopolitical institutions. This view of economy and non-western exchange has its roots in studies by Malinowski (1922) and Mauss (1925), although the focus in that earlier period of economic anthropology was on social relationships, whereas social change dominated the discourse in economic anthropology during the 1960s (Dalton 1969).

Mid-twentieth century substantivism was based on a functionalist view of society as static and aspiring to the maintenance of equilibrium within the social environment (Schneider 1974). Interaction took place through reciprocity, redistribution, and exchange. Sahlins' (1965) further elaborated on reciprocity based exchange by placing generalized, balanced, and negative reciprocities along a continuum that served to describe the dynamics of interaction within specific social contexts. Another distinction lay between the transfer of inalienable gifts between reciprocally dependent individuals "that establishes a qualitative relationship between the transactors" (Gregory 1982: 101) and alienable commodities as transfer between reciprocally independent people "that establishes a quantitative relationship between the objects exchanged" (Gregory 1982: 100).

A number of critiques have emerged of the substantivist approach. One critique of substantivist approaches to exchange, one that is true of functionalism more generally, is an early version of agency theory. In the substantivist view, society is constructed of consistent rules within agents must act and includes a moral obligation of exchange (Dalton 1969: 77). In this organic perspective, however, “[t]here is little room for individual construction of social strategies and manipulation of rules, and there is little intimation of conflicts and contradictions between interests” (Hodder 1982: 200).

A second critique focuses on the distinction drawn by substantivists between complex and small-scale societies. Among complex societies, formal approaches are supposed to be more relevant, but in the context of small-scale societies substantive approaches are appropriate, and this dichotomy creates a dilemma of where exactly to draw the line. Monica L. Smith (1999: 111) argues that the ethnographic cases to which many substantivist models refer (i.e., small-scale societies) are lower in population density and involve fewer layers of interaction than would have been found in premodern states and empires and therefore formal approaches might have more relevance in premodern complex societies than is presented by substantivists.

A third critique holds that the direct correlation between forms of exchange and level of socio-political complexity lacks empirical support (Hodder 1982: 201). Anthropological studies suggest that unpredictability in food supply correlates with more extensive reciprocal exchange systems. Reciprocity is encountered more frequently among hunters, fishers and farmers than among gatherers and pastoralists who exploit relatively predictable resources (Pryor 1977: 4).

In the current day, Polyani’s framework centering on the distinction between reciprocity, redistribution and market forces continues to be widely used in anthropology and archaeology, despite the development of alternative models that are particularly relevant to studies of commercialized pre-modern states. In particular, Michael E. Smith (2004) argues that more refined differentiation of transaction mechanisms can be used to distinguish the degree of internal and external commercialization in state-level societies, such as those presented by Carol A. Smith (1976a). However, the subtleties of ancient commercial enterprise are less relevant in places like ancient Egypt and the Andes where historical and archaeological evidence attest to strong state control of uncommericalized economies without market-based economics, money, and independent merchants. In other words, Polyani's coarser distinctions of reciprocity, redistribution combined with non-market trade are sufficient in regions such as the ancient Andes where most scholars believe commerce played an minor role in prehistoric development (LaLone 1982; Stanish 2003). In Mesoamerica, however, where evidence for prehispanic markets and traders is widespread, anthropologists have found that Polyani's distinctions are vague and that models with further refinement in modes of commercialization are applicable (Braswell 2002; M. E. Smith 2004; C. A. Smith 1976a).

Complementary applications of formal and substantive approaches

Formal and substantive approaches can be applied in a complementary manner. For example, in Stone Age Economics, Sahlins (1972) attempts to explain the existence of supply and demand curves among aboriginal exchange networks where social parameters determine the development of exchange. Winterhalder (1997) discusses some of the concepts presented by Sahlins (1972) using a behavioral ecology approach to gifts and exchange among non-market foragers. Winterhalder finds that issues such as *social distance* can be addressed more explicitly in a formal framework, albeit more narrowly, because economizing, neoclassical assumptions are a starting point for this type of analysis. As Hodder (1982: 200) points out, formal and substantive approaches are targeting different behaviors; formal economics relies on outputs and performance, while substantive analyses relate to social contexts of exchange.

While these differences make the two approaches irreconcilable on some levels, some studies attempt to integrate both avenues of research. Drawing on the advantages of both formalism and substantivism may be worthwhile, but a tendency to apply formal analyses to state-level societies, due to greater commercialism and specialization, and to apply substantive analyses to small-scale societies, should be resisted (Granovetter 1985; Gregory 1982; M. L. Smith 1999). The assumption that in premarket social contexts economic behavior is heavily embedded in social relations, but then is increasingly atomized and conforming to neoclassic analyses in modern, market-oriented societies is inconsistent. Granovetter (1985: 482) writes

> I assert that the level of embeddedness of economic behavior is lower in nonmarket societies than is claimed by substantivists and development theorists, and it has changed less with 'modernization' than they believe; but I argue also that this level has always been and continues to be more substantial than is allowed for by formalists and economists (Granovetter 1985: 482).

Similarly, Danby (2002) observes that there are serious logical flaws in the false dichotomy, widely applied by archaeologists, where neoclassic, cost-minimizing logic is applied to premodern, complex societies but increasingly assuming an embedded "gift" economy among smaller-scale economies.

This dissertation research project follows on the substantivist tradition in the Andes, but formal approaches have been influential in exchange studies worldwide. The weaker elements of the substantivist approach will be avoided by not assuming a direct correspondence between socio-political complexity and volume or type of exchange.

2.2.2. Transfer of goods and exchange value

In the 1970s much of the debate had shifted from formalism and substantivism, to Marxism and structuralism. Marxists approach economic anthropology comparatively by focusing on production, arguing that society's basic forms of exploitation and inequality are continually being recreated in modes and relations of production (Godelier 1979). Structuralists hold that one had to understand the total system of meaning in order to interpret the relative value of items in a society, but they reject the functionalist assumption that economic institutions serve to integrate society (Graeber 2001: 18).

In the 1980s, the emphasis shifted to consumption. In an influential paper titled "Commodities and the Politics of Value," Arjun Appadurai (1986) states that anthropologists can more effectively examine cross-cultural patterns in economy and exchange by focusing on exchange from the consumption perspective. Appadurai follows Georg Simmel (2004 [1907]) in arguing that the source of an object's value is based in its exchangeability and the desire of the buyer, not the labor that went into production. As with formal approaches, this emphasis on exchange permits broad cross-cultural comparisons because exchange activities are universal characteristics of human behavior. Appadurai's approach shares some of the limitations of formal approaches. Appadurai focuses on the commodified value and the value that goods accrue primarily through transfer, which put constraints on the analytical potential for looking at the social and symbolic significance of human relationships organized around exchange. Rather, Appadurai investigates an object's "life history" as it has passed through multiple hands. The emphasis is shifted from two individuals exchanging goods to the relationship of equivalencies between the two objects being exchanged (Appadurai 1986: 12-17).

A notable challenge to Appadurai's contention that "circulation creates value" is Weiner's (1976: 180-183) observation that among the societies discussed by Mauss (1925) the value of the objects in question is associated with their original owners and their specific histories, and value is not the product of transfer. Thus, the value is not predominantly a result of demand, as asserted by Appadurai, and it is often the case that value reflects the inalienable properties of specific heirlooms some of which, like the royal crown jewels, do not circulate at all. Igor Kopytoff (1986: 74) describes a variety of items that have "singularity" due to restricted commercialization. Examples of this include ritual items or medicines in western society that are destined specifically for the intended patient that have prohibitions against resale. In his critique, David Graeber (2001: 34) suggests that for any society it might be possible to map "a continuum of types of objects ranked by their capacity to accumulate history: from crown jewels at the top, to, at the bottom, such things as a gallon of motor oil, or two eggs over easy". Unlike Appadurai, Graeber's approach places goods in a continuum that does not depend on transfer to establish the relative value of an item. The distinction between alienable and inalienable goods is linked to relative abundance and exclusivity of the products in question and to historic characteristics, like the degree of influence of a price-regulating market (D. Miller 1995).

Exchange and social distance

The dominant ethnographic approach in twentieth-century substantivist anthropology contrasts non-western gifting and exchange with capitalist, market-oriented trade in alienable commodities. Malinowski (1922) describes forms of exchange ranging from *pure gifts* to *trade* with increasing self-interest and "equivalence" as one moves towards the trade relationship. Mauss (1990 [1925]) attacks the notion of the pure gift and instead focuses on the temporal aspects of gift-giving, with the establishment of what are effectively ancient forms of credit. Further, Mauss focuses on the sociality of gift exchange with the idea that gifting can take hostile forms by inflicting obligations that the recipient may fear. Sahlins (1972: 191) subsumes the sociality of exchange relationships into a single trajectory with the concept of social distance. The "social distance" between exchange partners is a way of conceiving of the degree of familiarity and information transfer between producer and consumer of goods.

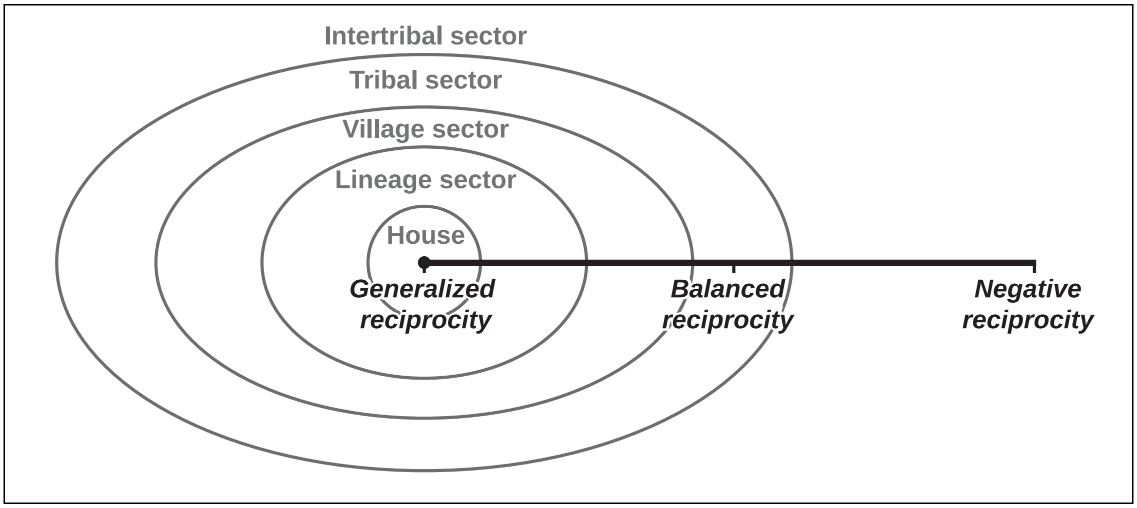

Figure 2-1. Varieties of reciprocal exchange (after Sahlins 1972: 199).

In Sahlins' classic taxonomy of reciprocity he identifies generalized, balanced, and negative reciprocity as a continuum from gift through exchange to haggling and theft, with explicitly different moral standards applying to transfers occurring in each sector. These modes of reciprocity were mapped directly on to increasing social distance originating in the household, although Sahlins was unspecific about the institutional forms of exchange, allowing for wide cross-cultural variation.

Besides the functionalist underpinnings of Sahlins' approach, one critique of his social distance model rests on his distinction between the role of the state and social relationships based on economic ties.

> Because Sahlins is constructing a general theory, he is not obligated to deal with the refractory ethnographic data of one particular group. Hence, Malinowski's multiple heterogeneous categories of gifting never arise. In its place, Sahlins has a single Big Idea developed in the famous chapter on Hobbes and Mauss. The idea is that economics is politics for primitives. The understructure of human society, the default, is the chronic insecurity of Hobbes' "war of all against all." Primitives lack the state that is Hobbes' preferred remedy (Danby 2002: 24).

The result for Sahlins rests on a weak dichotomy between *primitive|modern* economic contexts that includes (1) primitive contexts where relations are mediated by social and economic relationships, and (2) modern contexts given over to the logic of neoclassic economics because commercialization and the circulation of alienable commodities are qualitatively different. Danby presents instead a "post-colonial critique [that] sees *gift|exchange* as yet another mapping of *primitive|modern*, an ultimately tautologous *them|us* split in which 'they' are various negations of what 'we' think 'we' are" (Danby 2002: 32). Anthropologists have sometimes followed this dichotomy where long-term investment and the establishment of social relationships in transactions is given over to the *gift* side, while *exchange* in alienable commodities is expected in complex, state level economies where exchange transactions are analyzed following the neoclassical approach and spot transactions are conducted in open markets.

In contrast, Danby argues that, if anything, one should expect greater temporal complexity and mechanisms for extending forward credit with greater social complexity.

> Rather than building theory by pushing off against neoclassical exchange, let us put neoclassical exchange aside… the asocial spot transactions on the right-hand ends of [Sahlins' (Figure 2-1)] gift-exchange continua are *also* marginal to wealthy capitalist economies. Forward, debt creating transactions, embedded in social relations that often entail power, are central. Moreover, they are likely to be socially embedded in a variety of ways that should lead us to rethink the dichotomies between non-gift and gift (Danby 2002: 28).

Instead of framing the anthropological discussion of exchange in opposition to neoclassical approaches, Danby argues that the discussion should be reframed around institutions that underlie transactions in society and provide the long-term temporal milieu within which transactions occur. Temporality is particularly important when exchange is framed by production calendars based in agricultural cycles and by social calendars centered on gatherings and ceremonial occasions. By this standard, goods lying on the inalienable end of the continuum are fundamental to examining all economies in an anthropological light.

Common goods and luxury goods

The inalienability or uniqueness of an object sometimes parallels the categories of common and luxury items, with common items being mutable and replaceable. Yet, the classification as 'common' or 'luxury' for a given object is not discrete. It has been widely observed that the distinction between common and luxury items is contingent in space and time.

> The line between luxury and everyday commodities is not only a historically shifting one, but even at any given point in time what looks like a homogeneous, bulk item of extremely limited semantic range can become very different in the course of distribution and consumption…Demand is thus neither a mechanical response to the structure and level of production nor a bottomless natural appetite. It is a complex social mechanism that mediates between short- and long-term patterns of commodity circulation (Appadurai 1986: 40-41).

Appadurai presents sugar as an example of a product with widely varying significance, and he observes that it is not merely the possession of exotic goods, but also the social significance of the knowledge surrounding the production or consumption of these goods, that carries significance. Goods that are irregularly distributed in space, portable, and that have wide consumption appeal such as sugar, salt and obsidian, were transported great distances in prehistory. For example, in the Mantaro Valley of the central Andes, Bruce Owen (2001: 280) notes that a number of metal items such as copper needles went from being wealth goods found primarily in elite contexts prior to the Inka conquest, to being utilitarian items and found with equal frequency in commoner contexts under Inka rule.

The movement of commodities has the significant effect of reinforcing relationships between social groups in the sense that the *Kula* ring promotes regular contact (Malinowski 1984 [1922]). However, in circumstances where the elite strive to control consumption of commodities, exchange can threaten the position of the elite. In Appadurai's perspective, both rulers and traders are the critical agents in articulating supply and demand of commodities.

> The politics of demand frequently lies at the root of the tension between merchants and political elites; whereas merchants tend to be the social representatives of unfettered equivalence, new commodities, and strange tastes, political elites tend to be the custodians of restricted exchange, fixed commodity systems, and established tastes and sumptuary customs. This antagonism between "foreign" goods and local sumptuary (and therefore political) structures is probably the fundamental reason for the often remarked tendency of primitive societies to restrict trade to a limited set of commodities and to dealings with strangers rather than with kinsmen or friends. The notion that trade violates the spirit of the gift may in complex societies be only a vaguely related by-product of this more fundamental antagonism (Appadurai 1986: 33).

The suggestion that exchange promotes contact that threatens elite control results from either a relatively independent group of traders, or competing elites that utilize external contacts to advance their positions. Appadurai's point, however, is that in the realm of political finance one might expect established elites to strive to exert greater control over the values of production and exchange rather than relegate this important issue to those who traffic in long-distance goods, such as caravan drivers.

Following Polanyi, one might expect to find that in complex, premodern societies without market-based exchange there was dominance of administered trade. However, a number of scholars have observed that Polanyi (1957) appears to have ruled out precapitalist commercialism in ancient states a priori, as he claimed that there were no true markets or prices that reflected supply and demand in the ancient world, but rather equivalences in value that were set by rulers in an administered context. These "dogmatic misconceptions" (Trigger 2003: 59) appear to have caused Polanyi to distort the historical evidence as his views of administered markets in premodern states have been widely refuted (M. E. Smith 2004: 75-76; Snell 1997). Historian Philip Curtin (1984: 58) observes that even within contexts of administered control traders may have had more freedom than previously thought.

In some regional contexts, such as the prehispanic Andes, Polanyi's interaction types continue to be viable because there is little evidence of commercialization and open markets. The prevailing interpretation of prehispanic economy, for the Inka period in the central Andes at least, is "supply on command" (LaLone 1982) with elite economic domination primarily through labor mobilization. This issue will be explored in more detail in the Chapter 3, but Andeanists have largely found that Polanyi's non-commercial typology of premodern exchange suffices for analyses of prehispanic Andean economies.

Exchange promotes interaction between communities, yet Appadurai also explains that “such a tendency is always balanced by a countertendency, in all societies, to restrict, control, and channel exchange” (1986: 38). Under the rubric of “politics of value” Appadurai describes a pattern of institutional or elite control of commerce monopolizing or redirecting the flow of commodities. On this issue Graeber characterizes Appadurai’s 1986 framework as “neoliberal” and describes it as follows

> Appadurai leaves one with an image of commerce (self-interested, acquisitive calculation) as a universal human urge, almost a libidinal, democratic force, always trying to subvert the powers of the state, aristocratic hierarchies, or cultural elites whose role always seems to be to try to inhibit, channel, or control it. It all rather makes one wish one still had Karl Polanyi (1944) around to remind us how much state power has created the very terms of what is now considered normal commercial life (Graeber 2001: 33).

Appadurai cites examples of historic royal monopolies and sumptuary laws restricting trade items in Rhodesia and renaissance Europe support his argument (Appadurai 1986: 38). However, without the state-organized overhead of basic institutions guaranteeing peace, investment, and the protection of property, the movement of goods would involve much more danger of theft by brigands or goods could be simply confiscated by rival authorities.

Appadurai’s focus on consumption is a significant contribution in that it releases anthropologists to address activities specifically related to consumption behavior, even though the neglect of production presents an incomplete picture of economy. Consumption loci are often the contexts where the strongest evidence or patterning of interaction is found. Thus, consumption is particularly useful to archaeologists who may only have evidence of changing consumption patterns, or who must infer links between production and consumption indirectly.

Exchange in subsistence, cultural, and prestige technologies

The distinction between the circulation of common and luxury goods observed by anthropologists can be considered in terms of the larger economy and the organization of technology by linking these concepts to those of practical and prestige technologies. As described broadly by Hayden (1998), *practical technologies* are those that are primarily organized around principles of sufficiency and effectiveness, while the logic of *prestige technologies* is fundamentally different because it is oriented towards social strategies where greater labor investment in products serves to communicate the wealth, success, and power of the parties involved. A third category, termed *cultural goods,* will also be used to examine the relationship between material culture and exchange. The concepts of practical, cultural, and prestige goods will be used to link long term changes in the organization of technology and production with consumption patterns and socio-political evolution.

This framework is relevant to this discussion of anthropological approaches to exchange because it places the contrasting behavior that Appadurai terms "common" and "luxury" goods into an empirical and evolutionary framework capable of addressing change over long time periods. Thus while the earlier discussion of "luxury goods" that transcend social and political boundaries referred to particular contexts of circulation, these are specific manifestations of goods Hayden would include in the broad category of prestige technology, as these objects are labor intensive to produce or acquire.

The concepts of practical and prestige technologies parallel in some ways the economic distinction made by Earle (1987; 1994) between subsistence and political economies. The household level subsistence economy is based on satisficing logic, while the political economy involves the mobilization of surpluses and competition between political actors, and is subject to the maximizing strategies of elites. The organization of technology is sometimes approached in terms of three groups as Binford (1962) has done with “technomic”, “sociotechnic”, and “ideotechnic” categories. For Binford, technomic objects correspond to “practical technology”, and the sociotechnic and ideotechnic groups would largely, but not exclusively, overlap with “prestige technologies”. Hayden (1998: 15) observes that labor inputs are low but sociotechnic significance is high in Australian Aboriginal string headbands that signal adult status, and labor is low but ideotechnic significance is high in a pair of crossed sticks tied together to represent a crucifix. Hayden points out that despite these exceptions, items of ritual and social significance are often made with relatively costly materials (such as gold crucifixes) but he admits that many items fall between his categories such as decorated antler digging-stick handles, and “the analysis of such objects becomes especially complex where the prestige materials such as metals or jade are actually more effective, but far more costly, than more commonly used materials” (Hayden 1998: 44-45). Obsidian presents a similar dilemma where, on the one hand it is rare in many regions, and it is unusual-looking, and yet it is also more effective for many kinds of cutting functions and so the inducement to use the material is not straight-forward. As an object can move between categories it should be said that ultimately the significance of an item is not an inherent property of the object, but rather it is created by contexts of use or consumption and should best be considered in terms of labor, exchangeability or life-history (Appadurai 1986; Graeber 2001).

CATEGORY	DISTRIBUTION	EXAMPLES
Subsistence Goods	Practical technology. As a response to stresses item must be effective. Widely available, minimizing costs due to satisficing logic, distributed shorter distances.	Simple tools: axes, saws. Simple baskets and pottery. Bulky, low value foods (i.e., cereals, tubers). Common metals (later Old World prehistory).
Cultural Goods	Widely available goods, but with information content and social and ideological significance. Aesthetic but non-labor intensive and non-exclusive designs.	Some projectile technology. Textiles, shell, herbs and medicines such as coca leaf. Items for commonplace rituals.
Prestige Goods	High labor inputs, investment logic due to political potential of consuming labor, sometimes wide distribution in circumscribed contexts. Competition may mean that these are consumed or destroyed.	Rare metals; serving vessels: ceramics, baskets; jewelry; tailored clothing. Musical instruments, high value foods, rare or costly herbs and medicines.

Table 2-1. Three categories of exchange goods, the boundaries on these categories are contingent on contexts of production, circulation, and consumption. Many items like meat, maize, and obsidian tools can belong in any one of these groups depending on form and availability.

According to Hayden (1998: 44) any material that is transported more than two days should probably be considered a *prestige technology* due to labor investment, however he mentions that perhaps a useful intermediate category of "cultural goods" could be defined consisting of non-prestige ritual or social artifacts. In his analysis of long distance caravans in the Andes, Nielsen (2000: 66-67) borrows concepts from Hayden's practical and prestige technologies with some modification for a discussion of exchange goods. Nielsen defines "subsistence goods" and "prestige goods", but he also defines a third category as "cultural goods" to include maize used for subsistence but also for ritual, as well as coca and textiles. These goods are often non-exclusive, but their form and consumption carries significance and the circulation of such items does not conform to the satisficing logic of practical technologies and subsistence goods.

Ordinary goods and archaeological theory

The fact that many artifacts cannot easily be classified into one of the above groups in a particular time or cultural context shows the difficulties inherent in developing a generalized framework for addressing production and exchange through prehistory. Obsidian is a prime example of a material that has practical value, but it is visually distinct and it is also a material with cultural significance and prestige associations in some contexts. Thus, while the focus in exchange studies has been on prestige goods linked to status competition, because these activities have evolutionary consequences, subsistence goods may also contain social or cultural information. The association of items luxury or commonplace categories is a function of geography, technology, and socially defined valuation.

Information content and everyday goods

Monica L. Smith (1999) develops an argument based on a dichotomy between "luxury goods" and "ordinary goods", where some of the ordinary items used in household activities and moved through kin-based exchange networks form an important, material component of group identity. This essay could also be used to support an argument for an intermediate category of *cultural goods*. Smith notes that the circulation and consumption of such ordinary but visually distinct household goods serve to maintain cultural links and symbolize status markers that probably precede, and indeed form the structure for, later social ranking. She observes that archaeological discussions of exchange often falsely imply that exchange links were established by an exclusive elite population and these links eventually become established and expand to ordinary goods.

> Brumfiel and Earle (1987a: 6) find the distinction between luxury and utilitarian goods setting the stage for the organization of economic activity in early complex societies, citing "… the lack of importance of subsistence goods specialization for political development." The sequence in which different types of goods are incorporated into exchange patterns is explained as an evolutionary sequence paralleling developments in sociopolitical complexity, so that "as trading routes and trading relationships became more firmly established, everyday goods were added to the merchants' repertoire…and came to supply not only valuable items for elites but also food staples and utilitarian wares for people in the society generally" (Berdan 1989: 113; cited in M. L. Smith 1999: 113).

Some scholars have historically placed a priority on the influence of status or luxury goods by elites in some centralized political sphere in stimulating and maintaining long distance trade links (Brumfiel and Earle 1987a; C. A. Smith 1976a), arguing that the political objectives of elites and aspiring elites were the impetus for long-distance links. Yet as M. L. Smith (1999) applies the socio-semiotics of Gottdiener (1995), the consumption of particular materials can have social significance and can convey information content at a variety of levels. Thus the capacity for kin-based reciprocal exchange networks to distribute household items over distance, or household level caravans to emphasize relatively mundane products, should not be underestimated.

The intent of many archaeologists focusing on the role of status goods exchange seems to be not necessarily to deny the capacity and symbolism of household-level exchange as much as it is to emphasize the political and economic significance of exchange in status goods controlled by elites. Goods that circulate widely within a particular community may serve to express community participation or corporate affiliation (Blanton et al. 1996). Hayden's distinction of practical and prestige technologies focuses instead on effectiveness, for the first group, and high labor inputs for the second. Thus, to reconcile this with M. L. Smith's argument, the third group that includes "cultural goods" conveys important social and ideological information beyond the satisficing "effectiveness" stipulation, but simultaneously is widely available and cross-cuts social hierarchy.

Availability and consumption patterns

One reason that subsistence goods, cultural goods, and prestige goods are non-exclusive categories is that consumption patterns associated with these goods have changed as availability changed through time. The availability of a given material changes through time, be it obsidian in the prehispanic Andes or glass drinking vessels in ancient Rome, and availability conditions the importance of its consumption (Appadurai 1986: 38-39; M. L. Smith 1999: 113-114). In cases of intensified craft production, availability may be determined by labor specialization, production units, intensity, locus of control, and context of production (Costin 2000). With commodities based on raw materials, the primary determinant of availability in most cases is geographical distance from the source, but economic patterns, socio-political barriers, technology of procurement and transport, and rate of consumption all affect availability.

Along with naturally occurring raw materials that are irregularly distributed across the natural landscape, such as obsidian where sources are rare, one may expect behaviors associated with scarcity to apply to geologically occurring minerals only with diminished availability as one moves away from the source of these goods. Thus the availability of goods such as obsidian over the larger consumption zone for these materials will vary from abundant to scarce depending on geographical relationships and socio-economic links between the source and the consumption zone. The archaeological study of commodity distribution, and in particular the relationship to economy and to socio-political evolution, spawned years of research into regional exchange beginning with the work of Colin Renfrew (1969b) and that of his colleagues.

The circulation of flaked stone

Focusing here on the differences in artifact use in regions where raw materials are abundant, versus those places where they are rare, permits several generalizations with regards to raw material consumption. As a material class, flaked stone is durable and often the material is sourcable to geological origin point and due to these features, lithics analysis share some attributes with consumption studies of other artifact classes. One characteristic that differentiates lithics is that they are among the more resilient archaeological materials, and are sometimes used as a proxy for mobility or exchange. However, the lithics material class is comparable with other artifacts of consumption like ceramics, food goods and textiles, in that lithics are used to produce goods that range from mundane or subsistence-level to elaborate forms that imply the goods were inscribed with social or ritual importance.

Lithics have important differences from other artifact classes, however. Principally, the production of stone tools is a reductive technology and flaked stone tools inevitably become smaller with use. This directionality of lithic reduction, which allows for technical analysis and refitting studies, signifies that, unlike metal projectiles, textiles, and other widely exchanged materials, the down-the-line transfer and use of lithics has distinctly circumscribed use-life based on reduction. The second major implication of the reductive nature of stone is in regards to the social distance between the producer and consumer. As stone artifacts become inexorably smaller with production and use, larger starting nodules can take more potential forms and have a generalized utility that is progressively lost as reduction proceeds. In terms of the exchange value of a projectile point as a “cultural good”, the roughing out of a lanceolate point, for example, may have determined the cultural value of the preform such that it would have had less potential, and therefore less value, in contexts where triangular points are used. With scarce lithic raw materials the size of the item probably related directly with its reduction potential; therefore larger nodules would probably have had value in a wider range of consumption contexts.

Lithic procurement, distribution, and consumption are in some ways comparable with other classes of portable artifacts, and in some ways quite distinct. Archaeologists have used the spatial relationships between lithic raw material and behavior to study the ways in which the availability of a particular material type affects prehistoric behavior with respect to production, curation and mobility (Bamforth 1986; B. E. Luedtke 1984; Michael J. Shott 1996). Procurement, distance from source, and the embedding of lithic provisioning in subsistence rounds have specific consequences with respect to raw material use in the vicinity of a geological source area (Binford 1979; Gould and Saggers 1985), an issue to be discussed in more detail below. Regardless of mode of transfer and other distributional issues, the use of lithic raw materials, as with other artifact classes, is contingent on variability in a number of dimensions. These dimensions include whether the material is abundant or rare, lightly or intensely procured, laden with cultural or prestigious associations, as well as circulation and demand, although many of these variables can be difficult to isolate archaeologically.

2.2.3. Transfer of goods and socio-political complexity

Prehistoric exchange has long been central in anthropological and economic models of socio-political change. Exchange has been discussed by social theorists, anthropologists and archaeologists the debating the ultimate causes of socio-political inequality that emerged independently during the Holocene in different regions of the world. In the course of the last 12,000 years, archaeological evidence documents a change from a worldwide of hunting and gathering groups with relatively egalitarian, village-level social organization to, in a few places world-wide, in-situ development of state-level society with large settlements, greater concentration of wealth, and hierarchical economic and political organizations. While anthropological models accounting for political and economic change have been refined over the past century, evidence of exchange has consistently served as a material indicator of regional interaction and differential access to exotic goods within a community.

Exchange as a prime mover?

Regional exchange is of particular utility to anthropological archaeology because it is a material phenomenon that occurs at the intersection of social relationships, resource procurement, and individual or community differentiation. However, exchange has been attributed with great causal significance in the past and, while it provides evidence of particular utility to anthropologists and archaeologists, it is important to not ascribe excessive significance to exchange in human affairs. For example, to V. Gordon Childe (1936) long distance trade was a prime mover that had direct social evolutionary consequences. Engaging in trade had derived benefits that can affect the balance of power between competing polities and stimulate larger forms of organization.

In the 1970s, Rathje (1971; 1972) proposed that it was the lowland Maya need for "essentials" like obsidian, salt, and grinding stones that propelled them to seek external sources for these scarce goods, initiating long-distance relationships. Those who control access to scarce materials accrued benefits from their position in the trade network, he argued, and hierarchies emerged from the differential access to these required, or desired, trade goods. Virtually all of Rathje's postulates have since been disproved, but some variant of the theme first articulated in Rathje's exchange model underlies many contemporary investigations of ancient trade (Clark 2003: 33-34).

In the multilinear evolutionary framework of Johnson and Earle (1987), trade is part of an array of processes that are relevant to socio-political development, but trade does not become a dominant process until the formation of the Nation-State.

ECONOMIC PROCESSES IN POLITICAL EVOLUTION			
LOCAL GROUP	*REGIONAL CHIEFDOM*	*EARLY STATE*	*NATION-STATE*
WARFARE	WARFARE	WARFARE	WARFARE
RISK MANAGEMENT	RISK MANAGEMENT	(RISK MANAGEMENT)	(RISK MANAGEMENT)
TECHNOLOGY	TECHNOLOGY	TECHNOLOGY	(TECHNOLOGY)
TRADE	TRADE	TRADE	TRADE

Table 2-2. Economic processes in political evolution (from A. W. Johnson and Earle 1987: 304) where capitalized words indicates a dominance of that process, parenthesis indicate important secondary processes.

The approach taken here is that all human groups engage in exchange in some form and it therefore serves as a consistent index of regional relationships through time. Furthermore some trade items, such as obsidian, appear to have been part of a suite of features that, at particular times and socio-political contexts, serve to differentiate individuals or groups from the rest of their community for purposes relating to political strategy. While exchange is not a prime mover for socio-political change, transfer between peoples and groups in different forms provides a vehicle for social differentiation and a materialization of geographical relationships that are closely linked to socio-political organization. Thus, while one may see exchange occurring over the long term, it is not a prime-mover but it is changes in evidence of production, transfer, and consumption of non-local goods that inform theoretical models of prehistoric change.

Exchange concepts reflect the current theory

Forty years ago, advances in technical analysis in archaeology, in particular geochemical sourcing, initiated several decades of research into exchange by archaeologists. Following the dominant theoretical approaches of the time, adaptationalist or managerial models held that socio-political change was stimulated by factors that impacted the entire cultural system. Such changes could be stimulated by a combination of factors, including external pressures and internal pressures. External pressures include resource stress, drought, and warfare. Internal pressures include greater efficiency in organization despite larger population levels, irrigation, and organizational complexity due to circumscription.

More recent theoretical approaches focus on social and political strategies prioritize the active role of individuals in the process of political change. The role of commodity exchange in the onset and dynamics of socio-political complexity connects the exchange behavior documented by anthropologists with the long term changes that underlie the archaeological evidence of exchange in prehistory. Leveling mechanisms among hunter-gatherers promote intergroup sharing and are especially prominent when resource predictability is low. With greater resource predictability, and especially when resources are intensifiable, these leveling mechanisms often begin to break down and social differentiation is observed.

Exchange is thought to have been one of a number of interacting behaviors by “aggrandizing” individuals that had the indirect result of institutionalizing social inequality (Clark and Blake 1994; Flannery 1972; Hayden 1995, 1998; Upham 1990). What were the socio-political contexts that permitted individuals to differentiate themselves, and how did individuals pursuing their interests result in the long-term changes observed archaeologically?

Early leaders

While early social hierarchy emerged from the so-called egalitarian contexts of small-scale societies, Wiessner (2002: 233) observes that “hierarchy characterizes the societies of our closest non-human primate ancestors and seems to be deeply rooted in human behavior” and social hierarchy can therefore be considered a “reemergence” of hierarchy. Egalitarianism is not the “tabula rasa for human affairs on which aggrandizers impress their designs” (Wiessner 2002: 234); rather, it is the result of coalitions and complex institutions of weaker individuals in society that curbs the ambitions of the strong and results in egalitarian structures that were as complex and varied as hierarchical power structures. Wiessner argues that cooperative behavior, such as elaborate exchange relationships, in egalitarian institutions fostered ideologies of coalition building and cooperation in kinship-based networks that extended far beyond local groups. While the egalitarian ethos constrained the competitive activities of aggrandizers, these institutions also provided powerful tools to the cooperative structure that could be used to the advantage of aggrandizers. Exchange has particular significance in agency models that strive to explain how the activities of aggrandizers can result in institutionalized inequalities because exchange can contribute to an understanding of the relationship between structure and agency at this juncture.

Aggrandizers had to work within powerful institutional boundaries that already existed in egalitarian societies in order to forward their interests. The changing nature of exchange, embedded within shifting institutional contexts, complements the emphasis on alienable commodities (Appadurai 1986, see Section 2.2.2). Aggrandizing individuals operate within institutional contexts, indeed their vehicle to promotion is social recognition, yet the ability to organize resources to obtain lower costs for particular items benefits aggrandizers and their supporters. Exchange is a universal feature of human societies, and studies that document the diversity of forms that exchange takes in contexts of early social ranking can shed light on the specific strategies used by aggrandizers that resulted in institutionalized inequality (Clark and Blake 1994).

Prehistoric institutions

Beginning with settlement pattern studies explored by Julian Steward, processual archaeologists often assume regional perspectives that emphasized social and organizational processes (Willey and Sabloff 1974). Building on Polanyi's observation that fundamental aspects of human institutions are economic, archaeologists understood that documenting the regional distributions of artifacts resulting from prehistoric mobility or exchange could contribute to reconstructing past societies. Archaeologists can use direct evidence from the production and consumption of archaeological materials and inference about the likelihood and form of prehistoric exchange to point to the institutional contexts of the ancient economy.

In Polanyi's (1957) seminal article outlining the substantive approach, "The economy as an instituted process," the economy is characterized in terms of two linked properties. First, there is the material process by which items are produced, circulated, and consumed; second, there is the economic form organized around socio-political relationships that arranges interactions diachronically and spatially. In this context, institutions serve as rules and obligations connecting human organizations around the process of producing and circulating goods. The implication is that an archaeological study of variation in prehistoric economies requires that archaeologists can document differences in the institutions that structured past economies.

Many contemporary theoretical approaches downplay the importance of structural analyses in favor of agent-based models, however anthropologists using New Institutional Economics (North 1990) are emphasizing the interdependence of institutions and economics and the implications for activities of individuals (Acheson 2002; Ensminger 2002). Douglass North (1990: 3) defines institutions as "the rules of the game in a society or, more formally, the humanly devised constraints that shape human interaction". This view considers how institutions developed from the decisions of individuals over long periods of time, affecting transaction costs through the benefits of coordinated activity. “Based on the advantages of lower transaction costs in commodity flows, [these anthropologists] argue that political and social institutions developed to regulate commodity flows, maintain regional peace, and guarantee contracts” (Earle 2002: 82). In this perspective, institutional complexity developed as rules to govern the economizing nature of individuals, and the emergence of such institutions should be correlated with increasing quantities of commodity exchange in prehistory. The perspective that argues that volume of exchange should correlate with increased social complexity has roots in theories of progressive evolution (Childe 1936), adaptionalist views (Julian H. Steward 1955), and the managerial role of chiefs (Service 1962).

However, a positive correlation between evolving institutional complexity and a uniform increase in volume or variety of exchange in prehistory is not supported empirically (Brumfiel 1980; R. E. Hughes 1994; Kirch 1991). That is, contrary to the evolutionary expectations of some theorists, the volume or variety of goods transferred does not necessarily reflect the political or institutional complexity in a given society. Perhaps some of this inconsistency is the result of elite control of the circulation of commodities as proposed by Appadurai (1986: 38). Earle (1994: 420-421) observes that on the whole, the archaeological evidence is characterized by a great deal of variability in the types of goods exchanged, the volume of exchange, and the social contexts of exchange. In order to address this variability in an evolutionary framework, Earle suggests that exchange should be considered in terms of two categories, the *subsistence economy* and the *political economy*[1] (A. W. Johnson and Earle 2000), with exchange taking different forms in each category of the economy. The exchange in these two forms of economy correspond largely to the distinction discussed earlier between ordinary goods and prestige goods where, according to Earle, political strategy is advanced by elites by, among other things, the manipulation of exchange relationships.

In a non-evolutionist application of New Institutional Economics in anthropology, Wiessner (2002: 235) differs from North in arguing that transaction costs for exchange are actually high in small-scale societies due to the close relationship between social and economic transactions; there is less neutral space for "unembedded" economic behavior with their associated overhead costs. In such contexts egalitarian institutions developed to foster trust and make interactions more predictable.

> In non-market economies in which kin-based exchange systems play an important role in reducing risk (Wiessner 1982, 1996) the goal of exchange is to be covered in times of need. In this context, the social and the economic are closely intertwined (Mauss 1925) and it is undesirable for returns to be stipulated as to time, quantity, or quality (Sahlins 1972). The most valuable information in such exchanges is the details of the partner – what he or she has to offer and will offer over the long run (Wiessner 2002: 235).

Elaborate institutions regulating behavior are not new, argues Wiessner, but if there is a weakening in the egalitarian prohibition against the accumulation of wealth or power the "alchemy of ambition" (Wiessner 2002: 234) drives a few individuals to

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[1] Earle uses "political economy" in contrast to "domestic" or "subsistence economy" but this terminology is not to be confused with the larger field of "Political economy" as a theoretical approach to economics

seek preferential access to resources. In contexts of regional packing and circumscription it is argued that hierarchies emerge (Brown 1985; G. A. Johnson 1982) that are perhaps founded on the control of labor and surpluses, and instituted through ritual (Aldenderfer 1993b; Hayden 1995)

Materialist perspectives hold that economic gains are used to bring about changes in the social order, and that these changes are then legitimized and perpetuated through ideology. These economic gains are generally achieved through intensification of production and through finance organized by ambitious individuals (Boone 1992; Earle 1997; Hayden 1995). Clark and Blake (1994: 17), building on practice theory (Bourdieu 1977; Giddens 1979), describe a model whereby institutionalized inequality is the unintended outcome of political actors competing for prestige by using strategies that match the self-interests of their supporters. Ultimately, these strategies may develop into redistributive institutions that appear to build on the social-leveling mechanisms described by Wiessner (1996), but operate on a larger scale and result in political advantage for redistributing leaders and their allies. In other words, it is institutions themselves that form the basis for leveling mechanisms, and it is institutions that are transformed into vehicles that serve to, in part, legitimize social inequalities.

An important temporal component to exchange is connected to institutions as well because transactions involve anticipation and scheduling. As Colin Danby (2002) argues, most transactions in neoclassical economic analyses in anthropology are considered as synchronic “spot transactions” of commodities, while long term interpersonal relationships enter the domain of gifts in a *gifts*:*commodities* dichotomy. The temporality of reciprocation is a means by which economic transactions are embedded inside of social calendars, but various socially-mediated methods of extending credit are well-established and probably an ancient manner of precipitating exchange in market-based transfers as well.

Pastoralism, caravans, and social inequalities

The domestication of cargo-bearing animals contributed several important elements that transformed the nature of regional exchange relationships. First, there are some cross-cultural commonalities in the structure of contemporary societies practicing pastoralism, and it is probable that these factors had some role in prehistoric pastoral societies as well. Second, cargo-bearing animals transform the costs of transport and, consequently, the nature of long-distance interaction. Finally, the structure of wealth in animal herds conveys particular scalar advantages to powerful kin-groups that possess large herds. These factors condition long-term transformations such as sedentism, the nature of food production, and the institutionalization of social inequalities. These issues will be explored in three sections: household level articulation with agriculturalists, wealth accumulation among herders that is limited by risk and pasture, and caravans and the organization of pastoral labor.

Household level articulation with agriculturalists

An important structuring principle to pastoralist exchange is that herding systems are not economically independent because humans must consume a sufficient diversity of major food groups for nutritional reasons; a condition known as non-autarkism (Khazanov 1984; Nielsen 2000). Depending on available wild plants, herders may acquire a portion of their non-animal products from gathering activities but the more common solutions involve a mixed agro-pastoral strategy or articulation with agriculturalists. Furthermore, herders with animals capable of bearing loads are the natural agents for facilitating this articulation with agriculturalists (Browman 1990; Flores Ochoa 1968). Thus, exchange relations are a basic necessity for dedicated herders. For herders with cargo animals, the transport of exchange goods in some capacity was likely a regular feature of pastoral household economies that become more common and less laborious (in terms of quantity of goods exchanged) with the assistance of cargo animals. As pastoralist households are not autarkic, due to the need for non-animal foods on a regular basis, households usually have cargo animals as part of their herd and relatively brisk exchange networks are likely to develop between households without the need for elites, administrative oversight or investment from super-family organization.

Limitations to accumulation by herders

Inequalities are evident in most pastoral societies as owners with large herds are better able to maximize by grazing all available lands when conditions allow and hiring additional help with herding tasks like shearing and butchering. Furthermore, large herds can reproduce more quickly, are better able to survive hardship, and better maintain a minimum herd size threshold for viability. Nevertheless, pastoral wealth is widely recognized as unstable due to the overall vulnerability to drought, disease, parasites, predators, theft, and accidents that can cause declines of over 50% in a given year (Khazanov 1984: 156; Kuznar 1995; Nielsen 2000: 42; Salzman 1999). Herders mitigate this risk by diversifying production, maintaining extensive exchange networks, holding access to grazing land in common, and utilizing other institutional means of risk reduction, such as the redistribution mechanism of *suñay* among Andean pastoralists (Flannery et al. 1989).

A significant pastoral institution that appears to function as a leveling mechanism is the corporate ownership of pasture. While herds are typically held by individuals or kin-groups, herding is spatially extensive rather than intensive, and access to pasture in herding societies almost universally requires community negotiation (Ingold 1980; Khazanov 1984; Nielsen 2000: 46-51). Among pastoral societies that do not store fodder the carrying capacity of the land, and therefore the intensifiability of production, is limited by the season with the lowest productivity (Nielsen 2000: 43). Finally, in some regions of the world, such as the Andes, modern herds are bilaterally inherited which serves to prevent accumulation in specific descent groups (Lambert 1977; Webster 1973: 123). Thus, herding does not organizationally contain the seeds for social inequality, but intensified pastoral wealth in the form of very large herds has been documented as one principal form of investment in ethnohistorically known hierarchical societies in herding regions.

Caravans and the organization of pastoral labor

Pastoralist societies that organize into seasonal trade caravans share structural characteristics; some of these characteristics tend towards promoting social inequalities and others that counter-act the tendency (Browman 1990). The organizing of a trade caravan is often simplified among dedicated pastoralists because pastoralism is relatively efficient in the use of labor, and the herding and caravanning schedules can be prioritized (Nielsen 2000: 44-45). A single herder can monitor hundreds of animals on a typical, uneventful day of pasturing without a great deal of effort, and as physical labor is low as compared with agricultural tasks, children and the elderly often contribute and broaden the herding labor pool. As a consequence, during caravan season the loss of several capable family members (usually adult men) to the caravan journey for weeks or months during a single year may not unduly hamper the productivity of a household of dedicated pastoralists.

As mentioned above, all pastoral households must acquire non-pastoral products through diversification or exchange, however the ability to organize a caravan inherently favors the wealthier herders for several reasons.

(1) Herders with large herds are more likely to have a sufficient number of hearty animals capable of enduring long journeys with cargo.

(2) Caravan animals provide the mechanism of transport. Therefore, for direct exchange consisting of spot transactions, pastoralists must initiate the trade opportunity by traveling to their trade partners with a sufficient surplus of goods to acquire goods in exchange.

(3) The rewards of such trade caravans accrue differentially, allowing those who regularly participate in such ventures to acquire access to non-pastoral resources, a more extensive social network and perhaps fictive kin among distant trade partners, and enhanced prestige among their community.

While some elements of dedicated herding societies favor differential accumulation of wealth in the form of large herds, diversification of the resource base, and extensive trade networks, the realities of high risk to pastoral wealth and low intensity of land use affect all herding households equally to the extent that they dedicate themselves to pastoralism. Thus, while redistributive mechanisms and corporate tenure of pasture serve to stabilize pastoral systems, the structure of herding systems also provides a few opportunities for strategic advantage to more opportunistic and aggrandizing elements of prehistoric society. In addition, despite the risk in herding systems the ownership of a large herd may directly confer prestige on pastoralists (Aldenderfer 2006; Hayden 1998; Kuznar 1995: 45), and inequalities in pastoral wealth can be channeled into more enduring and intensifiable avenues such as increased exchange (ultimately resulting in large trade caravans) or a mixed agro-pastoral strategy. As a pastoral economy with cargo transport capabilities first takes hold in a region, increased social differentiation may reflect a co-evolution between more extensive exchange relationships, greater sedentism, population increases, and larger population centers.

2.2.4. Definitions of exchange

Studies of exchange can contribute to understanding human behavior because, more than any other species, humans have possessions and shift them between individuals. A person can acquire an object of wealth either by producing it or exchanging for it. In the terms used by economic anthropologists, exchange takes a number of forms in social interaction. *Wealth* is the objective of a person's labor and is therefore culturally determined. *Markets* refers to a market-based economy where prices reflect supply and demand (LaLone 1982: 300), as is not to be confused with aggregated transfers of various forms occurring in marketplaces. *Exchange* or *trade* are commonly used terms for processes referred to more generally by economists as transfer or allocation (Hunt 2002). *Commodities, goods,* and *products* are used here synonymously here and do not imply exchangeability or alienability.

Polanyi and the economics of exchange

The principal forms of economic organization outlined by Karl Polanyi (1957) – reciprocity, redistribution, and market forces – have been widely used in anthropological discussions of exchange. Paul Bohannan describes the relevance of these economic modes to exchange:

> **Reciprocity** involves exchange of goods between people who are bound in non-market, non-hierarchical relationships to one another. The exchange does not create the relationship, but rather is part of the behavior that gives it context.
>
> **Redistribution** is defined by Polanyi as a systematic movement of goods towards an administrative center and their reallotment by the authorities at the center.
>
> **Market Exchange** is the exchange of goods at prices determined by the law of supply and demand. Its essence is free and casual contract (Bohannan 1965: 232).

In principle, the price-fixing aspect of market based exchange has an integrative effect and entails communication between segments of the exchange sphere. For the trader, market exchange involves risk and potential profit. For the producer, the consumption patterns and fluctuations in demand should be sensed all the way back in the contexts of production. Market articulation in land-locked regions of Asia and North Africa provided the initial contexts for large-scale caravans in the Old World. With caravans perennially under threat of robbery or obligation to pay duties for crossing sovereign land, the “nomadic empires of the Turk, Mongol, Arabic, and Berber peoples were spread out like nets alongside transcontinental caravan routes” (Polanyi 1975: 146-149). In contrast to market mechanisms, Polanyi also described exchange modes of institutional or administered trade, where material needs were satisfied through the movement of goods but the practice was not motivated by “profit” for merchants in the market sense of the term but rather to meet institutional goals (Salomon 1985: 516; Stanish 1992: 14; Valensi 1981: 5-6). In this type of trade, value and equivalencies are established by political authority or by precedent.

Characteristics of a market economy

Markets are of particular interest in this discussion because while market principles, to a certain extent, underlie all formal economic approaches in anthropology, market-based economies are far from universal in the premodern world, even among state-level societies. A basic definition of a market is “the situation or context in which a supply crowd (sellers) and a demand crowd (buyers) meet to exchange goods and services” and where the market principle is operating (Dalton 1961: 1-2). Three characteristics used by Earle to evaluate the evidence for market-based exchange in the Inka state include: (1) The importance of specialized institutions of production and exchange divorced in their operations from other institutional relationships; (2) The development of a medium of exchange to facilitate the systematization of exchange values; (3) The percentage of goods utilized by a household that are obtained by exchange (Earle 1985: 372-373).

The presence of exchange institutions, either as bustling marketplaces or distributed as "site-free" exchange houses, have a characteristic described by Earle (1985: 373) as a context where "non-exchange relationships, such as kinship and political ties, will not unduly constrain choice". The alienability of products, the strong influence of price motive and the detachment from production and other social linkages, underlie many of the features of these proposed institutions. The consensus among Andeanists is that during Inka domination, and probably during the preceding periods, market-based economies were not found in the central and southern Andes with a few exceptions (Earle 2001; LaLone 1982; Stanish 2003; but see Salomon 1986).

The location of transfer becomes important with respect to price-fixing markets. In aggregations the public nature of the contact and the circulation of information is quite different from isolated exchanges. These issues are linked to the spatial and temporal configuration of exchange in market economies because just as periodic gatherings, central places, and rank-size geographic relationships serve to distribute goods in some settlement systems, these aggregations serve to distribute information about availability of products and changing prices to buyers and sellers (C. A. Smith 1976a, b). When exchange takes place in a private courtyard rather than a public marketplace then there is reduced risk of the neighbor overhearing the barter exchange value offered to another (Blanton 1998; Humphrey and Hugh-Jones 1992). Greater public visibility and monitoring in market contexts might be expected, and greater privacy, interpersonal negotiation, and temporal depth to exchange relationships in private barter exchange configurations.

Variations on Modes of Exchange

Some scholars have built on Polanyi's four original modes of exchange, others have developed entirely new schema (e.g., C. A. Smith 1976a). Earle (1977b: 213-216) argues that Polanyi's (1957: 250) definition of *redistribution* as "appropriational movements towards a center and out of it again…" is vague and Earle observes that this definition is so broad that it could to apply to economic systems ranging from central storage of goods in Babylonia to meat distribution in band-level hunters. Earle advocates separating leveling mechanisms from institutional mechanisms, where institutionalized redistribution involves wealth accumulation and political transmission between elites across broad regions in the mode of peer-polity interaction (Earle 1997).

Andean political economy

Stanish (2003: 21) expands on Polanyi's system by describing political economy in the prehispanic Andes with deferred reciprocity taking the form of competitive feasting and political support (Hayden 1995; Stanish 2003: 21). Stanish observes that while there was an implicit or explicit (Service 1975) evolutionary sequence going from reciprocity to redistribution and finally to markets, more recent evidence suggests that these modes can co-occur and that the relationships are too complex to collapse into a single sequence.

Types of reciprocity

Sahlins (1972: 194-195) further elaborated on aspects of Polanyi's reciprocal mode with generalized, negative, and balanced reciprocity. Generalized and negative reciprocity are opposite ends of a continuum (see Figure 2-1, above). Generalized reciprocity refers to sharing, altruism, and Malinowski's "pure gift", while negative reciprocity is the attempt to maximize personal gain from the transaction through haggling or theft (Sahlins 1972: 195-196). Polanyi's basic modes of exchange have persisted in economic anthropology for almost fifty years. Some argue that Polanyi's modes of exchange are limiting in that they do not provide a means to analyze precapitalist commercial activity (M. E. Smith 2004: 84), however the benefit to Polanyi's exchange modes is that they are sufficiently general to be comparable cross-culturally and the three modes are discrete enough to be, in some cases, archaeologically distinguishable. Furthermore, if commercial activity is unlikely in the study region, as in the prehispanic south-central Andes, Polanyi's modes capture the necessarily economic variability.

Geographical characteristics

Renfrew (1975) considers trade as interaction between communities in terms of both energy and information exchange. Renfrew (1975: 8) tabulated Polanyi's schema as follows

	Configuration	Geographical	Affiliation	Solidarity
Reciprocity:	Symmetry	No Central Place	Independence	Mechanical
Redistribution:	Centricity	Central Place	Central Organization	Organic

Table 2-3. Characteristics of reciprocity and redistribution (from Renfrew 1975: 8).

Renfrew follows with an exploration of the greater efficiency implied by central place organization in terms of material and information exchange. The universality of central place organization in the development of complex political organization worldwide has been called into question in pastoral settings. In the south-central Andes, anthropologists have proposed that alterative paths to complex social organization could have been pursued by distributed communities linked by camelid caravans with the anticipated central place hierarchy not occurring until relatively late, as proposed by Dillehay and Nuñez (1988) and in a different form by Browman (1981a).

Renfrew has developed a graphical representation of the spatial relationships implied by each mode of exchange.

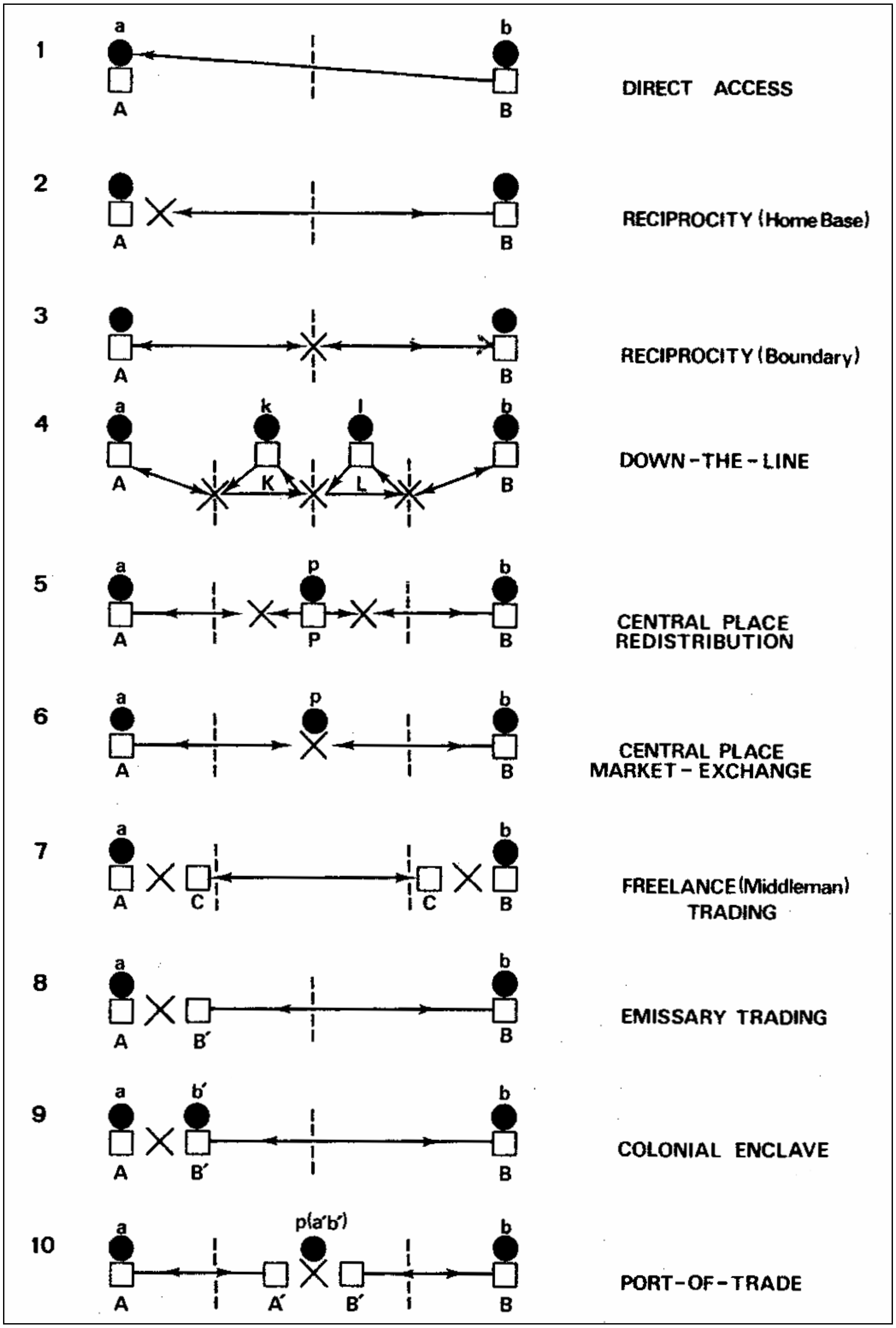

Figure 2-2. Modes of exchange from Renfrew (1975:520) showing human agents as squares, commodities as circles, exchange as an 'X', and boundaries as a dashed line.

The exchange modes depicted by Renfrew (1975:520), shown in Figure 2-2, efficiently convey the variety in organization represented by exchange relationships. In some regions of the world, such as the prehispanic south-central Andes, market-based economies are not believed to have operated which modifies one's expectations for the activities of traders. The full suite of these ten modes is not expected in any one particular archaeological context worldwide, but the figure serves to underscore the complexity of isolating particular types of exchange based on archaeological evidence. Furthermore, these modes are not necessarily mutually exclusive, as some of these modes may have been operating simultaneously unless restrictions on production, circulation, or consumption of goods were in place.

Exchange network structures

Based on geographer Peter Haggett's (1966) work, network configurations can be used to describe the characteristics of interaction that resulted in the distribution and circulation of goods. In describing Andean caravan transport, Nielsen (2000: 73-74, 91) uses the following terms: (1) *distance* that goods are transported; (2) *segmentary* vs. *continuous* - in segmentary networks a given node is connected to a small number of other nodes, while continuous networks each node is connected to all other nodes; (3) *convergent* (focalized) vs. *divergent* (non-focalized) – in convergent networks the individuals participating in exchange, and the goods they transport, tend to concentrate in a small number of central places or exchange locales.

Reciprocal exchange relationships that take the form of down-the-line trade may be described as *continuous* networks when these mechanisms serve to move goods between ethnic groups and across regions. Centralized political control by elites and true market mechanisms might result in network *convergence* at central places (C. A. Smith 1976b). To Nielsen's third set of terms, *convergent* (focalized), *divergent* (non-focalized), one may add *diffusive* to describe the pattern of a single type of item radiating from the center to the surrounding region as occurs with obsidian.

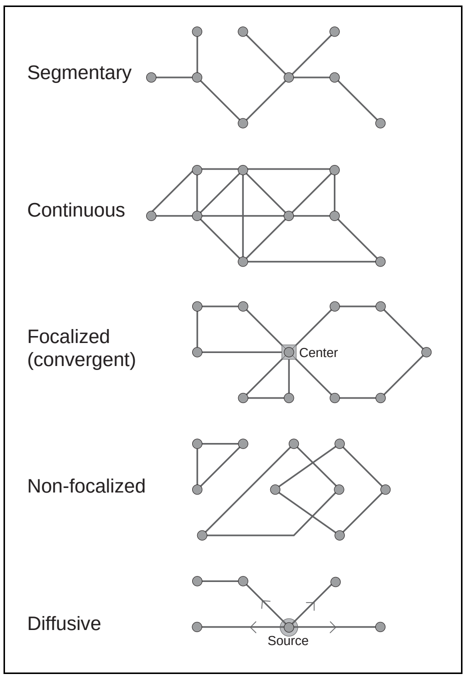

Figure 2-3. Network configurations.

These network configurations serve to draw attention to the limitations of using raw material distributions as a proxy for all exchange behaviors. Obsidian exchange is sometimes used by archaeologists as gauge of the volume, frequency, and structure of prehistoric exchange relationships. As noted by Clark (2003), raw materials from geological sources diffuse continuously from a single point to the region, presumably following trade routes, until the materials are found deposited at archaeological consumption sites. In contrast, much exchange between complementary groups, such as between agriculturalists and pastoralists, is non-focalized and often segmentary, as it links producers and consumers through a variety of localized articulation methods. The structural differences between diffusive exchange networks and regular, household-level interaction are well demonstrated in mountain regions with distinct ecological zonation, such as the Andes.

Archaeological inferences that do not differentiate the expectations of one network configuration from another are problematic. Often, diffusive configurations will have evidence of the transport of goods in the opposite direction, as one might expect in system where obsidian is acquired through reciprocity-based relationships. However, the pattern where goods are reciprocated to the source area is a configuration model to be tested rather than one that can be assumed.

2.2.5. Exchange and social distance

As discussed by Robin Torrence (1986: 5), exchange is not directly observable but requires interpretation of the evidence found in consumption sites and in the initial procurement and production areas for artifacts.

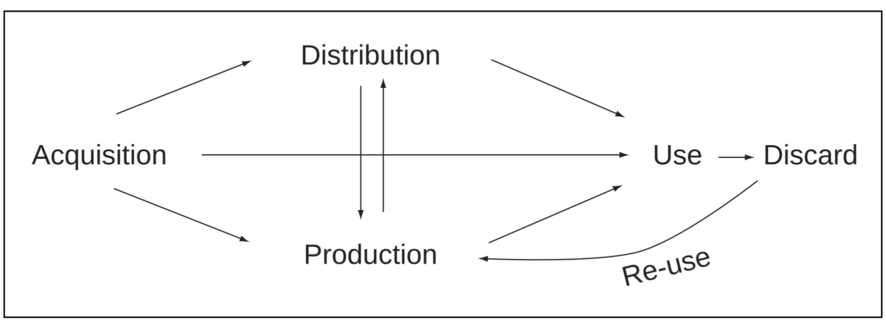

Figure 2-4. Model for inference about prehistoric exchange (from Torrence 1986: 5).

Seldom does the act of exchange leave direct evidence of having occurred in a particular location, and the activity must be inferred from the circumstances surrounding production, exchange, and consumption of the product. Note that "Acquisition" (Figure 2-4), or the source area for a product, links directly to all other modes except discard and re-use. In other words, as observed by Torrence, quarry areas are in a unique position for investigating a complete exchange system because it is only "Acquisition" at the quarry area that articulates in some form with most of the major nodes in the Figure 2-4 conceptual model.

When archaeologists encounter non-local materials in their studies, there are commonly three alternative interpretations for this evidence of contact: (1) migration, (2) trade or exchange, (3) conquest by a non-local group. Differentiating these forms of contact from archaeological consumption data can be difficult, and a larger view of the context of exchange is required.

In the 1970s when exchange studies were being widely discussed by archaeologists, two principal approaches were adopted: (1) The system-level view, presented by Renfrew and his associates (1969b; 1972; 1975), and, (2) the political or social view of trade relations (Adams 1974; Friedman and Rowlands 1978; Kohl 1975; Tourtellot and Sabloff 1972) that became more prominent in the 1980s. The systems-oriented approach integrates data into a comprehensive framework, but it is weakened by gradualistic and adaptationist underpinnings as it is

> …assumed to have a smoothly, internal inevitability of its own… however it is absurd to think of this as the path that at least the more complex societies have normally followed. They dominate the weaker neighbors, coalesce, suffer themselves from varying forms and degrees of predation, develop and break off patterns of symbiosis – all in dizzyingly abrupt shifts (Adams 1974: 249).

As more recent, agent-centered analyses argue, exchange is a dimension of society that is particularly susceptible to the ambitions of entrepreneurs or aspiring elites because expressions of non-local association and alliance are one manner in which social differentiation can be achieved (Appadurai 1986:38; Clark and Blake 1994; Wiessner 2002: 233).

Exchange across boundaries

Anthropological accounts relate that acquiring resources through trade with neighbors is sometimes a dangerous undertaking that is maybe not far removed from raiding and warfare. “There is a link, a continuity, between hostile relations and the provision of reciprocal prestations. Exchanges are peacefully resolved wars, and wars are the result of unsuccessful transactions” (Lévi-Strauss 1969: 67). Further, Sahlins (1972) observes that reciprocity in trade between unrelated exchange partners in contexts without overarching political control can be a very delicate affair because sometimes it is only the perception of fairness in the exchange that maintains peace.

> When people meet who owe each other nothing yet presume to gain from each other something, peace of trade is the great uncertainty. In the absence of external guarantees, as of a Sovereign Power, peace must be otherwise secured: by extension of sociable relations to foreigners — thus, the trade-friendship or trade-kinship — and, most significantly, *by the terms of the exchange itself* (Sahlins 1972: 302, emphasis in the original).

Yet exchange and markets across boundary areas are common features in world history. Such exchange could consist of “border mechanisms” with trade-partnerships or fictive-kin ties that permit “interactions across tribal boundaries under conditions of peace and personal security” (Harding 1967: 165). Zones between social groups are particularly likely to have active trade and markets if there is some cultural or ecological variation between the groups, such that the products circulating in each zone complement one another (Hodder and Orton 1976: 76). The No-man's-land described as the "Intertribal sector" by Sahlins (1965; 1972: 196-204) is a good locale for such exchange because complementary products are available for exchange, and because the morality of exchange in neutral geographical territories permits balanced or negative reciprocity between traders. In perception of value, as well as geography, these border zones can be conceived as overlapping social "spheres of interaction" as described by Barth, where "entrepreneurs will direct their activity preeminently towards those points in an economic system where the discrepancies of evaluation are greatest, and will attempt to construct bridging transactions which can exploit those discrepancies" (Barth 1967: 171). These discussions of the details and great the variability in entrepreneurial strategy anticipate the challenges of an agent-based approach to ancient trade (Adams 1974: 243; Hodder 1982).

Exchange and social distance

The question of the isolation of producers and traders from consumers also connects theories about exchange with the issue of the physical form of the exchange goods. Archaeologists investigating the role of stone artifacts in prehistoric economies observe that lithic manufacture is a subtractive technology as stone artifacts always get smaller with use and maintenance. The degree of reduction of stone material at a lithic source determines the kinds of forms that subsequent artifacts will take.

Jonathon Ericson (1984) applies Sahlins' concept of a continuum of social distance in exchange relationships, discussed above, to the directional, reductive nature of lithic production systems. He explores the idea that the degree of lithic reduction that may occur could be reduced when social distance increases because the producer would have less information about the consumer and the end forms that material will take (Ericson 1984: 6). For example, if the procurer does not know if the nodule will be formed into bifacial lancoleate knife or a triangular projectile point by the consumer, it would be better to leave the nodule in a larger form.

Exchange partners can be slow to respond to changes in the needs of consumers in a given exchange system (Ericson 1984: 6; Harding 1967; Rappaport 1967; Spence 1982), and the effects of social distance can impact production, exchange, or consumption patterns. The implications of social distance for lithic reduction are that, as a subtractive process, reduction circumscribes the potential artifact forms that a nodule of raw material may take in the future. Countering this tendency, people can reduce risk in tool production by producing blanks closer to the source of a raw material where the value of a material is lessened and the costliness of knapping error or breakage, and inconsistent or poor-quality material, is reduced. Stylistically, producers may wish to impart a local motif to the material; alternately, in order to maximize distributive potential, a good may be left in a minimally reduced form.

The exotic and value creation

Non-local exchange goods are prominent in anthropological models of socio-political change because exchange goods can accrue value directly as a function of scarcity, labor input, or through social and symbolic reference. As discussed above under the subject of practical goods and prestige goods, a given object may move between practical and prestige categories in different places, times, and social contexts. The availability of an item in a given milieu communicates not only the relative scarcity but, for alienable goods, the exchange value of that item; such items may also contain allusions to distant regions, social groups, and esoteric knowledge.

Theoretical models assert that in order for sacredness or exotic power to be conferred through possession of non-local goods, those goods cannot be widely available or mutable in economic circles accessible to just anyone (Clark and Blake 1994; P. S. Goldstein 2000). The possession and circulation of these goods have also been considered as part of a network strategy, distinct from a corporate strategy, towards acquiring influence and leadership (Blanton et al. 1996). These goods may have served as indicators of long-distance association for trade and alliance, and also have served as a means of differentiation during this time of incipient political competition. In another approach, one that focuses on differential reproductive success, Craig and Aldenderfer (in press) use costly-signaling theory in a formal, biological adaptationist framework to model the development of social inequalities through the differential use of obsidian in southern Peru at the Archaic and Formative transition. Exotic materials have been used to demarcate commonplace from supernatural referents, or are at least part of a constellation of behavior and objects that signal status difference.

A pattern noted frequently by archaeologists is that close to the source of a raw material there is no distinction associated with the commodity as the item is abundant, whereas farther from the source, where access is intermittent, the possession of such commodities may acquire greater symbolic importance (Knapp 1990: 161; Renfrew 1986). It follows that if one moves from a place where a product is scarce and found in ritual contexts, towards the source of that product such that it becomes less scarce, one may observe a reduction in ritual or exclusive association for that group of goods. This theme will be considered with obsidian use in the Lake Titicaca region.

Furthermore, what of those who transport exotic goods? Mary Helms argues that “we should consider long-distance travelers or contact agents as political-religious specialists, and include them in the company of shamans, priests, and priestly chiefs and kings as political-ideological experts or ‘heroes’ who contact cosmically distant realms and obtain politically and ideologically useful materials therefrom” (1992: 159). These agents are in a position to benefit, in an entrepreneurial way from the value difference, between the source and the consumption zone, but in many cultural contexts their participation and social roles appear to be circumscribed. The association of non-local goods with status or prestige, long-distance alliance or esoteric knowledge is contingent on a variety of factors upon which it is difficult to generalize, but one can examine these archaeologically through artifact form and context.

2.2.6. Territoriality and access to raw material sources

Exchange and social distance have particular configurations when they occur in contexts of unusual raw materials. The spatial dependence of procurement, distribution, and consumption on access to particular source locations creates a context where social distance may correspond directly with procurement and consumption patterns. There is broad cross-cultural variation worldwide in territoriality and access to raw material sources. The effort and the benefits associated with territorial circumscription and resource control are frequently considered in the context of specialized production. Resource control has been discussed for circumstances where competition for a resource can lead to an attempt to "monopolize" access (Torrence 1986: 40-42). Following formal economic principles, the value of a good should be a function of its availability where value would escalate as a result of restricted access and limited supply (Brumfiel and Earle 1987a: 7), a process that has been proposed for shell bead exchange among the Chumash of California (Arnold 1991). The variety of territorial control strategies documented worldwide invites a broader consideration of the diverse boundary negotiations that may have been occurring at a raw material source through prehistory.

Territoriality and resource procurement among foragers and pastoralists is a topic that has been explored in anthropology in recent years (Cashdan 1983; Casimir and Rao 1992; Kelly 1995). Approaches range from ecological models based in optimal foraging theory and site catchment analysis, to organizational models that include perimeter defense and social boundary demarcation, and finally to process-oriented models that consider the effects of sedentism, circumscription and population pressure. Carolyn Dillian (2002: 95-116) reviews the issue of territoriality and obsidian procurement using more contemporary theory.

California multiethnic access

One possible arrangement is multiethnic procurement at a geological source. Ericson (1982: 136) describes a situation in California's Napa Valley where the

Saint Helena obsidian source fell within the territory of the Wappo ethnic group and the Wappo were, in turn, surrounded by the Lake Miwok, Coast Miwok, Wintun and Pomo groups (Kroeber 1925). It is reported that in exchange for obsidian, the Wappo received items such as bows, beads, shells, mats, fish, headbands, and clams (Davis 1961), but it is not known if extraction was conducted by the local Wappo or through direct access by the surrounding groups themselves. Ericson (1984: 7) reviews evidence of multiethnic access to lithic sources. In California there are a number of distinctive obsidian sources that have been studied. At some areas the quarry management was "tribal but related and nearby groups had the right to quarry either freely or on the payment of small gifts. Wars resulted from attempts by some distant tribes to use a quarry without payment. On the other hand, the Clear Lake obsidian quarries were neutral ground" (Bryan 1950: 34).

The Wintun of California practiced round-trip fasting when traveling to obsidian sources (Dubois 1935). A functional interpretation of this behavior from Ericson (1984: 7) is that fasting would avert exhaustion of resources around much-visited obsidian sources. A regionally important quarry could conceivably get so much use, with many groups exploiting the source, that the ecology of the source area catchment would get depleted.

Geochemical studies of obsidian artifacts in California have revealed a concordance between obsidian distributions, as shown by chemical studies, and the geographical boundaries of ethnographically documented cultural groups (Bettinger 1982; R. E. Hughes and Bettinger 1984; Luhnow 1997). Dillian (2002: 294-297) found that despite ethnographic accounts of Karok direct procurement at the Glass

Mountain source in Modoc territory, the knapping evidence at the source suggests that local Modoc were conducting virtually all of the reduction on site and then exchanging with neighboring tribes where it was widely circulated.

Other Source Areas

The well-known red pipestone quarry in Minnesota “was held and owned in common, and as a neutral group” (G. Caitlin cited by Holmes 1919: 262). In the Western Desert of Australia, Gould et al. (1971) report that chert and chalcedony sources themselves are not held through a concept of quarry ownership. All material of usably good knapping quality is equally valued, and knapping is not a skill that is assigned great importance. However, an important totemic affiliation exists between a person and stone from the region in which they were born. Cherts from a person’s ancestral region are sometimes visually distinct and therefore materials of a particular region will be sought and transported over long distances as a physical link to those regions.

> These preferences appear to be a reflection of the close totemic ties each man has to the particular region in which he was born and from which he claims totemic descent. Thus, a man may have a sense of kinship with some of these localities, and he will value the stone material from them as a part of his own being. Stone materials thus acquired are not sacred in any strict sense but are nevertheless valued highly enough to be transported over long distances by owners (Gould et al. 1971: 161-162).

Ideological and emotive links to raw material are a consideration in human activities around source areas. Social and symbolic restrictions on quarries have also been documented ethnographically in New Guinea (Burton 1984; McBryde 1984). In terms of exchange behaviors, quarry areas present special problems and opportunities for archaeologists. One of the principal difficulties with examining ethnicity and access to quarries is correlating archaeological evidence with social and symbolic behavior associated with quarries. Some theoretical models are contingent on measuring evidence of maximization and control of production at quarry areas, and these models are often contingent on the detection of boundaries and restricted access based on material evidence (e.g., Torrence 1986). Unfortunately, as demonstrated by some of the studies above, many social and symbolic limitations on quarry access leave no direct material correlates and can be extremely difficult to detect archaeologically.

2.2.7. Discussion

While formal and substantivist economics have been used to investigate regional interaction and exchange worldwide, this dissertation research follows on the substantivist tradition in Andean archaeology. The exchange issues explored above can be summarized in following three themes.

Exchange value

Exchange from the perspective of commodity ‘exchangeability’ and demand by consumers is a cross-culturally comparable (and often archaeologically detectable) means of assessing value, but this approach depends on the goods actually circulating. Others have observed that some inalienable objects (heirlooms) are valued precisely because they do not circulate, and the ability of an object to “accumulate history” is another means of establishing value albeit a measure that is difficult to establish archaeologically.

Social distance

The continuum of social distance is useful in that it captures the role of different behavior and institutions in exchange as one moves away from the household, and it may parallel formal models of kin selection. Further, the concepts of production and social distance for a commodity like obsidian can be empirically linked to expectations about the degree of lithic reduction as one moves from production to consumption contexts. The use of the social distance concept to position a diachronic, "primitive" household (substantive) exchange against a synchronic, "modern" and commercialized (formal) realm is a problematic and false dichotomy. Virtually all exchange contexts contain elements of both social contracts and economical behavior. Social distance, territoriality, and access to products can be manifested in a variety of ways that range from the organization of technology, socially circumscribed access, and symbolic restrictions; a situation that poses difficulties for archaeologists attempting to establish the relative accessibility of a particular product prehistorically.

Social and political consequences of exchange

Exchange is a mechanism that brings goods and people together between ecological zones and across social boundaries, and exchange creates strategic opportunities for individuals and institutions. Exchange is sometimes used to reinforce status differences because the possession of exotic goods, and the necessary surplus to acquire non-local products, differentially favors those with established regional ties. However exchange across boundaries, along with warfare and ritual, can be dangerous and may be the domain of strategic and opportunistic individuals as traffic in the exotic, and contact with foreign elements, is liable to challenge the social order. Conversely, one of the often-noted social consequences of regular exchange is more mundane: exchange serves to reinforce long distance social ties over time, to buffer risk, and to express cohesiveness through common access to distinct resources.

In recent decades, exchange studies in archaeology have acquired new technical rigor with advances in chemical proveniencing. While the cultural, institutional, and theoretical ramifications of exchange remain complex and nuanced, the demonstrable fact of chemical characterization offers refreshing certainty to the otherwise conditional and qualified study of ancient exchange.

2.3. Chemical provenience and exchange

In the early twentieth century archaeologists investigated prehistoric exchange, primarily by using stylistic criteria, in order to demonstrate contact between two culture areas from a diffusionist perspective. Modern studies of exchange through scientific sourcing began with the work of Anna O. Shepard (1956) who found that petrographic analysis of ceramic tempers could be used to differentiate ceramic types. Since Shepard's early work, methods for chemically characterizing artifacts has grown rapidly (M. Glascock 2002). By the late 1960s, with geochemical evidence for long-distance interaction accumulating worldwide, archaeologists began developing systematic approaches to evaluating exchange.

The fundamental issue for many archaeological studies of exchange is that exchange processes have social evolutionary consequences (see Section 2.2.3). In current debates over the role of exchange, theoretical approaches range from those premised on looking at efficiency in production and exchange, and those approaches that focus on the role of social dynamics and agency models for long-distance relationships.

2.3.1. Quantitative approaches to regional exchange

An influential approach to long-distance exchange was developed by Colin Renfrew and his colleagues (Renfrew et al. 1968) who asserted that the spatial distributions of a raw material like obsidian could be used to infer not only extent of interaction, but mode of exchange. In subsequent investigations these distance decay relationships were further explored and in 1977 Renfrew defined the Law of Monotonic Decrement (LMD):

> In circumstances of uniform loss or deposition, and in the absence of highly organized directional (i.e., preferential, nonhomogeneous) exchange, the curve of frequency or abundance of occurrence of an exchanged commodity against effective distance from a localized source will be a monotonic decreasing one (Renfrew 1977a: 72).

Here, and in other publications, Renfrew (1975; 1977a) and Hodder (1974; 1978; Hodder and Orton 1976), sought to interpret exchange relationships and the friction of distance from the shape of "fall-off curves" where the abundance of material is plotted against cost, usually distance from the source. The novelty in this approach is that it sought to determine "types" of exchange that substantive anthropologists had placed in evolutionary sequence using explicit, formalist measures of abundance and cost. These distance decay graphs included "Down-the-line" exchange thought to represent reciprocity, "freelance" trade representing barter, and even laissez-faire capitalism. More general and robust characterizations were described as well. For example, low value, often cumbersome goods were shown to have different distance decay profiles than prestige-goods exchange (Hodder 1974; Hodder and Orton 1976: 124).

Other scholars adopted this approach and in places like Mesoamerica the method held promise because obsidian sources were abundant, and material from many sources, were for the most part, visually distinct (Braswell et al. 2000). Raymond Sidrys developed a “Trade Index” that, he argued, showed that major ceremonial centers acquired obsidian in volume from greater distances.

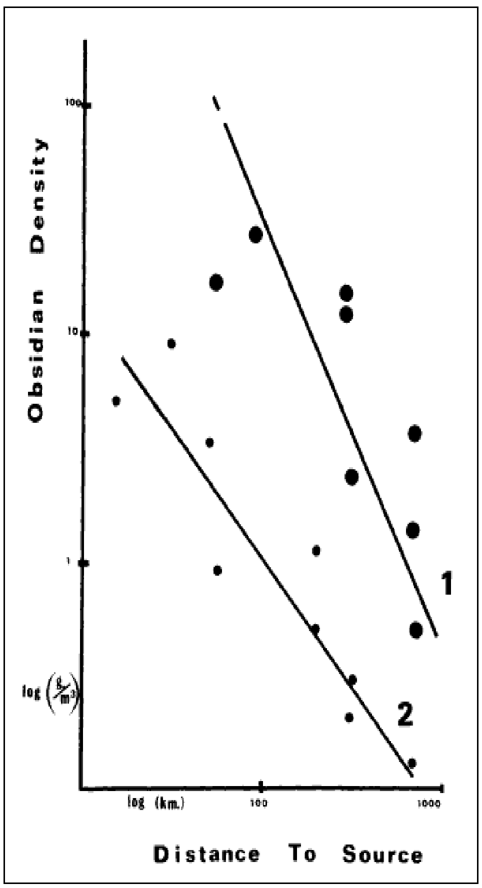

Figure 2-5. Log-Log fall-off curve of obsidian density (grams of obsidian/m3 of fill). Line 1 is a regression line derived from major ceremonial centers while line 2 is derived from minor centers (Sidrys 1976: 454).

The axes of the fall-off graphs are on linear, power or logarithmic scales. Depending on the data available, interaction can be measured by using absolute or relative measures. Abundance of a non-local good at site A is assessed in absolute terms using weight of material from site A divided by estimated population for site A, or abundance is measured in relative terms using percentage by weight or artifact count from site A in the total raw material class for that site (Earle 1977a: 6; Renfrew 1977a: 73).

In his work with Neolithic Near Eastern obsidian Renfrew (1969b: 157) specifies that areas less than 300 km from the geological source area, at least for Neolithic modes of exchange, are in the "supply zone" because obsidian represents over 80% of the material in lithic assemblages at sites found in that zone. Areas beyond the 300 km band Renfrew refers to as the "contact zone" and it is in that area that he argued the shape and angle of the fall-off curve could provide insights into prehistoric economy. The "interaction zone", or universe of study, for a sourceable material was defined by Renfrew to be the area within which 30% or more of the obsidian was derived from a single obsidian source. A similar approach was taken with Mesoamerican obsidian in the Oaxaca area by Jane Wheeler Pires-Ferreira (1976: 301) but in this case a 20% threshold was used to define the interaction zone. There appears to be no ethnographic basis for the source, contact, or interaction zone threshold values used by Renfrew and others.

In the course of further exploration of the parameters associated with fall-off curves, serious weaknesses were identified that limit their utility for identifying forms of exchange solely on the basis of the shape of the curve. Hodder (1974; 1978;

Hodder and Orton 1976: 127-154) simulated a large number of simple random walks and found that generally similar fall-off curves could be produced by different combinations of variables, a condition known as *equifinality*. In other words, a Gaussian artifact distribution that results in a fall-off curve that Renfrew would have described as "down-the-line exchange" could as have been the result of random walks. Hodder and Orton (1976: 142-143) found that the more convex curves have higher α values and that these are the result of a greater number of short steps usually associated with highly portable value goods. Ammerman et al. (1978: 181-184) explored the fall-off curve with simulation studies and found that in the interpretation of down-the-line models one must consider the accumulated effects of time over the long-term. Further, they argue that accumulation rates in archaeological studies of down-the-line systems can modeled by using realistic estimates of "passing" and "dropping" of artifacts in distribution systems. Critical evaluations of the utility of fall-off curves demonstrate that Renfrew's goal of distinguishing reciprocity, redistribution, and market exchange from two-dimensional graphs was overambitious. It has been shown, however, that the relative shape of fall-off curves can aid in differentiating high value commodities from bulky, utilitarian goods. These graphs are valuable for highlighting variations from the LMD, and these deviations can point towards avenues for further data exploration. Hodder and Orton (1976: 155-160) suggest applying trend surface analysis to distribution data, an approach that was implemented in the 1970s raster-based computer mapping package

SYMAP. Trend surface analysis and geostatistics have become considerably easier using modern GIS methods.

2.3.2. Other Distance Decay studies

Approaches to the study of attenuation with distance were applied in a variety of other regions worldwide, and these studies have been ably summarized by Torrence (1986: 10-37). A valuable theme in these studies has been the exploration of deviations from Renfrew's Law of Monotonic Decrement, and suggestions for improvement of distance decay models. Gary Wright (1970) proposes that predictions made by the LMD could be improved by controlling for variations in consumption through time and between types of consumer sites, and he emphasizes that investigators consider the influence of alternative materials in the study area, such as the effects of local flint on demand for imported obsidian. Wright (1970; Wright and Grodus 1969: 47-52) also advocates using weight of a non-local good as a measure of abundance, rather than count or percentage of each artifact class. For time periods prior to the domestication of beasts of burden in the Near East, when the weight of artifacts was borne directly by human carriers, weight would more likely influence behavior and discard patterns. Renfrew also considers weight in his analysis, but he observes that weight would be influenced by stylistic and functional factors.

Geographical relationships are considered in more detail in subsequent research. Jonathon Ericson (1977a; 1977b; 1981; 1982) conducted an exhaustive study of California obsidian distributions and, by focusing on deviations from the LMD, and using regression analysis, he was able to assess the strengths and weaknesses of the approach. Ericson uses trend surface analysis available in the early raster-based mapping system SYMAP to produce maps showing isometric distributions of obsidian types in consumption sites (Ericson 1977a: Figures 1-4). In comparing this form of analysis with Renfrew's distance decay graph distributions Ericson states that "in two-dimensional analysis only the magnitude of an observation and its distance from a source is considered, the spatial position of the observation is not considered in its local context; and this simplification masks significant variability in the data" (Ericson 1977a: 110). Ericson's density maps demonstrate that, while distance from source is a primary determinant of obsidian type, the distributions of obsidian consumption locations are not symmetrical around the source areas. Ericson explores the spatial relationships by superimposing trail systems, alternative material distributions, and ethnolinguistic group boundaries (after Kroeber 1925) on the obsidian consumption density maps and finds that these spatial phenomena influence obsidian distributions.

Similar to Ericson's implementation of trend surface analysis, Findlow and Bolognese (1982: 60-70) perform a SYMAP analysis using the percentage of lithic assemblages represented by obsidian throughout their study region. Their maps are useful in that they show the changing territoriality and direction of obsidian procurement through time in the region. However, as their obsidian percentage isolines only display aggregated *obsidian* versus *not obsidian* data, and do not differentiate between source types of obsidian, the maps are difficult to interpret in terms of exchange distances from the sources through time.

Quantitative data available for Ericson's (1977a: 121-123; 1977b: 249-257) analysis include isotropic distance calculations between discard locations and geological source areas, and estimated population by consumption area. A multiple linear regression analysis using the percentage of obsidian from a single source showed that, as stated by the LMD, the distance from the source had the highest predictive power. However, the estimated population in a given consumption area had only slightly less power in predicting the source of the obsidian being used than did distance to the closest source, and the distance to the second closest obsidian source had virtually no predictive power. Ericson interprets these data in terms of the degree of utilitarian use of a commodity and level of necessity for the average person in the community. Thus, in the proximity of the geological source of a raw material widely used in the community, the source types with high population levels in the immediate vicinity of the source would have been more widely used in exchange systems (Ericson 1977a: 120).

An improvement in the calculation of effective distance with an incorporation of the influence of topographic relief in the cost accumulation with fall-off curves was first explored by Findlow and Bolognese (1980; 1982). In their study in the U.S. Southwest the authors manually develop the linear solutions known today in GIS as "Least-cost paths" or, as Findlow and Bolognese (1980: 239) express it, "the line between the site and the source that at once minimized distance and topographic relief". They find that when these paths are used in the cost function then variability is accounted for more strongly than when using an isotropic distance estimate.

The technology of transport can dramatically alter the effective distance, and changes in mode of transportation have been proposed as explanations for variability in distance decay curves through time (Hodder and Orton 1976: 113,117-118; Renfrew 1977a: 73). Torrence (1986: 122-123) reviews the issue and she also discusses boat transport (1986: 135-136). The adoption of river and sea-going vessels in Mesoamerica are discussed by Sidrys (1977: 103-105), and in the Mediterranean by Ammerman (1978; 1979). Gary Wright (1970) mentions the importance of considering the weight of transported material for the period before the domestication of cargo animals and the availability of caravan trade networks in the Near East. Similarly, working in the Andes, Richard Burger and his co-authors (2000: 348) consider the impact of camelid domestication and llama caravan networks on obsidian distributions.

The prediction, following the LMD, that artifact size or weight should diminish with distance from the source area (Wright 1969: 47-52; 1970; Wright and Grodus 1969) is not necessarily supported in cases where the form of the artifact, such as projectile points or bladelets, take precedence over effective distance from source. Angela Close (1999) found that at early Neolithic sites in southwestern Egypt flint backed bladelets, even very close to the source, were produced to be very narrow due to hafting requirements, defying the prediction of LMD. Close (1999) also found that among the late Neolithic sites unretouched, unbroken flint debitage did not conform to the LMD either, a situation that she attributes to the probable use of domestic cattle in transporting flint cores (Close 1996). With formal tools, such as projectile points, artifact form may take precedence over size. Hofman (1991) found with

Folsom points that did not diminish in size with distance from the raw material source. However, incidence of resharpening can be expect to increase with distance from the source, affecting tool size (Andrefsky 1994).

The gravity model was another approach borrowed from geography and applied to the study of regional artifact distributions (Chappell 1986; Hallam et al. 1976; Hodder 1974; Renfrew 1977a: 87-88). Gravity models are used in situations where artifacts made from raw materials from a number of competing sources are found in a given consumption site. The claim is that the approach quantifies the "attractiveness" of a given material type over other types available to the consumers in a site by comparing actual proportions with expected proportions of the material given the predictions of the LMD. However, as Torrence (1986: 27) observes, "in reality, the gravity model is merely a means for describing and comparing distributions which are already reasonably well documented." While gravity models could be useful in parsing complex temporal patterns in raw material use in production and consumption at a given site, the approach does not provide a means of inferring the character of exchange relationships between consumption sites in prehistory.

Throughout the 1970s, the regional exchange literature shows an increasing awareness of the limitations of a purely spatial approach to inferring modes of exchange through formal geographical regression analysis. Renfrew's ambitious models linking geographical distance–decay with substantive modes of exchange connected to an associated evolutionary socio-political level, were meant to be sufficiently general to operate through time and in different cultural contexts. However, from simulation studies and from archaeological applications, researchers observed that it was necessary to incorporate supplementary information along with the geographical data on long-distance exchange and consumption, in order for distance decay studies to be useful. The view that chemically derived exchange data must be considered in association with information about archaeological context was first expressed by Wright (1969) and was widely echoed in the contributions to Ericson and Earle's (1982) volume "Contexts for Prehistoric Exchange" as well as in later volumes on exchange including Ericson and Baugh (1993) and Baugh and Ericson (1994). Preserving the strengths of geographical analyses from the 1970s period of investigation and combined with a greater consideration of artifact form, regional variation in reduction strategies and site-specific contexts of consumption, offers a fruitful way forward.

2.3.3. Site-oriented studies of exchange

> As obsidian moved farther from its source, the size of the pieces traded progressively decreased and the relative value increased. …Small blades were obtained simply by smashing a large block with a stone, while in time blades were broken into smaller fragments to obtain newly sharp edges (Harding 1967: 42).

Establishing consistent links between the types of social structure and the forms and organization of production in association with exchange was the approach taken by Ericson (1982) and, most explicitly, by Torrence (1986). By investigating the standardization and error rates in blade reduction strategies at obsidian production sites on the Greek island of Melos, Torrence was able to evaluate the degree of specialization involved in the quarrying and production of obsidian at the source.

In her review of archaeological site-oriented studies of exchange, Torrence (1986: 27-37) uses a few major themes to characterize site-oriented investigations. These themes include measures of abundance, source composition percentages, and the variability in archaeological context and artifactual form of import.

Measures of abundance

Investigators have compared changes in the abundance of non-local material with domestic goods that are assumed to represent population. The ratio of the weight of obsidian to volume of excavated dirt (as shown in Figure 2-5) or as a ratio of weight of ceramics (as a proxy measure for population) has been used in a number of studies in Mesoamerica (Sidrys 1976; Zeitlin and Heimbuch 1978: 189). In studies of Near Eastern obsidian exchange Renfrew (1969a; 1977a) develops indices for the presence of obsidian based on counts and weights per phase and per excavated cubic meter, and he also uses the count of obsidian artifacts as a percent of the total lithic assemblage count. Renfrew qualifies his conclusions due to a lack of consistency in the data, but he estimates that the total quantity of to arrive at the site was relatively small and he observes a decrease in obsidian at Deh Luran sites. Working at the Olmec site of San Lorenzo Tenochtitlan, Cobean et al. (1971) develop an index that compared the number of obsidian flakes, blades, and total debitage with grinding stones and slabs for each phase at the site, with the abundance of grinding equipment serving as an estimate of number of households. The authors interpret the increasing index of obsidian to grinding slabs as evidence of a gradual rise in “prosperity” for individuals at the site, though they only briefly explore the implications for changing exchange relationships (also see Cobean et al. 1991).

In Torrence's examination of the aforementioned studies she concludes that "the major difficulty with studies of consumption based on measures of resource abundance is that they lack the necessary linking arguments between patterns of consumption and type of exchange" (1986: 28-30). She states that what is needed for site-level studies of abundance and exchange is "a series of arguments describing how resource use will respond to specific types of exchange" akin to the explicit connections that Renfrew developed on the regional scale between distance decay and forms of exchange.

Site level composition from multiple sources

When raw material is available to consumers from several competing sources, investigators have used the relative quantity of materials from the different sources at individual sites to gain insights into ancient exchange. Broad exchange relationships are frequently inferred from the presence of obsidian from a distant source. When material from several rival obsidian sources are represented, either strongly or weakly, in different phases at a site, the cause of the changes in representation is often attributed to shifts in the geography of regional political or economic relationships. Geographical explanations are invoked when there is a clear deviation from the LMD, and yet evidence of significant in-situ political change is not found in investigations among studies in Mesoamerica (Zeitlin 1978: 202; 1982) and the Near East (Renfrew 1977b: 308-309).

Changes in the mechanisms of exchange, rather than simply geography, are attributed to changes in the source composition from different sources when socio-political changes are perceived by investigators. Studies have inferred redistribution occurring when sites that act as central places (Christaller 1966 [1933]) at the top of the settlement hierarchy have disproportionate quantities of non-local materials irrespective of their distance from the source. This phenomenon has been discussed for Tikal (Moholy-Nagy 1976: 101-103; Sidrys 1977).

When sourcing studies are conducted at the scale of the household unit, though it is often labor intensive and costly to conduct proveniencing studies to an extent that are statistically meaningful, it is possible to discern convergence patterns that can be connected to exchange mechanisms (Pires-Ferreira and Flannery 1976; Santley 1984; Torrence 1986: 35). The most common application of evidence of variability between households in source composition is to infer redistribution from the presence of low inter-household variability in source composition.

> In a reciprocal economy where individual households negotiate for their own obsidian, we would expect a good deal of variation between households, both in the sources used and the proportions of obsidian from various sources. Conversely, in an economy where the flow of obsidian is controlled by an elite or by important community leaders, who pool incoming obsidian for later distribution to their relatives, affines, or fellow villagers, we would expect less variation and more uniformity from one household to another (Winter and Pires-Ferreira 1976: 306).

The concept is been depicted in a graphic form (Table 2-4).

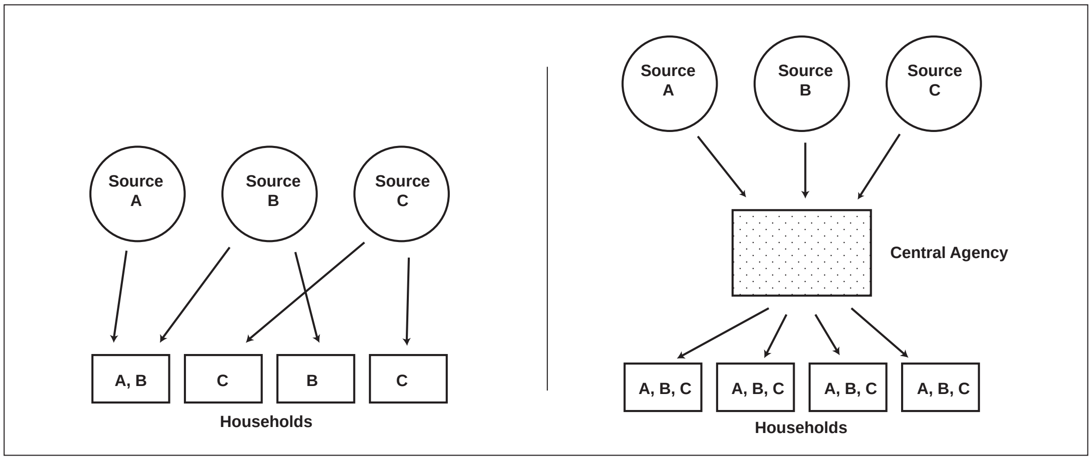

Table 2-4. Household composition of raw materials should vary with different types of exchange. On the left, individual households acquire source materials more directly, on the right pooling and redistribution results in greater inter-household consistency in raw material composition (based on Winter and Pires-Ferreira 1976: 311).

This approach was influential in Mesoamerica (Clark and Lee 1984; Santley 1984; Spence 1981, 1982; 1984) where the technology of transport did not change significantly except for perceived changes in the form of boat technology. Transport changes could significantly impact the inter-household diversity of source composition in places, such as the Near East, where caravan exchange networks followed from the domestication of pack animals (Wright 1969). The impacts of caravan exchange on artifact variability has long been discussed in the Andes (Dillehay and Nuñez 1988; Nuñez and Dillehay 1995 [1979]), although household-level sourcing data has not been available to date.

Variation in site-level contexts and artifact form

Intrasite variability in lithic distributions, and the morphology of those artifacts, can shed light on exchange patterns. Several projects in Mesoamerica have inferred redistribution as the mechanism of exchange when concentrations of non-local lithic materials at major sites point to debris associated with specialist workshops and other kinds of intrasite use of space. Blade manufacturing debris has been used in this manner at Tikal (Moholy-Nagy 1975, 1976, 1991, 1999), the Basin of Mexico (Sanders et al. 1979), and Teotihuacan (Spence 1967, 1984).

The proportion of artifact forms of a non-local material in a single site has been used to characterize mechanisms of exchange. This approach has proved useful with obsidian exchange in places where distinctive reduction strategies are associated with finished artifact form, such as blade technology, and these strategies can be recognized in lithic material found in consumption sites. Winter and Pires-Ferreira (1976: 309-310), working at two sites in Oaxaca, argued that blades of high quality, non-local obsidian were introduced to the sites in finished form and that this constituted evidence of elite pooling for prismatic blade reduction followed by redistribution to local sites. The higher quality material was transformed into more valuable artifact forms in workshops located outside of their study area, and then in the Oaxaca sites the presence of these artifacts that were apparently the result of contact with elite spheres of exchange, was interpreted as evidence of redistribution of the finished artifacts. The sourcing and exchange work of Pires-Ferreira has come under some criticism because in her initial proveniencing study she only used two diagnostic chemical elements, and more recent analyses suggest that many of her sourcing attributions are incorrect (Clark 2003: 32). Further, Sheets (1978: 62) argues that the edges of prismatic blades are too fragile to have been transported in completed form (but see Clark and Lee 1984: 272).

Systematic studies of the intrasite contexts and artifact form of non-local material have the potential to provide insights into exchange and social structure. Intrasite spatial patterns can be investigated in combination with both quantitative data stemming from geographical distances and artifact abundance, and with qualitative data inferred from artifact form and technological aspects of production (Torrence 1986: 36). These kinds of intrasite patterns are susceptible to distortion by dumping patterns and intrasite studies must be sensitive to the problems of conflating material from workshop refuse, household middens and construction fill (Moholy-Nagy 1997).

In a useful review of Mesoamerican obsidian studies Clark (2003: 32-39) summarizes major advances in provenience and trade models, and highlights important avenues for improvement. One important observation made by Clark is that in archaeologists' efforts to design systematic approaches to exchange, early studies failed to distinguish "power as energy and power as legitimacy" (Clark 2003: 38). It could be argued that these forms of power are largely comparable, as the ability to procure, display, and redistribute non-local goods demonstrates power in both energy and in prestige. However, as was emphasized by substantivists in their discussion on the inalienability of certain products, the value of particular status items rests precisely in their incommensurate nature.

> Sanders and Santley's (1983) proposal that special goods were returned to Teotihuacan in exchange for obsidian products, and that these were cashed in for corn from the fringes of Teotihuacan's domain in hard times, fails to appreciate that once symbolic goods circulate like economic goods among the hoi polloi such goods lose any legitimizing powers (Clark 2003: 38).

A framework for investigating prehistoric exchange must negotiate between these features of the archaeological record. Material evidence of long-distance exchange is abundant and easily measured, but interpreting the significance and perceived value of these non-local products in the social and political context of their consumption is the measurement of greatest relevance to comprehending the role of exchange over time.

2.3.4. Discussion

A period of vigorous exploration of spatial models of exchange followed on the initial availability of chemical characterization methods in the 1960s. In addition to responding to new proveniencing methods, these developments also reflected a convergence between formal analytical models borrowed from quantitative geography (Haggett 1966; Harvey 1969) and the spatial models of processual archaeology in the early 1970s. As the potential and the limitations of the formal geographical approaches have became more evident, archaeologists have been able to take stock of the insights from that period (R. Bradley and Edmonds 1993: 5-11; Clark 2003: 32-42; Hodder 1982; Torrence 1986: 10-37, 115-138).

Exploration of a variety of promising measures and ratios for regional analysis is one of positive products of these regional distance decay studies. For obsidian distance decay, the ideal analytical situation would involve a variety of metric measures for each artifact, and the chemical type would be known for every artifact of sourcable material. While such detailed analyses have not been generally available, analysts have made do with other measures such as visual assessment of obsidian type (although it is unreliable in many regions) and relative measures of abundance. These measures of abundance include: (1) proportion of obsidian in total lithic assemblage by count or weight, (2) proportion of obsidian flakes to other artifact classes like ground stone or ceramics, and (3) density of obsidian by excavated volume of soil. A variety of additional inventive measures were explored during this period. Further details from consumption contexts, such as variability in material type by spatial and temporal provenience, are important for regional studies, although acquiring consistent and comparable measures from various archaeological projects can be difficult.

Technological innovations promise to lend greater support to both chemical characterization and geographical analyses in coming years. Developments in GIS and other spatial technologies have greatly facilitated the management and analysis of spatial data. An associated technological development is portable chemical characterization devices such as portable X-ray fluorescence (XRF) units. It is likely that, in the not-too-distant future, XRF analysis will become a routine part of lab analysis for many archaeological projects (Jeff Speakman, May 2006, pers. comm.), a development that will significantly expand the archaeological significance of quarry studies and geographical relationships between production and consumption locales.

In sum, the confluence of spatial technology with the widespread use of non-destructive chemical characterization methods in archaeology will likely result in the emergence of a rigorous proveniencing and spatial analysis sub-discipline in archaeology in coming years. The foundations of this sub-discipline were explored in the 1970s but with greater refinement in theoretical approaches to exchange and the organization of technology, as well as the issues of artifact variability, and the consumption contexts of exchange, one may expect significant contributions from regional analysis in coming years.

2.4. The View from the Quarry

For over one hundred years archaeologists in the Americas have noted the potential of studying quarries, yet consistency is lacking in the approaches that have been taken, making it difficult to compare quarrying behavior cross-culturally. The principal theoretical objective for quarry studies in many parts of the world is establishing a link between models of social change and the extraction of resources at a give quarry through time. Despite the productive research into quarrying during the early part of the twentieth century, quarries worldwide have received insufficient attention by archaeologists.

Beginning with the pioneering work of William Henry Holmes (1900; 1919), archaeologists have recognized that the remains of quarrying and mining have the potential to provide valuable information about the past. Holmes’ work was a major contribution as he discussed the broad issues of the geographic locations of known quarries and workshops, artifact manufacture, the quantities of waste material, and the use of fire in quarrying. The sole major component of modern quarry studies that Holmes did not explore was technical flake analysis, which wasn’t developed yet, and a discussion of the chronology of the use of the quarries, which was very difficult to achieve prior to radiocarbon dating.

With the development of geochemical sourcing methods during the 1960s that linked materials with certainty to their geological source areas, quarry studies began to be of greater interest. The goal of most quarry studies is, through a combination of evidence from the resource procurement and the consumption contexts, to examine changes through time in the mechanisms of exchange that link the production and consumption together. These mechanisms are believed to reflect the prevailing organization of the stone tool economy.

A central challenge in conducting archaeological research at quarries is that at the typical raw material source, due to the sheer volume of archaeological materials and the variability in procurement contexts in prehistory, it is vital to have a clear research strategy. By targeting research questions and theoretical goals, and then determining the appropriate sampling methods, the abundance of material at a quarry can be approached with a few specific guiding questions to be answered, as well as an eye for new, unanticipated findings. Several researchers have discussed frameworks for studying the ancient quarrying of stone. Torrence describes the rich potential of studying production and exchange from the perspective of the quarry in terms of the unique position of the quarry for the study of a "complete exchange system" (Torrence 1986: 91, see Section 2.2.5).

These frameworks for quarry research fall into three sets of approaches, corresponding roughly to major theoretical groups in archaeology, and most will use a combination of these approaches emphasizing (1) efficiency, (2) social factors, and/or (3) ideology. The theoretical approach taken is often conditioned by the available data. For example, an ideological approach is strongest when demonstrable ethnographic, historical, or archaeological data are available that display a clear ideological basis for behavior concerning the stone tool procurement. Similarly, efficiency and error rates are more measurable from some reduction strategies, like prismatic blade production, and therefore cost minimizing analyses are very fruitful with such data.

2.4.1. The specialization and efficiency framework for quarry studies

The most thoroughly-articulated efficiency model is the one developed by Torrence during her dissertation work on the Greek island of Melos (Torrence 1981, 1986). Her approach at the obsidian quarries of Melos focuses on lithic reduction sequences in order to detect the changes in morphology of flakes that point to increased specialization due to standardization of reduction strategies. Her goal is to establish "a framework for measuring exchange" by developing a continuum for production efficiency that aims to link particular levels of efficiency with the social correlates that indicate the existence of different forms of exchange. Citing Rathje (1975: 420-430), Torrence approaches the study of long-term changes in the efficiency of extraction and manufacture in terms of sophistication of technology, simplification, standardization, and specialization (Torrence 1986: 42). In her research she is able to establish a continuum of efficiency starting with the irregular, non-specialist production on one end, and high efficiency production characterized by ethnohistorical evidence from modern gunflint knapping, on the other end.

Characteristics of prismatic blade production facilitate the kind of examination for efficiency and specialization used effectively by Torrence. First, core-blade reduction sequences leave relatively visible evidence of the technical stages for archaeological analysis. Secondly, prismatic blades are extremely efficient as measured experimentally using cutting-edge to weight ratios (Sheets and Muto 1972). Finally, archaeologists have developed measures of error rates for obsidian blade production with the aim of establishing the degree of knapping expertise from debitage, and these measures correlate with efficiency gauged in both time and consumption of material (Clark 1997; Sheets 1975). These efficiency measures are relevant in areas with blade production, but they are not applicable to research in areas with exclusively bifacial reduction traditions, such as in the south-central Andes.

The efficiency measures that Torrence develops in her approach linking production with exchange has the advantage of being explicit and comparable across regions. Further, her measures of production efficiency complement the formal assumptions that underlie the fall-off curves used to analyze regional exchange models in an evolutionary approach that projects greater efficiencies in organization through time. That is, specialized blade production is the most efficient means of producing cutting implements, and freelance trade in a market based economy, following Polanyi's schema, is the most efficient means of moving goods to consumers. Efficiency measures have heuristic value, as divergences from expected efficiency models can prompt the pursuit of theoretical inquiries into the cause of the deviance from the anticipated efficiency models.

The most problematic aspect of this framework is the dependence on the theoretical link connecting efficiency measures to prehistoric institutions (R. Bradley and Edmonds 1993: 10), particularly in light of the substantivist/formalist debate in anthropology specifically referencing gifting and exchange relationships. Bradley and Edmonds (1993: 10) observe that, as with Renfrew's regression approach, the problem of equifinality undermines the system of inference when the principal link between production efficiency and elaborate institutions is reduction evidence from workshops. They question the supposition that larger socio-political structure and evolutionary stages can be reconstructed from the limited perspective of workshop production and regional distribution patterns based largely on consumption sites that often have poor temporal control and few contextual associations.

More recent studies have pursued another direction and have avoided comprehensive formal "frameworks" in favor of more willingness to incorporate case-specific details, social dynamism, and historical factors in developing social models of exchange (Friedman and Rowlands 1978; Hodder 1982).

Formal, cost-minimizing assumptions about human actions and incentives have provided archaeologists with a much-needed analytical structure to the study of prehistoric exchange, but critics note that it cannot provide a complete picture of ancient economies.

> As Hodder notes, most studies have been predicated on the idea that progress can be made by assuming that people in the past considered costs and benefits along formal economic lines (Hodder 1982). Torrence's (1986) study is a case in point, for it is only by making this assumption that she is able to apply the same scale of measurement to people as different from one another as hunter-gatherers procuring workable stone for their own use, and the makers of gunflints for sale in the modern world market (R. Bradley and Edmonds 1993: 10).

A formal approach can serve as one of the layers in a more comprehensive analysis that also integrates finer scale social factors as well as historical particulars into the analysis.

2.4.2. Analysis of a production system

In a multi-tiered approach that examines evidence from workshops, from residential sites in the vicinity of the quarry and finally lithics from more distant, consumption contexts, Ericson (1984) describes a general “Lithic Production System”.

Name	Variable (numerator)	Normalizer (denominator)	Unit(s)
Exchange Index	Single source	Total material	Count, weight, %
Debitage Index	Debitage	Total Tools and debitage	Count, weight, size, %
Cortex Index	Primary and secondary reduction flakes	Total debitage	Count, %
Core Index	Spent cores	Total cores and tools	Count, %
Biface Index	Bifacial Thinning Flakes	Total debitage	Count, %

Table 2-5. Measurement indices for procurement system (after Ericson 1984: 4).

The indices presented by Ericson depend upon general artifact type categories and provide a basis for comparing activities between workshops, local sites, and distant consumption locales. Note that Ericson did not separate complete flaked stone artifacts from broken artifacts, as this was the early 1980s, and thus his resulting indices using weight measures were likely skewed.

The measures in Ericson’s table emphasize the goal of allowing comparability between archaeological datasets over widely studied areas by principally relying on general metrics that are commonly gathered in laboratory analysis. In contrast, the current Upper Colca study employed technical analyses of complete flakes and cores in order to highlight differential reduction strategies between assemblages, or between bifacial core versus flake-as-core reduction.

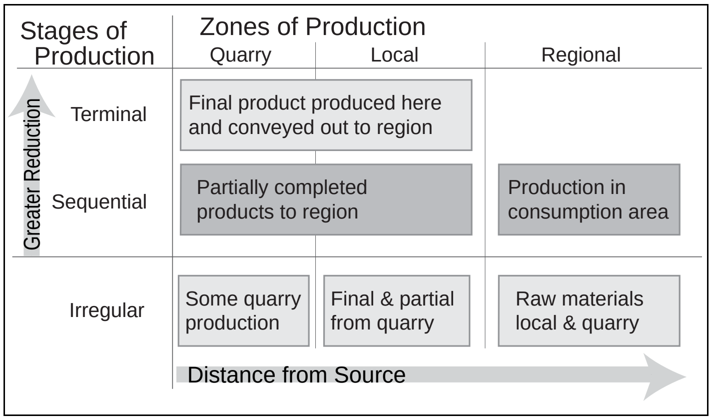

Figure 2-6. Stages of production from quarry, local area, and region (after Ericson 1984: 4).

Ericson presents the spatial distribution of lithic production in terms of stages of production and zones of geographic proximity to the source area. A consistent implementation of this approach on a local and regional scale requires the sourcing (visually or chemically) of the lithic material. Despite the use of commonly gathered measures in indices of production, it would be necessary to ensure that relatively consistent practices in excavation and analysis procedures were in place to permit this kind of regional comparability.

Ericson asserts that workshops should be studied on a general level rather than pursing spatial and temporal variation in activities at the source. He writes that if "there are a number of different workshops at the source, the data must be merged to form a composite picture of production" (Ericson 1982: 133). The emphasis is on documenting the predominant production strategy at a given source area, but at the cost of characterizing variability within a production context. If changes in the use of a given material have been differentiated from stratified deposits at consumption sites in the larger region, how are these changes to be linked with production activities? While workshop sites often lack datable materials or temporally diagnostic artifacts, collapsing all excavated workshop data, and perhaps surface evidence as well, into a single composite picture sacrifices the detail that stratified deposits can provide.

Excavation and analysis procedures in Ericson's California dataset appear to be relatively consistent for the past half-century, however the systematic collection and analysis of non-diagnostic lithics has been historically deemphasized by archaeologists in some regions of the world, such as the south-central Andes. Archaeological practices worldwide have not placed equal emphasis on gathering and quantifying lithic artifacts which would lead to problems in applying the kinds of metrics Ericson suggests on a regional scale. Ericson's approach emphasizes the use of quantifiable and comparable measures over a geographically extensive region.

Barbara Purdy (1984) emphasizes chronology in her study of a chert procurement site in Florida. She did not find datable, organic remains in association with stratified excavations that would provide greater evidence of the temporal associations, but the strata in her test units allowed her to differentiate distinct episodes of use of the site. She found that weathered chert artifacts in a sandy-clay soil were separated by a lithologic discontinuity from less-weathered artifacts produced using a different technology. She was also able to use the relative weathering of chert and thermoluminescent dating on fire-altered chert cobbles from the quarry site.

2.4.3. Specialization at a Mexican Obsidian workshop

Obsidian quarry workshops at Zináparo-Prieto in the state of Michocan in western Mexico were investigated comprehensively by Veronique Darras (1991; 1999). Darras undertook excavation as well as systematic survey of vicinity of the substantial quarry area that was used most intensively during the Classic to Post-classic transition (A.D. 850-1000). She documented mines and workshops, as well as associated residential structures and public buildings, in an inventory of 45 sites in the region.

Darras describes mine shafts and open-air quarry pits that parallel obsidian procurement methods elsewhere in Mesoamerica. The mine shafts (Darras 1999: 72-80), are over 25m in depth and include support pillars as well as evidence of torch lighting and ventilation shafts, can be compared with Classic and Post-classic period mining methods used at other Mexican quarries that include the Sierra de las Navajas (Pachuca) source in Hidalgo (Pastrana 1998), and the Orizaba mines (Cobean and Stocker 2002). Open-pit quarry depressions are reported by Darras at Zináparo-Prieto that measure between 10-15m in diameter, with a few larger than 15m in diameter. Quarry depressions with an encircling debris mound were described by Healan (1997) at the Ucareo source, also in Michocan, as “dough-nut quarries”.

The lithic analysis approach used by Darras, citing the tradition of Tixier (1980), addresses the abundance of material (the typical problem with quarry research) by employing two levels analysis (Darras 1999: 108-115). The first measures abundance using a relatively expedient typological classification based on material quality, technical class, reduction stage, and relative size and form of artifact. The second level of analysis, conducted only on a representative samples, consists of a techno-morphological analysis of flakes including a detailed study of platform characteristics and fracture and termination types.

Darras finds no evidence of pressure flaking or prismatic blade technology, a situation that makes this workshop analysis to be more comparable to reduction sequences elsewhere outside of Mesoamerica where prismatic blade production also did not occur, such as obsidian production the south-central Andes. Darras finds that percussion industries follow two contemporaneous sequences: one that uses “cada plana” (plane-face) cores, and the other that uses conical cores, each sequence meticulously outlined. These twin industries, and the lack of prismatic blade production, are unusual in the region and Darras suggests that this is due to a lack of regional political control during this stage.

Darras succeeds in integrating household archaeology with her workshop studies, and as revealed by comparison with obsidian consumption in an associated village, Darras documents substantially more obsidian production than appears to have been used locally. However, she does not extend her analysis to the immediate region beyond villages adjacent to the quarry areas, leaving a disjunction between reduction evidence from the immediate quarry workshops and the larger pattern of obsidian artifacts radiating into the region. Darras’ study is one of the most thorough workshop investigations to date, and her work provided a valuable model for the current Upper Colca project research because in the manner that test excavations were used to connect quarry evidence with initial reduction trajectories at associated workshops.

2.4.4. A contextual approach to Neolithic axe quarries in Britain

A focus on social context is emphasized in more recent studies of exchange. Building on Hodder's (1982) development of a "contextual approach" to exchange, archaeologists following this approach argue that the study of production sites has been incomplete because the social and sometimes historical elements of quarries and production systems have been neglected in processual tradition that focuses overwhelmingly on the organization of technology and production efficiency. In particular, Hodder and others have argued that the perspectives on exchange articulated by Mauss (1925) and even by Sahlins (1972) have been largely neglected (to judge from citation patterns) in the formal approaches previously described.

A study by Richard Bradley and Mark Edmonds (1993) focuses on axe production and circulation in Neolithic Britain through an examination of quarry production at the Great Langdale complex in the Cumbrian mountains in the Lake District of the English uplands. This area was a source for a fine-grained volcanic tuff material used for producing stone axe heads that were flaked, ground, and often polished, and have been found in Neolithic. Through petrographic analysis it has been possible to connect many axes made from tuff and granite found throughout Britain with the raw material source in the Great Langdale region, but subsourcing resolution has not been possible.

Background and methodological approach

Bradley and Edmonds (1993: 5-17) begin with a useful critique of the formal approaches to exchange first articulated in the work of Renfrew and his colleagues. In reviewing prior approaches, Bradley and Edmonds perceive weaknesses and untenable assumptions in the links asserted by prior researchers connecting (1) efficiency in reduction strategies, organization of production, and degree of hierarchy in social organization (Torrence, Ericson, others), and (2) geographical distributions of types of artifacts with the nature of social organization (Renfrew et al.).

Bradley and Edmonds emerge with a strategy that permits them to connect temporal change in quarrying and the organization of reduction in the immediate vicinity of the source with perceived changes in knapping strategies. They also explicitly attempt to incorporate evidence from social and symbolic constraints on quarries, where historical specifics about specialization, quarry access, and socio-political boundaries appear to trump the larger patterns of circulation documented during the 1970s by Renfrew, Hodder, and others (R. Bradley and Edmonds 1993: 9, 63). Further, the authors observe that while these social and symbolic control variables are extremely difficult to appraise from archaeological evidence, these unknowns were ultimately some of the most important variables informing Torrence's (1986) formal approach to efficiency and socio-economic control of production. On these grounds, Bradley and Edmonds devote more effort to methodological and theoretical goals that they feel are attainable: documenting variability in production, inferring connections with regional consumption evidence through temporal context, and exploring social and symbolic generalities through ethnographic analogy from quarries and with evidence of regional ground axe distributions in Britain.

Technical analysis

Bradley and Edmonds' (1993: 83-104) lithic analysis begins with experimental knapping studies that allow them to identify the character and frequency of different classes of flaked stone generated during production. Establishing reduction stages from flakes of Great Langdale tuff material is particularly difficult because the material does not contain a visible cortex. Bradley and Edmonds pursue strategies that produce a wide range of flake and core morphologies in an effort to capture the range of possible variation in reduction at production sites. Their expressed aims are to move beyond simple measures of efficiency in production, and they also seek to use their experimentally-derived assemblages to inform their analysis such that that they do not merely derive a single, generalized reduction sequence but, instead, shed light on how knappers controlled form, and anticipated and avoided mistakes.

> It was just as important to discover which methods *could* have been used to make an artifact as it was to establish which were actually selected. It is clearly important to understand *how* the production process was structured in a given context, but we also need to discover *why* it took the form it did (R. Bradley and Edmonds 1993: 88, emphasis in original).

In earlier work Edmonds (1990) cites from, and applied, the *chaîne opératoire* approach to his investigation of quarry production. Curiously, in the Bradley and Edmonds (1993) volume the French term does not appear (although they cite the *chaîne opératoire* literature), and in their quarry production studies they instead choose terms like "pathways" to describe sequential reduction.

Part of Bradley and Edmonds' aim is to reintegrate symbolic and social perspectives into the study of quarry production and exchange, empirical archaeologists may ask: how do Bradley and Edmonds conduct symbolic and social analysis with lithic attribute data from a quarry workshop? In their data-oriented investigation of reduction strategies, Bradley and Edmonds gather standard lithic attribute data that is largely in common with those that follow the processualist tradition; it is in the interpretations and assumptions about economy that the differences emerge. For example, many of the assemblages are described by Bradley and Edmonds along a production gradient that range from “wasteful and inefficient” to “careful preparation” or ad-hoc versus structured production using evidence from flake dimensions, platform morphology and preparation, flake termination type, and other attributes.

For Bradley and Edmonds, efficiency is investigated primarily in a heuristic manner in association with spatial context in that they suggest expediency, investment, and reduction strategies over the larger quarry area. Their technical analysis is able to conclude, among other things, that axes appeared to be exported from the quarry area in two forms: (1) crude asymmetrical rough-outs with hinges and deep scars, and (2) more processed and nearly finished artifacts that lacked only polishing.

They also note that some processing appeared to occur at some distance from the quarry, and in other cases nearly all of the production sequence occurs at the quarry. The authors used evidence of excessive labor expenditure, such as in axe grinding and polishing, as a contrast to the “rational”, cost-minimizing expectations of efficient production expectations. For example, they explain that polishing of axe heads is laborious, but it results in greater longevity in the axe because during use the irregularities can act as platforms for unintentional flake removal. Furthermore, polished axes remain in their hafts more consistently. Polish over the entire surface, however, is not necessary and is labor intensive. Were axes polished over their entire surface to increase their exchange and gift value through greater labor investment? In evolutionary approaches, labor investment in goods is cited as a form of prestige technology (Hayden 1998, see Section 2.2.2). Bradley and Edmonds present an insightful review of existing approaches and bring quarry analysis one step further with their in-depth technical analysis that informs a novel yet cautious interpretation with an incorporation of elements of the symbolic and social theory current in the early 1990s.

Chaînes opératoires at quarry workshops

The *chaîne opératoire* analysis of quarry materials described by Edmonds (1990) deserves further mention. The *chaîne opératoire* approach conceives of lithic reduction as a comprehensive system or "syntax of action" from the origin of lithic material at the quarry to reduction, reuse, and abandonment within a larger context of human action. Sellet (1993: 106) writes that the *chaîne opératoire* is a "chronological segmentation of the actions and mental processes required in the manufacture of an artifact and its maintenance in the technical system of a prehistoric group. The initial stage of the chain is raw material procurement, and the final stage is the discard of the artifact."

In the realm of lithic production, Shott (2003) and others question whether the *chaîne opératoire* approach is notably different from Holmes' century-old concept of "reduction sequence" (Holmes 1894) and Schiffer's Behavioral chain analysis (Michael B. Schiffer 1975). Two major differences distinguish *chaîne opératoire* from the lithic reduction sequence analysis in the North American tradition. First, while the American reduction sequence focuses solely on lithic production, *chaîne opératoire* applies to apprenticeship and expertise relating to *all* material culture behavior beginning with lithic production but also including ceramics, textiles, architecture, wine-making, and others (Tostevin 2006: 3). Second, even when confined to lithic production, the *chaîne opératoire* approach explicitly attempts to infer the choices and intentionality of the knapper, as well as to capture greater context and breadth by seeking to address the larger context of activity and action.

> French archaeology has a long tradition of attributing archaeological variability to choice, stretching back from Boeda (1991) to Bordes to Breuil. This tendency is balanced by an equally strong American-based resistance to attribute variation to cultural choice until all other factors, particularly reactions to environmental stimuli, have been excluded, forming one of the central tensions in the current debate (Tryon and Potts 2006).

Others argue that while attempts to consider the intentionality of the knapper are commendable, in their weaker form sequential models like *chaîne opératoire* run the danger of being overly typological and rigidly unable to incorporate behavior that diverges from a one particular linear progression (Bleed 2001; Hiscock 2004: 72).

From the perspective of quarry procurement and workshop activities, production would have proceeded with a goal in the mind of the knapper based on the quality of the raw material as well as organizational issues like technological requirements and mode of transport. For Edmonds (1990: 68) implementing a *chaîne opératoire* approach at a quarry workshop appears to have been complicated by an overwhelming presence of flaked stone belonging to early stages production, and a paucity of evidence concerning consumption. It seems that observing a complete “syntax of action” is hampered by the incomplete view of reduction, as the evidence is overwhelmingly from workshops and not from consumption sites. Thus, while quarry workshops have relatively few classes of artifacts the techniques, such as refitting, are seldom practicable when there is an abundance of early stage material and an under-representation of advanced reduction flakes and complete, or near complete, tool forms.

Variability in initial reduction of cores observed at the Great Langdale quarry workshops reflect the available raw material and the quarrying methods used to procure the material, and these frame the starting context for following a *chaîne opératoire* analytical model. However, the *chaîne* sequence is often truncated and largely capable of merely determining early reduction characteristics that are basic to all reduction sequence analyses in the tradition of Holmes (1894). For example, at Great Langdale the researchers determine, mostly from platform characteristics, that there was expedient, ad hoc production in one period and more precise and controlled flaking in another. Sequence models seem to be of limited utility in contexts where only initial workshop production is available, a condition that perhaps explains the avoidance of an explicitly *chaîne opératoire* approach in the later Bradley and Edmonds (1993) volume. In sum, *chaîne opératoire* is roughly synonymous with American ‘reduction sequence’ and Schiffer’s Behavioral Archaeology in terms of low and mid-level theory, but in high level theory it is not generally presented except for the theory of *chaîne opératoire* itself (Tostevin 2006). Given the difficulties of meaningfully applying *chaîne opératoire* to data based almost entirely on quarry workshop contexts, the concepts will not be attempted in this research.

Interpreting the axe trade

While earlier approaches focused on efficiency and evolutionary schema in a commodified vision of production, Bradley and Edmonds (1993) attempt to take a middle road where they use measures of efficiency and investment observed in workshop contexts in a heuristic manner, but they principally base their interpretations of production on the changing socio-political context of the larger consumption zone. They consider artifacts in terms of dichotomies that probably existed in some form, dividing the circulation of inalienable gifts from alienable commodity production. They seek to consider the implications of gifts in the theoretical terms that relate gift-giving and status acquisition with the political strategizing of elites in Neolithic Britain. Further, they consider the "regimes of value" where gifts and commodities circulate and are assigned value that is a construction of political contexts and not merely a reflection of measurable costs using the concepts of social distance borrowed from Sahlins. Finally, Bradley and Edmonds consider the circulation of axes as wealth goods and the ways in which elites may influence the specialized production of axes (sensu Brumfiel and Earle 1987a) and the circulation and consumption in a peer polity situation (Renfrew and Cherry 1986) or through control of deposition (Kristiansen 1984). Ironically, while neoevolutionist approaches are explicitly rejected, one is left with the question: what is theoretically significant about changes observed in the circulation of axes if not the link to evolutionary changes in socio-political organization? In both Edmonds (1990: 66-67) and Bradley and Edmonds (1993), evolutionary explanations are avoided in the analysis of production, but in regional exchange the changes observed attributed to increasing levels of social ranking as indicated by competition over exchange networks and specialized knowledge during the Later Neolithic.

2.4.5. Discussion

The principal challenges of quarry research in archaeology were articulated in the seminal work of Holmes, one hundred years ago. These difficulties include the sheer quantity of non-diagnostic artifacts and sampling issues, the lack of temporal control, and stratigraphy that is either complex or non-existent, it is no wonder that relatively few projects have targeted quarry areas in the intervening century.

Advances in the last few decades include methodological improvements like rigorous attribute analysis and greater standardization of measures and digital measurement devices that have sped up lab work. Theoretical advances include an exploration of principles of production efficiency and subsequent articulation of the problems and prospects of this formal approach. Principal among these are further incorporation of data from adjacent contexts, the use of other lithic material types close to a major source, and the incorporation of evidence from other material classes like ceramics. More recent advances include the incorporation of additional datasets into quarry and workshop analysis, a wider theoretical scope, and an attempt to understand the wider intentionality and decision sequence of quarry procurement and initial production.

A promising theoretical approach to procurement and exchange would recognize the need for a consistent framework against which to assess changes in production, circulation and the regional demand, but it is also one that responds to local variation and multiple reduction trajectories outside the scope of formal concepts of efficiency. Production and circulation of lithic raw material from quarry sites often span broad time periods and must reconcile with a great variety of cultural and organizational forms. In regions of the world (such as the south-central Andes) where foraging was largely replaced by agro-pastoralism, where residential mobility was replaced by sedentary communities with mobile components, and where egalitarian social structure changed into ranked and ultimately stratified societies, these large scale changes must be reconciled with evidence of technological organization and exchange. While a skeleton of expectations can be built from the general anthropological evidence provided in this chapter, the regional specifics of Andean prehistory flesh out the character of production and exchange of Chivay obsidian through time. Models that are applicable to the case of Chivay obsidian and that assimilate issues from this chapter with the Andean regional trajectory are presented at the end of the following chapter.

– Chapter 3 –

The Regional Context of Chivay Obsidian Research

The role of interaction across long distances has been a persistent theme in archaeological studies in the south-central Andean highlands. The emergence of the Tiwanaku state in the stark and sparsely populated altiplano seems improbable unless one considers the larger geographical setting and the apparent importance of sustained links over long distances that contributed to developments in the Lake Titicaca Basin. Archaeological research that focuses on the Formative Period, the time that preceded Tiwanaku in the Titicaca Basin, has demonstrated that regional centers coalesced out of a multitude of small villages that were articulated through a highly mobile sector of the economy based on camelid caravan transport. This chapter examines the roots of this mobile sector in the economy of the Terminal Archaic and the Formative by focusing on the transport of obsidian and the significance of early evidence of transport in the origins of long distance relationships in the south-central Andes.

This chapter will contextualized the theoretical issues surrounding raw material production and exchange in the south-central Andes. Subsequently, this chapter will explore some models of long distance interaction in the south-central Andes. Next, a review of the regional evidence for the production and circulation of Chivay obsidian from the a few major sites in the highlands will be followed by a temporal survey of Chivay distributions revealed by previous archaeological research. These regional data will be discussed by progressing through time beginning with Chivay obsidian use by early mobile foragers, and continuing in time through to the Inka period. A subsequent section considers broader patterns for use of obsidian in the Andes. This chapter concludes with a discussion of four models for obsidian procurement and circulation from the Chivay source, and the associated material correlates for these models.

A larger set of questions guides this chapter: Do the distributions of Chivay obsidian conform to those of utilitarian products like salt and dried meat, or do the distributions resemble those of prestige goods like spondylous, copper, or gold? Escaping the utilitarian / prestige goods dichotomy, a third group termed "cultural goods" better captures the traditional networks that circulated material like obsidian in the Andes. This chapter will argue that obsidian is an example of a class of material that moves between these simple classifications and that it requires a consideration of context. What pressures were responsible for the rapid change in production and circulation of obsidian during the Terminal Archaic Period? What can obsidian circulation reveal about the regional context and the strategies of early aggrandizers at the beginning of the Formative in the Titicaca Basin?

Developments in obsidian production at the Chivay source intersect with a wide swath of the Andean prehistoric sequence, and these developments will be explored below in three broad cultural periods: the "Archaic Foragers", "Early Agropastoralists", and "Late Prehispanic".

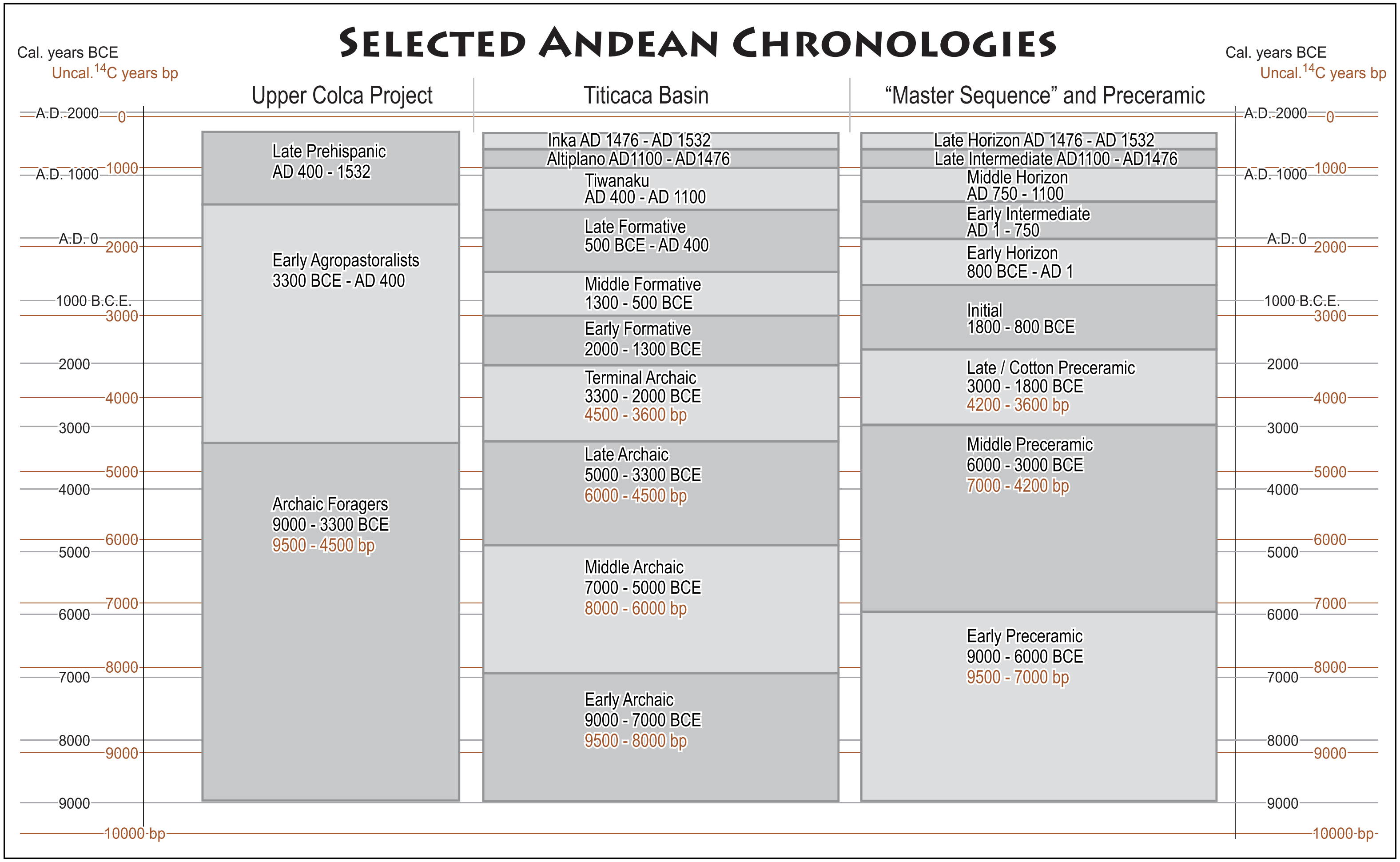

Figure 3-1. Chronologies discussed in the text.

“Archaic Foragers” are characterized as mobile foraging groups responsible for the early human use of the obsidian source, exchange, and consumption of the material. Use and exchange of obsidian by Andean mobile foragers during the Early, Middle, and Late Archaic Periods will be considered in light of ethnographic and archaeological evidence.

Next, with the domestication of camelids and chenopodium occurring sometime during the Late Archaic, food production came to dominate the economy by 3300 cal BCE heralding sweeping changes that included early social ranking that first appeared during the Terminal Archaic and early Formative Periods. During this period, referred to here as the Early Agropastoralist period, the production and exchange of obsidian appears to have changed as the material became more widely circulated in the consumption zone and mobility was facilitated by the gradual inception of regular camelid caravan transport routes. Reciprocity-based exchange systems would have coalesced, while personal procurement activities persisted from the earlier period, resulting in distinctive production evidence in the source area. The evolution of expansive states during the Middle Formative and Late Formative through to the Tiwanaku Horizon shifted the regional political structure, and these developments had repercussions in the Chivay source region. As regional centers in the Titicaca Basin emerged and began to dominate the political landscape, the established exchange patterns may have shifted to reflect the role of redistribution believed to have been occurring at the centers. Political forces became increasingly powerful in the Titicaca Basin, as well as expanding out of the site of Wari far to the north in Ayacucho, and the procurers of Chivay obsidian in the Colca area were increasingly working in a border land between powerful polities. What kinds of evidence will be reflected by the combined impacts of local provisioning, reciprocity, and elaborate redistribution systems in the Chivay area and in the Titicaca Basin consumption zone? With the collapse of Middle Horizon polities, the effects of warfare on exchange are apparent in the limited distributions of obsidian during the Late Intermediate Period. Finally, the Inka period was a time of great regional integration and tremendous redistribution of goods, but it appears that obsidian had reduced significance in favor of competing materials like metals. The changing nature of prehispanic obsidian exchange, and the link between exchange theory and the south-central Andean sequence, will be considered in this chapter.

3.1. Andean Economy and Exchange

The Andes present a valuable opportunity for examining anthropological models of economy and exchange in prehistory. Distinctive historical aspects of Andean development, including the emergence of pristine states at high altitude, the administration of vast empires without a formal system of writing, and the wealth of ethnohistoric data provided by Spanish chroniclers, offer important research problems for economic anthropology. This study investigates the procurement and circulation of obsidian from the Chivay source in the south-central Andes during a broad time period that includes major shifts in the economy and in socio-political organization.

Throughout prehistory, the long, narrow Andean cordillera presented distinctive challenges to human groups that were addressed through a variety of technological and social strategies. Here, a focus on lithic raw material procurement and exchange permits obsidian circulation to serve as an indicator for particular types of regional interaction.

Exchange has a complex role in mediating human relationships over distance (see Section 2.2.2), and in the south-central Andes, obsidian appears to have served as both a political tool and relatively ordinary aspect of economic activity. In part, the persistence of exchange in herding regions reflects lack of autarky among the dedicated pastoralists; they require vegetative and agricultural products, and such items are widely available in the sierra and foothills. In reference to the early development of long distance caravan networks in the altiplano, David Browman (1981a: 413) notes “[t]he trade in consumables is less spectacular than the trade in luxury items, and more difficult to detect archaeologically, but it was much more important to the average altiplano inhabitant.” In other words, due to the environmental contrasts in the Andes, relatively mundane consumables like salt, *aji* peppers, and even coca leaf could precipitate a low-level but persistent demand for exchange of goods between adjacent ecological zones and, in some cases, across larger distances.

A central point of the following discussion is that wide-ranging exchange networks, apparently organized at the level of the household and facilitated by caravan transport, are a persistent theme in the south-central Andean highlands. These networks do not integrate easily with the exchange typologies presented above

(Section 2.2.4), and this form of articulation is sometimes seen as irrelevant "background" reciprocity in models of early competitive leadership. However, this distributed mode of integration may have served as an early foundation for subsequent political organization in the region. This study focuses on obsidian procurement and distribution and infers that other goods were also being transferred along these networks. While the simple assumption that evidence of obsidian circulation is analogous to prehistoric trade in a multitude of other more perishable goods is problematic, the persistence of obsidian exchange in the south-central Andes is compelling evidence of generalized contact over distance. Andean approaches to regional economy are reviewed here in order to examine the distribution of obsidian and other goods through diverse mechanisms of procurement and exchange.

3.1.1. Economic organization and trade in the Andes

In a cross-cultural perspective, Andean exchange relationships throughout prehistory exhibited characteristic organizational traits of societies dwelling in mountain ecological zones; although in the late prehispanic periods distinctive features of inter-zonal control emerged in the south-central Andes. There is general consensus among Andeanists that the mechanisms of merchantilism and market economies – prices reflecting supply and demand – did not exist in the late prehispanic south-central Andes[2].

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[2] Important exceptions to this pattern are described below.

Polanyi's substantivist economic typology based on peasant households in non-capitalist settings is still widely used in the Andes with some modification.

> Reciprocity, redistribution, and non-market trade are the institutional means by which indigenous Andean economies operate. All evidence points to the overriding fact that true market systems did not operate in the central Andes, as they did in central Mexico and in a number of complex societies of the Old World. Exchange did exist on a massive and pervasive scale, however, and the concept of administered trade is the superior means of understanding this phenomenon in the prehispanic central Andes. Trade existed, but it was not one based on market principles. Virtually all cases of trade were administered by some corporate group, constituted along sociological (kinship) or political lines (Stanish 1992: 15).

The major modes of economic interaction will be reviewed below. Finally, the closing section of chapter 3 will explore more specific material expectations of how each of these economic modes may appear in procurement areas such as the Chivay obsidian source.

Direct Access

Direct household procurement of goods is largely structured by the geographic relationships between consumer residence and a given resource. Access to products from complementary ecological zones by consumers who undertake a personal voyage to acquire and gather those goods is a form of direct access. For resources that are widely distributed in ecological areas or along altitudinal bands, direct access is a recurring theme in Andean prehistory. The procurement of unique or unevenly distributed or resources, such as salt or obsidian, is a different configuration entirely in a vertically organized region like the Andes, because distant consumers are forced to articulate with production areas far beyond their immediate and complementary neighbors in an altitudinally stratified exchange relationship. This kind of multiethnic, direct household procurement for salt occurs in the Andes to this day

(Concha Contreras 1975: 74-76; Oberem 1985 [1974]; Flores Ochoa 1994: 125-127; Varese 2002).

Direct access by foragers was the first mode of procurement in the Andes, and this acquisition mode probably dominated in Early Holocene prior to the population growth that permitted the development of reciprocity networks. The procurement of raw materials in a manner that is incidental to other subsistence activities is a more efficient means of acquiring these goods, an activity described as “embedded procurement” by Binford (1979: 279). Communities, ethnic groups, and even prehistoric states appear to have maintained direct access to resources in other zones, and (as is stipulated by the definition of the *direct access* mode) this kind of articulation is for direct consumption or redistribution on the level of the corporate or state entity. This is part of a much celebrated pattern in Andean research, a feature known as vertical complementary (Murra 1972), a topic that will be returned to in more detail below. Direct access by states to unusual sources of raw material such as metals and minerals are well documented in the Andes. These include as Inka mine works, and distinctive Inka artifacts and architecture are commonly encountered in association with the procurement areas. In access between herding and agricultural sectors, there is also an ethnographically documented direct access mode described as “ethnic economies”. In this direct access mode, ethnic groups will control parallel strips of vertical land holdings, and sometimes non-contiguous tracts, ranging from lower agricultural zones to high puna that may lie several thousand vertical meters above. This pattern is documented on the eastern slope of the Andes for the Q’eros of Cuzco (Brush 1976; Flores Ochoa et al. 1994) and several communities in northern

Potosí in Bolivia (Harris 1982, 1985). The important concept of the direct access organization is that entities that were consuming the goods were directly responsible for acquiring them. If there is inter-household barter or transfer of any kind, then the arrangement likely belongs to a type of reciprocity relationship.

Reciprocity

The institution of reciprocity is important in all societies, and in the contemporary Andes reciprocal relationships are elaborate and permeate village life. It is an arrangement for the transfer of labor or goods that is organized without coercive authority between entities equal in status, although sometimes disputes are settled by community leaders. Andean labor reciprocity includes agricultural work, roof raising, canal cleaning, terrace building, and other services; as such, reciprocity structures the traditional village economy in the Andes (Alberti and Mayer 1974; Stanish 2003: 67). These kinds of reciprocal arrangements are frequently delayed, although compensation can be accelerated through recompense in products. For example, a herder might bring a caravan down to a farming area in the lower valleys and spend some days contributing labor to the agricultural harvest in exchange for some portion of the yield.

In many premodern economic transactions relationships of balanced reciprocity structured these arrangements. Two forms are likely in the Andes, that include (1) a multitude of small, household exchanges creating "down-the-line" artifact distributions (see Figure 2-2), presumably this type of exchange is responsible for the long distance transmission of small, portable goods for much of the pre-ceramic period. A second form consists of (2) barter exchange relationships with regular long distance caravans that articulated with settlements, and perhaps at periodic fairs, that transported goods over potentially greater distances. This mode would effectively consist of *unadministered trade*. The institution of reciprocity will be explored in more specific contexts below.

Redistribution

The basis of relations between political elites and non-elites in the prehispanic Andes was shaped by redistribution. In Andes during the later prehispanic period, redistributive mechanisms linked elites to non-elites through the redistribution of consumables like coca, and feasts of food and *chicha* beer in exchange for labor and political support. “The manipulation of redistributive economic relationships among the elite and their retainers, most notably of exotic goods and commodities, stands at the core of the development of Prehispanic Andean complex societies” (Stanish 2003: 68). Often these surplus goods were produced through efficient mechanisms orchestrated by elites, and the benefits and prestige derived from these surpluses would be accrued disproportionately by political leaders.

The central collection of goods for redistribution or use by the state includes taxation which, in the Inka period, was through *mit’a* labor. With respect to the exchange of lithic raw materials, Giesso (2003) argues that at Tiwanaku household stone tool production was a form of taxation. Giesso cites ethnohistoric evidence referencing the Inka period and argues that the household knapping of projectile points could have contributed to the provisioning of the state armory. The means by which non-local material arrived in the Tiwanaku homeland is unclear, but in the Inka case the raw material was acquired locally or it was provided by the state

(Giesso 2003: 377). Earle (1977b: 215) argues that *redistribution* should be considered as two major groups with leveling mechanisms on one side and complex institutional mechanisms for wealth accumulation on the other (see Section 2.2.4).

Administered Trade

Non-market administered trade was another major means of transfer in the prehispanic south-central Andes. Building on Polanyi's classic definition of non-capitalist economic types, Charles Stanish (2003: 69) describes a form of elite-administered, non-market trade that was capable of procuring non-local goods and that provided wealth to elites as follows. Garci Diez's Titicaca Basin *visita*, a 16th century Spanish census document (Diez de San Miguel 1964 [1567]), describes how local elites in the Lake Titicaca Basin would have their constituents organize llama caravans for trading expeditions to adjacent regions. In neighboring areas such as the Amazon basin to the east, the Cusco valley, and western slope valleys, agricultural goods such as corn, fruits, and other products were sweeter, faster growing, and more abundant than in the Titicaca Basin. The colonial *visita* indicates that, based on the colonial currency, corn in the Titicaca Basin was worth 5.7 to 6.9 times the amount that it was worth in the Sama valley (an area in modern-day southern Bolivia) where it was abundant. Stanish (2003: 69-70) argues that administered trade benefited elites because they were able to appropriate this difference in value, and through feasting and other ceremonial functions, a portion of this wealth was redistributed to commoners. It is important to mention that these same colonial sources indicate that the commoners also organized trading ventures and would take advantage of these elite-organized journeys to conduct private barter exchange on the side. With reference to herders conscripted into elite orchestrated trade caravans “those in Lupaca country ‘who had their own cattle [cargo llamas]’ (Diez de San Miguel 1964 [1567], f. 13v) went to the coast and to the lomas to barter on their own. …the maize growers on the irrigated coast were eager for the highlander’s animals, their wool and meat” (Murra 1965: 201). Thus, elites organized large caravans and apparently possessed the surplus wealth and the camelid caravan animals in advance to initiate the trading expedition, but the herders that they conscripted also engaged in household-level barter. For the elites, their organizational efforts earned them significant wealth and status for a relatively modest outlay of costs. For the herders, it appears that they were able to embed household economic transactions with their *mit’a* labor service by conducting their side barter activities. Apparently, even the powerful Lupaca elite had to concede some independent trade activity to their caravan drivers. What, then, of the relationship between *caravaneros* and elites during earlier periods, when elites probably had less consolidated power than during the contact period?

The evidence suggests that “administered trade” was not the first form of long distance caravan exchange. As mentioned above, relationships of balanced reciprocity have long served to articulate herders with those living in complementary ecozones such as sierra agriculturalists, coastal fishers, and residents of the eastern lowlands. But the long distance transport of diffusive goods like obsidian are well-demonstrated and form a continuous network configuration that contrasts with the segmentary, vertically organized exchange between valley and puna (Figure 2-3). Archaeological distributions (Browman 1981a; Burger et al. 2000; Dillehay and

Nuñez 1988; Nuñez and Dillehay 1995 [1979]) and contemporary ethnoarchaeological studies (Lecoq 1988; Nielsen 2000; T. L. West 1981b) attest to the capacity for small scale, household-level organization of multi-week caravan expeditions. This evidence suggests that there were probably at least two major types of long distance caravans operating from the Late Formative onwards. The question then becomes: what was the relationship between household-level caravans and elite-administered trade? Did elites co-opt functions that were previously coordinated on the household level? If elites acquired control of some segment of caravan traffic, what strategies did elites use to wrest control from caravan drivers that, the evidence suggests, were very independently-minded people (Browman 1990: 419-420; Nielsen 2000: 517-520)? These questions concerning the origins and configurations of regional interaction in the south-central Andes are at the center of this discussion of changes in obsidian procurement and the regional circulation of goods in prehistory on the perimeter of the Lake Titicaca Basin.

3.1.2. Economy and exchange in mountain environments

Cross-cultural studies of human adaptation to mountain environments have revealed a number of common features between production strategies employed by people in the Andes, the Himalaya, and the Alps (Funnell and Parish 2001; Guillet 1983; Rhoades and Thompson 1975; Tomka 2001). These commonalities in adaptation to mountain settings include:

(1) Both specialized and mixed procurement systems are found, but there is a predominance of mixed systems.

(2) Specialized procurement systems are interconnected through regional exchange.

(3) Land holdings by a particular social unit can be non-contiguous and distributed across multiple ecological niches.

(4) In extensive procurement zones, such as grazing areas, land tenure is communal, whereas in intensive procurement, such as irrigated farmland, tenure is often family based.

These strategies are responses to characteristics of mountain settings that include altitude-based biotic ecozones, limited productivity in any single zone, and risk to herding and farming in production activities.

These regular features of production in mountain settings provide a comparison against which to evaluate procurement strategies in the Andes. A number of characteristics of production common to mountain environments have been inappropriately conceived as exclusively Andean in an essentialist tradition referred to as *lo andino* (Starn 1991; M. Van Buren 1996), while conversely others have sought to impose Andean models on regions where the model do not necessarily apply (M. C. Goldstein and Messerschmidt 1980). These models of regional interaction in mountain environments, both in Andean and general geographical models, can be contrasted with regional distributions of raw materials. Obsidian and other raw materials circulated widely in the Andes, and the spatial patterns described by these materials, may be examined in light of other regional patterning like stylistic distributions, as well as economic models of regional interaction.

Vertical complementarity

The contrasting ecological zonation found in low-latitude mountain regions worldwide has resulted in distinctive social configurations that appear to reduce risk, broaden the selection of products available in a given zone, and provide opportunities for strategic advancement by particular individuals or groups. These configurations have been investigated in two broad sets by Andeanists. First, there are a number of scholars who address vertical complementarity as a general process that is comparable with other mountain regions of the world. Second, there is a particular configuration known as "Vertical archipelagos" first described by John Murra (1972) that has been widely discussed in the Andean literature.

Verticality writ large

Vertical complementarity encompasses a variety of strategies for the problems posed by human use of resources at different scales, and by the broad natural diversity across relatively small distances in mountain environments (see contributions in Aldenderfer 1993a; Masuda et al. 1985). These problems of articulation are addressed through mobility, through direct control of different zones by a single group, by mutualism between residents of different zones, and through a variety of exchange relationships. Vertical organization has been recorded among modern Quechua and Aymara communities (e.g., Brush 1976, 1977; Flores Ochoa et al. 1994; Harris 1982, 1985; Platt 1980).

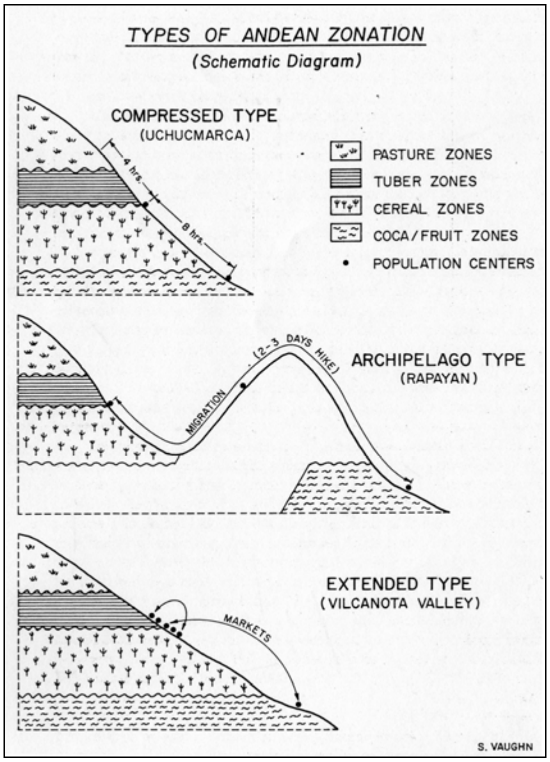


Figure 3-2. Contemporary types of Andean zonation (Brush 1977: 12).

Based on contemporary observations, Brush (1977: 11) describes three systems: (1) the archipelago type, or vertical complementarity, as conceived by Murra; (2) a compressed type, where a single village can access and control all resources without resorting to means of long distance control; (3) the extended type that corresponds to horizontal complementarity.

On a more localized scale it is possible to see vertical control strategies within a particular valley in a mixed agropastoral strategy that has been called "compressed archipelago" (Figure 3-2). In the central part of the Colca valley on the western slope of the Andes in Arequipa, Peru, Guillet describes vertical household relations.

> To what extent do households integrate both puna pastoralism and valley farming into their production and exchange strategies? First, most households residing in the puna tend to specialize in herding and do not have agricultural fields that they cultivate directly. Similarly, many village households neither belong to family surname groups with access to puna pastures nor count themselves among those who have gained control of communal pastures (*botaderos*) on the slopes behind the village. Households that follow such specialized strategies must perforce use the exchange nexus to obtain complementary products (Guillet 1992: 133).

Additional evidence for micro and macro vertical complementarity is discussed in the context of the Colca valley (Casaverde Rojas 1977: 172; Málaga Medina 1977: 112-113; Pease G. Y 1977; Shea 1987: 71).

Vertical complementarity can viewed as an anthropological principle that describes the propensity for social groups in mountain environments, from foragers to state societies, to geographically broaden their social and economic base and reduce risk by exploiting a variety of environmental settings (Salomon 1985; Aldenderfer 1993a; Guillet 1983). Salomon (1985: 520) presents complementarity strategies in prehispanic Ecuador as varying in two dimensions.

→ Increasing centralized control →

	Decentralized (reciprocity)	Centralized (redistribution)
Direct Access	1. "microverticalidad", "transhumancia", "compressed archipelago", "doble domicilio" Modes: direct access	2. "Archipiélago vertical", "horizon-talidad" Modes: direct access, central place redistribution
Dyadic (inter) Dependence	3. "Huari-llacuaz", "hermanación" Modes: Home base reciprocity, boundary reciprocity	4. "interactive dyad" Modes: down-the-line exchange, emissary trading
Multiple Alliance Exchange	5. "caravaneering", "liquira", "wasa q'epi" Modes: home base reciprocity, freelance (middle-man) trading	6. "mindaláes", "status traders", "yndios mercaderes", enclaves de rescate Modes: emissary trading, colonial enclave
Open Barter	7. "rescates y granjerías", "trueque", household expeditionary trading Modes: home base reciprocity, boundary recipro-city, down-the-line trading	8. "tianguez", "port-of-trade", "extended archipelago" Modes: central place market exchange, port-of-trade

↓ Increase in number of political units in contact ↓

Fig. 23.1 Diagram of Institutions of Andean Complementarity.
Note: "Modes" refers to the classification "Modes of Trade and Their Spatial Implications" by Colin Renfrew (1975:41–3).

Figure 3-3. Diagram of institutions of Andean complementarity (from Salomon 1985: 520). Numbered modes reference the "Modes of Trade" in the figure from Renfrew (1975: 41-43) shown in the previous chapter as Figure 2-2.

One is between decentralized systems based on reciprocity, and the other is based on centralized systems of redistribution. There is an underlying neo-evolutionary correspondence implied in many of these models, as chiefdoms and states are believed to have been responsible for the network convergence perceived in redistributive systems, however it is important to observe that due to the variety in products, social relationships, and economic configurations, it is likely that a great many of the institutions presented in Figure 3-3 occurred simultaneously, and in general there is no direct correlation between confluence and evolutionary typologies. Another important dimension involves the number of political units participating in the interaction ranging from direct access, dyadic relations, exchange systems and open barter. The vertical complementarity literature in the Andes is valuable for considering prehispanic exchange relationships in that it has compelled a number of scholars to explore explicitly the relationship between ecological zonation, production, and social organization.

Vertical archipelagos

The work of John Murra on vertical complementarity has been among the most influential ethnohistoric studies in the Andes. The premise of the vertical archipelagos model is that the rapid altitudinal change along the flanks of the Andes produced a pattern where social groups residing in non-contiguous ecological strata formed distinct communities that developed around intensified production in these strata. Polities and ethnic communities sought to control a variety of these resource pockets following the Andean ideal of self-sufficiency.

Murra's (1972) seminal article distilled observations from ethnohistoric sources, in particular the *visita* census Garci Diez (1964 [1567]) of Chucuito in Puno, conducted only 35 years after the Spanish invasion. Murra showed that late prehispanic altiplano societies obtained direct access to products from a variety of ecological niches through this practice, and that the strategy was a guiding model of organization in some Andean polities (Salomon 1985). According to Murra (1985) the principal characteristics of the vertical archipelago model can be summarized as follows:

(1) Ethnic groups aimed to control numerous "floors" or ecological niches in order to exploit the resources that are found there and maintain self-sufficiency. As a consequence, powerful polities residing in the altiplano had considerable wealth in pastoral herds but also controlled land on both the western and eastern flanks of the Andes.

(2) The population was concentrated on the altiplano and those living in the peripheral 'islands' maintained continuous social and economic contact with the core region.

(3) The institutions of reciprocity and redistribution guaranteed that those living in 'islands' maintained the rights to products available in the center. These rights were defined through kinship ties that were ceremonially reaffirmed in the center.

(4) A single 'island' could be shared by different ethnic groups, though the coexistence could be tense.

(5) The relationships and functions of these colonies changed through time and may have become more exploitative. They are perhaps an antecedent to the *mitimaq* strategy of the Inka empire.

While a chiefdom level of organization and centralized power is a principal characteristic of the Late Intermediate polities that practiced vertical complementarity in the period examined by Murra, the concept was been explored and expanded by archaeologists in the subsequent decades. In Murra's original description, verticality referred explicitly to direct control of a diverse resource base without engaging in trade with other ethnic groups, thereby preserving what Murra (1972) has described as the ancient Andean ideal of economic self-sufficiency that permeated Andean society and ideology far beyond his Lupaca case study. Stanish argues that Murra was explicit about excluding exchange processes, in part, because he perceived "a structural linkage between exchange and markets" (1992: 15). As prehispanic market mechanisms were absent in the south-central it was believed that barter and exchange were also of minimal importance and other means of articulation, such as direct control, were emphasized. Murra, however, later modified the definition to include specialized exchange centers, a change which Browman (1989: 324) argues confuses the issue because it subsumes a variety of processes into a single model.

On a theoretical level a further limitation of the original 'verticality archipelago' model lies in its adaptationalist orientation (Earle 2001). Adaptationist models of exchange and regional control have their basis in Service's (1962) proposal that these arrangements arise from environmental diversity, and then chiefs emerge to administer and redistribute goods produced regularly by their retainers. As observed by Van Buren (1996: 346), the archaeological origins and perpetuation of the archipelago pattern was founded on the assumption that groups benefit, as a whole, from the control of multiple tiers and the ecological resources that are produced in those archipelagos. As mentioned above in the discussion of administered trade, colonial documents emphasize the independence of commoners and the ability of subjects to practice subsistence barter, a pattern that leads authors to suggest that the vertical archipelagos pattern may have had more of a political basis than a foundation in ecological and subsistence practices. The ultimate roots of such a system may lie instead in the capacity of the rulers of such groups to organize larger scale trade and convert the value differential between products in the different ecological zones into political prestige through feasting and ceremony (Stanish 2003: 69-70).

Horizontal complementarity

Soon after Murra published his 1972 paper about vertical complementarity, researchers began noting that vertical complementarity is only one of a number of strategies employed in the Andes. A different kind of geographical interaction pattern, one that stays within broad regions such as the altiplano or the littoral, has been called *horizontal complementarity*. Contrasted with Murra’s vertical complementarity model, in horizontal complementarity polities would directly control many parcels in a given niche. Here, the adaptationalist argument is somewhat less obvious since a horizontal complementarity strategy seems redundant unless particular resources were only available in one sector of a given horizontal territory. This phenomenon could reflect a cultural mechanism for the continued social integration of communities distributed widely across a vast region. An analogous situation can be observed in the culturally-constructed Yanamamö trade for ceramic wares, maintained to provide a social catalyst for villages to come together for feasting and marriage-making, despite the risk of conflict and treachery (Chagnon 1968).

Relations of horizontal complementarity between coastal valleys have been observed on the littoral (Netherly 1977; Shimada 1982; Rostworowski 1977), and for the higher altitude altiplano area where this kind of organization is referred to as the "altiplano mode of economic integration" (Browman 1977) and, to a lesser extent, the modern "extended type of Andean zonation" (Brush 1977: 12-16; Gade 1975). The extended type takes place in regions of expansive, contiguous production where exchange forms the basis for circulating products from other zones. In the expansive altiplano where there are fewer impediments to travel and, with the domestication of camelids, relatively low transport costs with cargo animals, materials may have been conveyed over substantial distances.

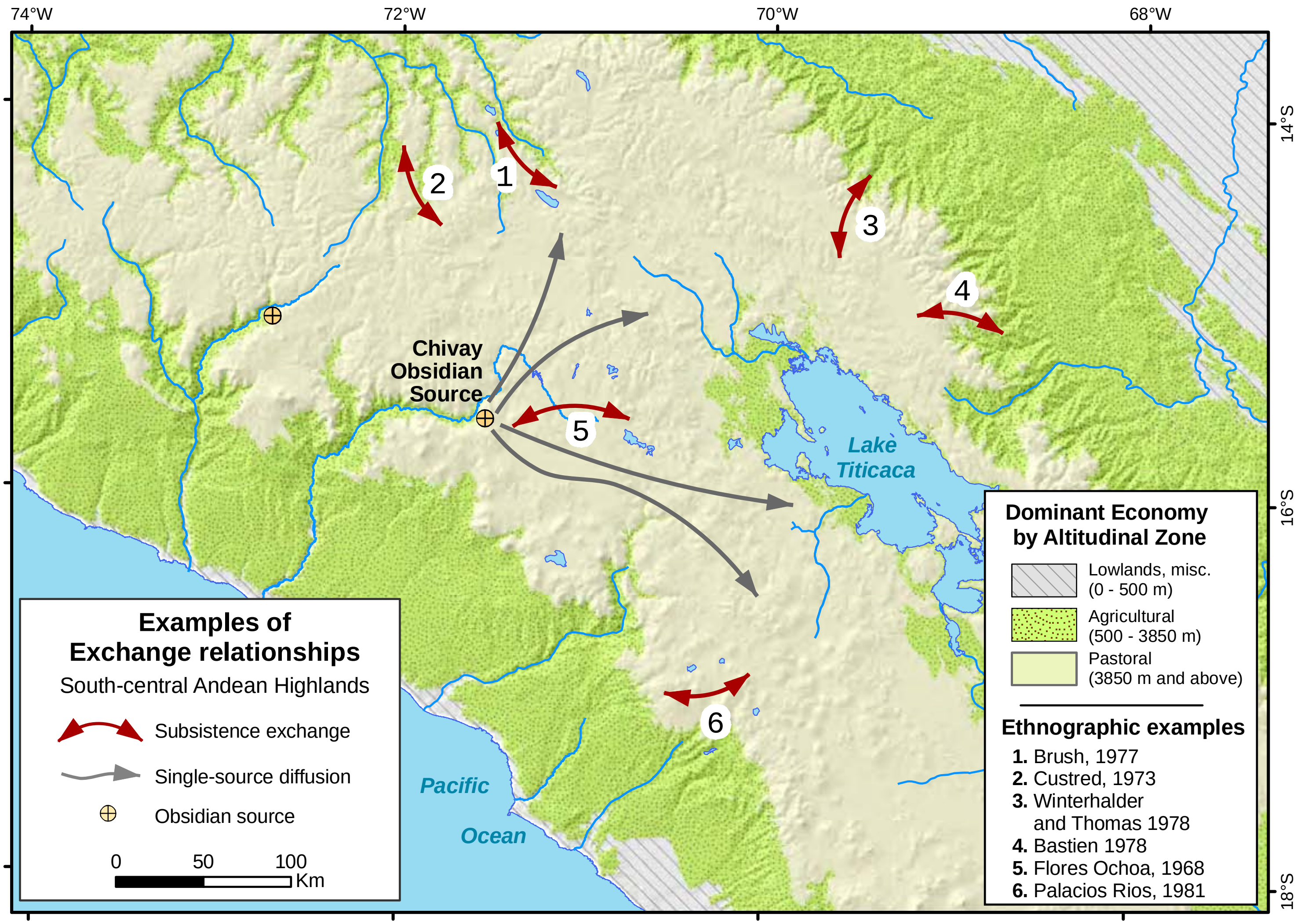


Figure 3-4. Subsistence exchange for products by ecozone versus single-source, diffusive goods.

A general schematic of these contrasting relationships is shown in Figure 3-4. While there is a great deal more complexity and variability to economy and exchange than is communicated in Figure 3-4, for example tubers are grown in the high elevation zones and herding does occur below 3800 masl, the purpose is to highlight the contrasting network characteristics. These two characteristics include

(1) *Subsistence exchange.* The acquisition of products available by zone contrasts

(2) *Diffusive.* The network for goods that radiate diffusively, such as obsidian and salt.

While the mixed agropastoral strategies are also very common, particularly in ecotone areas such as the puna rim, the subsistence exchange that articulates dedicated pastoralists with agriculturalists has been documented ethnographically in many studies of which only a selection are shown in Figure 3-4 (Bastien 1978; Brush 1977; Custred 1973; Flores Ochoa 1968; Palacios Ríos 1981; Winterhalder and Thomas 1978).

Ecological complementary has long served to transfer goods between ecozones, however the movement of goods laterally through areas of homogeneous resources, such as horizontal complementarity across the puna, implies other mechanisms of transfer. In addition to strategies described previously, it has been proposed that large periodic markets are a possible solution to the problems of social and economic integration among agropastoralists living in widely distributed settlements.

Browman (1990: 405-411) reviews the evidence for prehispanic and colonial period markets in the Peruvian and Bolivian altiplano. The colonial period aggregations in the Andes are products of historical circumstances, however

Browman's evidence suggests that periodic fairs in some form were a feature of the prehispanic economy. While evidence concerning the actual goods exchanged at periodic fairs during the prehispanic period is scarce, these events could have been an effective way for obsidian to have been distributed in highland Peru and these fairs will be discussed in more detail below. Seasonal or annual gatherings are also ethnographically known among foragers in arid regions of the world with low population densities (Birdsell 1970: 120; Julian Haynes Steward 1938). Social aggregations in some form can be expected to date back to the foraging period and these aggregations probably included, among other activities, the exchange of goods.

Evidence for barter, markets, and marketplaces in the Andes

> "They did not sell… nor did they buy… they thought it was a needless operation" and all universally planted what they needed to support their households and thus did not have to sell foodstuffs, nor raise prices nor did they know what high prices were… (Garcilaso 1960 [1609]: 153; cited in Murra 1980: 142).

Was obsidian exchanged through a market system reflecting supply and demand in the prehispanic Andes? Were exchange specialists present in the prehispanic Andean highlands? If so, when did they appear and what did they transport? While extensive exchange has been documented in the prehispanic Andes, it is widely believed by Andeanists that exchange in the prehispanic central Andes was not based on market institutions. Building on the typology developed in Chapter 2 following Renfrew (1975) and Salomon (1985), differing degrees of specialization and independence can be expected to have existed among actors in exchange relationships (Figure 2-2 and Figure 3-3). If specialized traders were present in prehispanic Andes, how did they interface with state authority during the Middle Horizon and Late Horizon, and what was their position during periods of regional conflict like the Late Intermediate Period?

Much of the evidence supporting the alleged lack of market-based exchange is derived from studies of Inka economic organization, where ethnohistorical accounts and archaeological datasets converge. A great deal has been written on the topic of Inka economy, and obsidian exchange was relatively diminished during this period, therefore this discussion will be limited to a few relevant issues regard exchange specialization. Several of the sixteenth century chroniclers are clear that while barter was widespread, the barter values of goods did not reflect fluctuations in supply and demand as in a market economy. However, the lack of consensus on the issue of markets and commerce during the Inka period stems from inconsistency in the *cronistas* themselves. As reviewed by Murra (1980: 139-152) and LaLone (1982) the denial of a market exchange by Garcilaso de la Vega (quoted above) can be contrasted with numerous accounts of large and small markets, and a long tradition of barter exchange of various types.

The issue of Late Horizon marketplaces and market exchange is explored here because one of the principal questions that may be considered with changing obsidian distributions through time is the possible role of commercialism in prehispanic Andean exchange. The appearance of exchange specialists, such as freelance caravans moving certain commodities and responding to the changes in barter values that result from surpluses and shortages, would have presented a mode of transport distinctive from that of local reciprocal exchange or regional or state redistribution.

The vertical archipelago model functioned as an alternative to trade for goods from neighboring areas because "regional differences in production were, by preference, handled by means of colonization instead of through barter or trade." (Murra 1965: 201). As mentioned, Stanish argues that Murra initially excluded exchange mechanisms because of a perceived association between exchange and market economies. Further it can be argued, building on Appadurai (1986: 33), that in certain contexts of ranked or stratified societies with elaborate redistribution mechanisms, market systems of exchange represent a threat to the centralized ideological power of redistribution. "There is great advantage to leaders who are able to portray their resource-control strategies as reciprocity, redistribution, and generosity. Non-centralized resource-control strategies are, by definition, not 'control' strategies" (LaLone 1982: 296). If centralization is a principal determinant of state control on market exchange, were the peripheries involved in greater numbers of barter transactions?

Merchants in the Andes: Late Prehistoric and ethnohistoric evidence

Coastal Trade

The strongest evidence for merchant specialists in the Andean region comes from relatively peripheral areas of the Inka Empire, from the Pacific coast of what is now Peru, and from the coast and highlands of prehispanic Ecuador. The coastal Late prehispanic traders of Chincha, near the Paracas peninsula, have been described as consisting of 6000 merchants who traded in Cusco, among the Colla (and presumably the Collagua), and in Ecuador, but little is known about how these expeditions were organized (T. C. Patterson 1987; Rostworowski 1976, 1977; Sandweiss 1992). LaLone (1982: 308) notes that Rostworowski was not able to connect Chincha traders with marketplaces despite her assertion that these represented commercial exchange. Sandweiss (1992: 10) believes that Chincha trading expanded a great deal under the Inka following the Inka conquest of the Chimu to the north.

Coastal products such as spondylous and other goods were known to have been transported in large balsa rafts. There are numerous contact-period accounts of merchants plying the Pacific littoral beginning with the renowned loaded boat of balsa logs encountered off the coast of Ecuador by Pizarro on his second trip south, several years before the actual Spanish invasion of the Andes (Hemming 1970; Murra 1980: 140). The boat had a crew of 20 and had a small cabin and cotton sails. Murra is confident the boat was an Inka "registry" because the crew knew Quechua and a few were captured by the Pizarro's army who later used them as interpreters. While the Spanish paid particular attention to precious metals, the contents appear to have contained wealth goods including gold and silver ornaments, bracelets and anklets, headdresses and mirrors, and a great deal of cotton, wool and rich embroidery. A small weighing scale as well as a great deal of shell, probably spondylous and strombus, were found on board (Hemming 1970; Murra 1980: 140). Although the activity of this boat was described as trade (the word *rescatar* is used in the text) by the Spanish observer Sámano-Xerez written in 1527-1528 (Porras Barrenechea 1937: 21), it is highly likely that this boat, with its cargo of elite goods, was in fact carry ritual offerings from the Inka to some northern destination. The evidence for long distance exchange between Ecuador and Mesoamerica has been long been a topic of interest in New World archaeology (Coe 1960; Zeidler 1977).

Ecuadorian highlands

The strongest evidence for mercantilism and markets in the prehispanic Andean highlands comes from colonial Ecuador (Hartmann 1971; Salomon 1986). Hartmann argues that the Inka economy had a significant market component based the following evidence: (1) the Spanish saw gatherings that they identified as "markets" from the very earliest reports, although as they were coming from Mexico the Spanish used the *Nahuatl* word "*tianguez*"; (2) commodities were plentiful and varied, including both staple and luxury items; (3) both Quechua and Aymara had specialized terms for buying and selling; (4) market activity was not suppressed by the Inka authorities, only regulated to suit their interests (Hartmann 1971).

The existence of markets in prehispanic Ecuador is a particularly interesting question because the Quito area was conquered by the Inka only 30 years prior to the Spanish invasion and therefore the region had only recently been absorbed into the Inka Empire. Salomon (1986) examined the ethnohistoric evidence for precolonial and colonial markets in highland Ecuador and found that the contact period evidence provides insights into pre-Inka customs as well as the Inka response. The Quito valley is in a position to serve as a hub for the transfer of products from the Amazon lowlands, the Pacific coast, and the *páramo* highlands. In this sense, the Quito valley is in a similar geographical configuration, but on a smaller scale and a different ecological zone than the Lake Titicaca Basin. The strong dependence of early

Spanish residents on the markets, and the founding of new markets by Spaniards, leads to some uncertainty as to the precolonial importance of markets. However, there is a variety of evidence for a pre-Inka merchant class in central Ecuador called *mindaláes* that gathered in stationary markets and controlled trade in cotton, coca, and salt that they would bring from lower-lying regions (Salomon 1986: 203-204). Barter exchange between non-specialized traders occurred as well, typically of household surplus goods, and Salomon argues that both *mindala* merchant organization and non-specialized barter were ancient developments in Ecuador. In contrast, Patterson (1987) argues that the merchantile organization was not a long-established system but rather a Late prehispanic period response to opportunities presented on the northern border of Tiwantinsuyu. Vertical archipelago organization is also found in Ecuador both in agricultural production and in targeted procurement communities such as stable colonies for salt production (Oberem 1981 [1976]: 79). However, Salomon shows that archipelagos were, in most cases, a late phenomenon that was introduced by the Inka. In addition, obsidian distributions in Ecuador can provide insights into Andean exchange in a context with functioning markets (Burger et al. 1994).

As for trade specialization elsewhere in the Andes, LaLone (1982: 307) sees a latitudinal gradient from north to south where markets and freelance traders may have been more abundant in the northern periphery of the Inka empire, and subdued or non-existent in areas full under Inka control. A notable exception to this gradient are the sea traders from Chincha (Rostworowski 1977; Sandweiss 1992). The evidence is far less secure for the southern periphery of the Inka Empire, but the implication of the Ecuadorian data is that solving zonation problems through the vertical archipelago approach was promoted by the Inka in Ecuador following the Inka conquest, which perhaps calls into question the pervasiveness and pre-Inka antiquity of the vertical archipelago strategy in the south-central Andes as well.

Traveling 0eddlers in the south-central Andes

In contemporary contexts, peddlers are found with frequency in areas that form boundaries areas between different commercial spheres of interaction and lacking in consistent distribution of goods. Browman (1990: 422) reviews ethnographic evidence for mobile peddlers who perform bulk-forming and bulk-breaking services in the south-central Andean highlands. The peddlers will provide manufactured items to rural pastoral communities, though often at a substantial mark-up, and will trade for items like hides and wool in time for purchasing fairs in the regional centers. The puna between Lake Titicaca and the western slopes in Arequipa are particularly active with *comerciantes ambulantes* who schedule their travel cycles to correspond with patron saint festivals, as well as distributing goods to communities without regular markets (Flores Ochoa and Najar Vizcarra 1976; Flores Ochoa 1977: 148) as well as traveling herbalists and related groups (Bastien 1987). In the small community of Cerrillos in southwestern Bolivia near the Argentinian border, Nielsen (2001: 166) reports that peddlers, referred to as *cambalacheros*, would pedal bicycles from the city of Oruro bringing clothes and metal pots to sell or to barter for hides.

The Collaguas of the Colca valley were frequently visited by itinerant peddlers from Puno, according to Casaverde (1977: 185). These vendors known as *polveños* maintain established *compadre* relationships with Colca valley households in order to have reliable hosts and potential buyers in the valley. Although transactions frequently take place through barter and the host and other residents are not obliged to trade, the profit motive of the peddlers is understood. These examples illustrate some of the variety in forms of distribution that may have had some basis in the prehispanic economy.

Limitations of ethnohistory and ethnography

Ancient economy in the Andes has been most fruitfully studied by combining archaeological evidence with ethnohistoric and contemporary sources. General models of great importance to Andean studies such as vertical complementarity, the question of the commerce in the prehispanic economy, and a structure of dual organization in the Inka administration are examples of models emerging from ethnohistoric sources but with empirical support from archaeological research. Ethnohistorically based models also have their limitations in that they can unduly influence interpretation much in the way that the "tyranny of ethnography" (Wobst 1978) should not necessarily define the range of archaeological possibility and inference. Ethnographic sources are valuable for the evidence of pastoral patterns, the priorities of caravan drivers, and the articulation between mixed and specialized pastoral and agricultural practices. However, modern features including the presence of the cash economy, markets, truckers plying the highways, and various modern job opportunities impact the structure of exchange relationships and caravan transport (Browman 1990; Nielsen 2000).

Ethnographic studies of contemporary llama caravan drivers are focusing, by necessity, on relatively marginalized communities that are sufficiently conservative to continue to herd llamas despite a variety of often more lucrative alternatives (Lecoq 1988; Nielsen 2000). Scholars have noted, however, that caravan drivers enjoyed relatively high status and autonomy in the late prehispanic and early colonial period which contrasts strongly with the economically marginalized modern day *caravanero* (Murra 1965). Furthermore, herding has become relatively low status in many regions of the contemporary Andes because the economic focus has moved downslope since Spanish contact due to the growth of the coastal economy and the importation of various low altitude crops and livestock. In other words, the prominence of caravan drivers as central economic agents has been greatly diminished in recent centuries, and ethnographically documented interactions with agriculturalists is one circumstance in which this relative shift in power may result in distorted perceptions of prehispanic interaction patterns. The relatively high status accorded to truck drivers and other purveyors of goods and information in contemporary Andean villages was likely to have been ascribed, instead, to the relatively cosmopolitan drivers of llama caravans during prehispanic times.

3.2. Long distance trade

The transport of goods over distances that exceed immediate complementarity relationships in mountain environments is well-documented archaeologically and ethnographically in the south-central Andes. Point specific resources like obsidian and salt have a distinctive, radiating distribution pattern as compared with subsistence exchange between ecological zones (Figure 3-4). Mechanisms that include direct acquisition and down-the-line exchange (boundary reciprocity) are likely to have been long-term exchange modes that served to disseminate of goods horizontally through a single ecological setting like the Andean altiplano. However, it is known ethnohistorically that long distance transport with the aid of camelid caravans, either with direct procurement and including very few transfers (long distance trade caravans), was a common method for the lateral distribution of goods. When did long distance caravan transport begin to dominate regional exchange in the south-central Andes, and who initiated this form of transfer between far-flung populations? Principal factors that influence the origin and perpetuation of long distance trade routes by highland pastoralists in the south-central Andes include the following features.

(1) *Cargo animals:* While not exceptionally strong, llamas are effective cargo animals because they are relatively compliant, they are not water tethered, and they can consume a range of grasses found on the altiplano so that they do not have to transport their own fodder.

(2) *Topography:* By virtue of the open and predominantly low-angle topography of the altiplano, the movement of loaded cargo animals across the altiplano requires lower effort than travel along the eastern or western sierra that are bisected by deep valleys.

(3) *Resources:* On an inter-regional scale, the altiplano divides complementary resource areas from the Amazon lowlands to the Pacific Ocean and these converged on the altiplano during particular time periods.

These features created circumstances that allowed for the wide-distribution of materials like obsidian and other products in the south-central Andean highlands. Long distance exchange and spatial relationships have been presented as a primary factors in the appearance of early social complexity during the Middle and Late Formative (Bandy 2005; Stanish 2003: 159-164). However, given the antiquity of camelid domestication in the Andes the long distance caravan pattern probably predated the Middle Formative by a millennium or more. The presence of caravans and the transport of complementary goods around the high, flat altiplano are part of a number of characteristics that created the circumstances within which social inequalities evolved. Competition for social power emerged during the Formative from a context that included these features of long distance exchange both in terms of the capacity for regional interaction, and the social institutions that surrounded the organization and scheduling of exchange in the region. These regional exchange mechanisms had long term consequences based the theory of Clark and Blake (1994: 17) who argue that social ranking was the unintended outcome of early political actors, operating within the institutional constraints of their circumstances, pursuing short term prestige goals for themselves and for their supporters. Following this model, the established circulation mechanisms of non-local products during the Early Formative, and perhaps earlier, are likely to have had a significant influence on the strategies pursued by aggrandizers during subsequent periods such as the Middle Formative.

3.2.1. Household-level caravans

Adaptationalist explanations for the origins and significance of long distance caravan networks are unsatisfactory, yet the more explicit aggrandizer models for the rise of elite-administered caravans that are documented ethnohistorically, refer to a regional-scale phenomenon that occurred relatively late in the prehispanic past (Stanish 1992: 14; 2003: 69). As was discussed above, the evidence suggests that household level organization of long distance caravans should be considered as a possible hypothesis for the long distance circulation of goods prior to the Middle or Late Formative when archaeological evidence for ranked society appeared in the Titicaca Basin.

In terms of the two configurations described above as *subsistence exchange* and the *single-source diffusive* goods (Figure 3-4), the capacity and incentive for long distance caravan activity appear to be much older than the evidence for elite administration. In other words, on a geographical level and in terms of archaeological distributions one should consider that long distance caravan exchange was possibly organized on the household level thousands of years before elites were clearly organizing labor for the construction of monuments and the hosting of feasts.

What were the contexts in which individuals and households to began to organize long distance caravans in prehistory? Many of the "diffusive" goods with radiating distributions were not required for subsistence, strictly speaking. While small quantities of salt are biologically necessary for humans, salt is available in low densities in many parts of the altiplano and hunters and pastoralists can actually acquire salt from the consumption of meat and blood. In terms of the need for obsidian, it is evident that obsidian has flaking characteristics not available in other stone materials, but high quality cherts are available in many regions where the archaeological evidence shows that obsidian was imported from relatively large distances. Semi-precious stones like lapis lazuli are found in archaeological contexts such as burials after 3300 BCE in the south-central Andes. A variety of perishable goods probably circulated along such exchange networks as well, and as wild plants and agricultural products from particular regions are renowned to this day, such as hot peppers, sweet corn, herbs, and potent coca leaf, there was likely to have been variability in products available from particular valleys over others (especially during the earlier stages of plant domestication). If these products were transferred by caravans, perhaps in dried form, they would have radiated along distributions that were closer to diffusive sources like obsidian.

At risk of creating a rigid dichotomy, these items that were relatively common-place in some regions may have been closer to "prestige goods" because they were transported substantial distances. Following agency models for early leadership, those who mobilized resources to acquire such goods may have been striving to differentiate themselves from their communities and their neighbors. However, it is important to note that many of these goods, such as obsidian, do not appear to have been used exclusively by a small, restricted segment of the population in the archaeological contexts where they are found. Nevertheless these goods were widely transported and the mere presence of these goods indicates that some effort was expended to acquire the product (and, according to Hayden (1998: 44), these are automatically a form of *prestige technology*). In terms of the importance of "ordinary goods" (M. L. Smith 1999, see section 2.2.2), such products may have had important cultural and ethnic associations that lent value to the acquisition of these goods and prestige to those who could acquire them while simultaneously having widespread availability in a community. Archaeologists often define "prestige goods" based on spatially-delimited contexts that imply restricted or elite contexts of consumption, and this sometimes leads to claims that these alleged prestige goods were the impetus for long distance exchange. Rather than inferring that prestige goods defined the exchange networks and then "everyday goods" followed suit, Smith (1999) notes that the cultural information and these non-local yet widely-consumed materials like obsidian are perhaps better considered as "cultural goods", linked to ethnicity signaling and practice among herders (Nielsen 2000: 521-526), and complemented by other markers of ethnicity the most visible of which were probably textiles. As regional links became established, obsidian may have become a means for demonstrating participation and cultural affiliation with the subsistence level networks that exchanged goods including obsidian. Even if archaeologists are not able to detect exclusivity in the access to such goods in intra-site spatial distributions, as the materials were widely consumed in the community, it seems probable that the ability to acquire these goods reflected positively on the individual or household capable of procuring non-local products.

3.2.2. Incentives for early caravan formation

Down-the-line exchange can account for many archaeological distributions of cultural goods such as obsidian, both in volume and in temporal persistence. In terms of efficiency, down-the-line reciprocity networks require lower travel distance and less risk than is incurred traveling through unfamiliar territory (Renfrew 1975: 44). Furthermore, as Nielsen (2000: 24, 514) notes, caravan driving is hard work and it only becomes worthwhile when distances are large and/or loads are heavy or bulky. These bulky items tend to be transported medium distances (40-120 km), but smaller and more valued items might be transported long distances (Nielsen 2000). Traveling peddlers also carry small and light items without the added responsibility of managing many camelids in a caravan, therefore in some ways caravans and peddlers are complementary alternatives for the independent circulation of goods. Nielsen further observes that ancient caravans probably carried a variety of products in their cargo to reduce risk, and they likely carried *anything* that was worth transporting and that could be traded within their social and cultural parameters.

Given the evidence for increased sedentism from the Terminal Archaic and onwards (Aldenderfer 1998b; Craig 2005), down-the-line exchange may be considered as the null hypothesis, with direct procurement and household level trade caravans as alternative hypotheses. Consistent but low levels of down-the-line exchange embedded in social relations form the background against which to examine other exchange modes such as caravans and possible non-market mercantilism. What kinds of possible incentives existed for the development of household-level caravans in order to acquire such goods, given the wide variety of potential trade and consumption patterns in prehistory? Incentives for household level caravan organization may include

(1) The maintenance of a social network and a demonstration of extra-local alliances that exceed the level of basic regional interaction implicated in subsistence-related exchange.

(2) Demand for a greater quantity of types, and the number or sizes of products than can be acquired from down the line exchange.

(3) A need or desire to exceed the products available to one's neighbors or to avoid dependency on an entire reciprocity network of neighborly relations.

(4) In a biological adaptationist framework, the risk and potential of caravan driving was a form of costly signaling (Aldenderfer 2006; Craig and Aldenderfer in press).

Secure evidence of caravan activity, beyond simple evidence of pastoralism from faunal remains and evidence of corrals, may be a challenge for archaeologists and the systematic study of spatial distributions of non-local goods may shed light on the differences between subsistence pastoralism and caravan trade activity. One example of caravan activity from consumption contexts may come in the form of distinctive evidence of pooling of certain goods at particular sites along major transportation corridors, but establishing changes in relative density probably requires representative samples from archaeological collections from contexts that were presumably major caravan networks and those that were more peripheral to principal caravan routes. Sourcing from contemporary household-level assemblages may serve to differentiate such pooling (Figure 2-4), as was attempted with Oaxaca obsidian by Pires-Ferreira (1976). In the south-central Andes, stronger evidence for differentiating caravan trade from down-the-line trade may come from differences in artifact form and context from a variety of non-local products. In short, differentiating caravans from down-the-line exchange will require inference from multiple lines of evidence and from domestic contexts, evidence that is extremely scarce in the south-central Andes.

3.2.3. Exchange between herders and farmers

Ethnographic accounts of the interaction between caravan drivers and agriculturalists may be colored by the comparatively low status of caravan drivers in modern circumstances. Among isolated agricultural valleys in prehispanic Andes caravan drivers likely represented an important link to both information and non-local products. As the owners of the means of transport and the initiators of long distance interaction, caravan drivers were in a strong position to influence trade negotiations with dedicated agriculturalists that did not have their own llama herds or did not have schedules that permitted them to undertake long voyages. Strong links and commitments between herders and particular agriculturalists are, then, in some ways against the interests of herders because in a market context they "held the cards" in terms of negotiating favorable conditions of exchange. From the perspective of regional economic interaction two principal groups that, as per Dillehay (1993: 253), largely complement one another and may result in a relatively stable political and social environment:

(1) Mobile herders with an economic focus on hunting, pastoralism, and who are limited in their scheduling by the needs of the herd and annual cycle caravans.

(2) Relatively sedentary agricultural communities, often with an animal husbandry component as well. These households are largely restricted in their scheduling and long distance travel due to the requirements of agriculture.

In this configuration the mobile herders have greater autonomy, but they depend on articulation with dedicated agriculturalists. The relationship between mobile pastoralists and sedentary agriculturalists in Old World contexts has been the subject of comparative study by Khazanov (1984: 198-227). One common pattern is for trade between nomads and sedentary society to be manipulated for political purposes by administrators and elites in the regional centers. In the fifteenth century, the Chinese state sought to regulate exchange with nomadic tribes occurring at trading posts on the frontier. A recurring pattern occurred where the Chinese government would attempt to control the nomads by restricting trade, and nomads would, in turn, "acquire the right to trade by using arms." (Khazanov 1984: 206). That is, if exchange was curtailed the nomads would resort to violent means as described by Levi-Strauss (1969: 67) and Sahlins (1972: 302) who note the link between exchange and warfare (Section 2.2.5).

In the Near East, nomads were in a more profitable position because often they were the essential link between isolated oases. While administrators may have sought to control nomads trading with their communities, the demand by farmers for the milk and meat products from nomads, and the transportation services offered by nomads, often placed the herders in an advantageous position (Khazanov 1984: 208). In the Andes, a similar pattern linked agricultural valleys like the Colca in the high sierra, the mid-altitudes, and perhaps the littoral, by way of camelid caravans, although by the Late Prehispanic it appears many valley communities had their own large herds pastured in the adjacent puna.

3.2.4. Types of products carried by caravans

Ethnographic and ethnohistoric accounts of the types of goods carried by llama caravans provides a context for discussing the volume of trade and spatial relationships in the prehispanic period. Nielsen (2000: 65-67) observed that caravan drivers transport virtually anything that they think they can transport and will be able to trade, and therefore the argument that certain caravans were transporting purely subsistence goods, while others carried purely prestige goods, is probably unfounded. Nielsen notes that as part of their diversification strategy, caravans in prehistory probably variously transported subsistence goods, cultural items, and prestige goods as they articulated with networks at different levels with a diversity of social associations.

Informative ethnohistoric evidence for caravan transport comes from reports describing the provisioning of the infamous silver mines at Potosí that are reviewed by Browman (1990: 408). These reports state that 40,000 llamas were reserved by Potosí for provisioning and another 60,000 were brought as support for indigenous workers fulfilling their tax obligations through labor. Although with these Potosí data it is difficult to extrapolate from the substantial transportation requirements for mining and ore milling, and the demands of the Spaniards overseeing the mining operations, to a conception of goods that may have circulated during prehispanic times, these data are informative on the variety of items mobilized for the mining effort. Goods included manufacturing items such as cloth, wool, wood and dung as fuel, and building supplies. Subsistence goods included potatoes and *ch'uno,* meat, maize and *chicha*, and various fruits and vegetables. Goods that could be classified as cultural / prestige items included herbs, medicines, stimulants including quantities of coca leaf, and hallucinogenics like *ayahuasca* (1990: 408).

In Mesoamerica, where cargo animals were not available, human bearers carried goods for hundreds of kilometers and canoe transport was used extensively. Drennan (1984: 110) observes that textiles may have represented a significant portion of the goods being transported long distance in the prehispanic period. Similarly, woolen textiles in the Andes were an important trade good for highland pastoralists and probably represented a substantial part of the goods offered for barter between pastoralist caravan drivers and agriculturalists from the beginning of the mutualistic relationship between pastoralists and agriculturalists. This demand for textiles would have been especially strong among agriculturalists living outside of the cotton-producing coastal area. The domestication of camelids for cargo transport sometime in the latter part of the Archaic allowed for more efficient transport of goods throughout the remainder of the prehispanic period. However, this is not to suggest that daily staples were transported, as in modern circumstances where fruits are trucked to the altiplano markets where they are bought for daily consumption.

3.2.5. Caravan travel distances and speeds

Ethnoarchaeological studies provide details on the more immediate decision making practices of caravan drivers including the daily routine, the rate of travel, and the scheduling of rest days. References in the ethnographic and ethnohistoric literature concerning to the velocity and capacity of llama caravans provides benchmarks for estimating the rate of travel in prehispanic times. There is some variability in the reported weights, speeds, and distances in the ethnographic and ethnohistoric literature (Bonavia 1996: 501-515).

Mode	Weight	Distance	Time	Reference
Caravan distance calculated by coca chews		3 km level, 2 km uphill	Approximately 40 min per "cocada", 6-8 per day.	(Zahm 1911: 180)
Llama	Up to 40-45 kg			(Tschopik Jr. 1946: 533)
Llama caravan (ethnohistoric)	75 - 100 lb loads (34.1 - 45.4 kg)	10-12 miles (16-19 km) / day		(Murra 1965: 185)
Llama caravan	25-30 kg (< 40 kg)	15-20 km / day	Ten hour marches. A long trip can last 30 days.	(Flores Ochoa 1968: 118, 130)
Llama caravan	Approximately 35 kg	25 km / day (150 km journey)	From 8-9am to nearly 4 pm, or 8 hrs per day	(Custred 1974: 277)
Llama caravan (ethnohistoric)		11 miles (17.7 km) / day	1 day: from daybreak to noon	(Murra 1980: 48)
Llama caravan	Approximately 25 kg	20-25 km / day	1 day: 7 am to 2-3 pm.	(Lecoq 1987: 8, 20)
Llama caravan	Approximately 25 kg	15-20 km / day	Journey: 2-3 months	(Flannery et al. 1989: 106, 115)
Llama caravan (ethnohistoric)		10-20 km / day	1 day: From dawn until early afternoon	(Hyslop 1984: 294-298, 302)
Llama caravan (model for long trips)	30 kg	20 km / day	6 days a week of travel	(D'Altroy 1992: 85)
Llama caravan		15-20 km / day	1 day: From dawn until early afternoon.	(Browman 1990: 403)
Llama: Lighter loads	25-35 kg	300-400 km journey	Journey: 2-3 months	(Browman 1990: 403)
Llama: Heavy loads	50-60 kg	Short distance	Short duration	(Browman 1990: 403)
Llama caravan (salt blocks)	23 kg	15-25 km / day	From 4-5am to 2-4pm, or 6-9 hrs/day, no stops	(Nielsen 2001: 169-176)

Table 3-1. Reported llama caravan loads, distances, and times.

Caravan drivers generally arise at first light and begin preparing for the journey and loading animals for an early departure. Caravans often travel until early afternoon when camp is established and the animals are allowed to graze. As camelids do not pasture at night (whereas *Equus* do) ample time must be provided for animals to feed during the afternoon in order to avoid stressing the animals (Nielsen 2000: 446-449). Rest days are taken regularly on caravan routes that exceed six days, with Nielsen (2000: 461) reporting one rest day for every three to five days of travel (c.f., Lecoq 1988: 185-186; T. L. West 1981a: 70). The top priority with respect to nightly campsite selection is the needs of the herd animals. Quality pasture is sought for the animals, the next priority is sufficient water, and additionally the emotional condition of the llamas is considered as reported the llamas can be restless in certain camps. Subsequently the needs of humans are considered including hunting opportunities, trade opportunities, and the comfort of the camp. Thus, while economic and social demands frame the larger scale decisions of caravan routes and products to transport for trade, the needs of the herd animals dominate in short term decision making (Nielsen 2000: 490).

Male llamas are larger and caravan animals are typically castrated males, based on some reports, but "left intact" according to others. Flores Ochoa (1968: 118), reports that castrated llamas produce better meat and wool, but non-castrated llamas make better caravan animals. According to most other reports caravan llamas are castrated because they are stronger and tamer, and this practice allows herders to manage mixed herds (Browman 1990: 398; Nielsen 2001: 168; T. L. West 1981a: 66).

Estimating travel velocity

A computer model for estimating travel speed based on topography, where velocity over a segment of trail is calculated as function of slope, could be derived using the function presented by Tobler (1993) for hiking and horseback riding (the source of cost paths shown in Figure 3-5). While these topography based calculations have serious limitations (Connolly and Lake 2006: 252-255), for general estimates over larger regions with measurable changes in terrain steepness these estimates are superior to the simple use of slope for estimating velocity. Such models would preferably be derived using original data from fieldwork, perhaps based on a contemporary study that takes into account the size and weight of the cargo animal, the amount and type of cargo, and the performance of the cargo animals based on trail conditions mapped using GPS receivers.

In the course of ethnoarchaeological fieldwork accompanying a llama caravan in Bolivia, Nielsen (2000: 449; 2001: 184) notes that there were differences in the going and returning portions of a 2-3 month caravan journey that had implications for the overall travel speed. The out-going trip involved visits with companions and a variety of rituals at propitious locations along the route. During the return journey, in contrast, no rituals were performed but the animals moved more slowly because they were carrying large loads of produce uphill from the eastern lowlands; and they had been traveling for months and reportedly their feet hurt. Thus the lack of ritual performance and visiting and bartering saved time, but the walking speeds were slower, breaks were longer, and layover rest days were more frequent and longer.

Evidence of relative travel distances in the region

In the Mantaro region of the central Andes, Earle (2001: 310) notes that long distance exchange (classified as taking place over a distance of 50 km or greater, to lands beyond those held by the local ethnic group), rarely includes staple items. During the Late Intermediate and Late Horizon, items that were found in the Mantaro area include items of metal and shell described as "wealth items", emphasizing the political nature of long distance exchange in this period.

While Colca valley obsidian was primarily conveyed throughout the Titicaca Basin during prehispanic times by unspecified groups, during the colonial period Colca valley polities are known to have been dominant caravan operators in the region. Residents of the Colca valley owned large camelid herds and they were responsible for extended caravan journeys to the altiplano during the Colonial period. Documentary evidence shows that the Collaguas from the main Colca valley initiated caravans to transport products, such as Arequipa wine to Cusco and Canas, and Colca corn to "wherever they would like to sell it" (Crespo 1977: 56). A testament to the role of the Collaguas, and the Colca valley in Arequipa more generally, comes from Toledo's (1924 [1570-1575]) *visita general* describing populations of Colca community members resettled as farmers in the new city of Arequipa, Yanahuara, and environs. Toledo states that these Collaguas *mitimaes* groups should produce wine in these lower-altitude areas for transport to Cusco and to the mines of Potosí in Bolivia over 700 km to the south-east (Málaga Medina 1977: 114).

3.2.6. Circuit mobility and role of the periphery

The circuit mobility model of Nuñez and Dillehay (1995 [1979]; Dillehay and Nuñez 1988) conceives of the development of regional interaction in the south-central Andes in terms of decentralized "circuits" traveled by regular camelid caravans. This articulation between far-flung communities is envisioned as beginning in “Late Archaic” (rather, during the “Terminal Archaic” using the terminology in this dissertation) and Formative times.

> Herder-caravan societies moved in fixed spiral-like transhumance paths between two or more axis settlements either along a puna-to-puna vector, a puna-to-coastal vector, or a puna-to-selva vector… Continuity and stability was given to the circuit herder-caravan movement by settlements at both ends of its pathway. For this movement to have maintained equilibrium, its pathway must have been balanced by relatively homogeneous, fixed axis settlements which offered multiple resources and services from their particular ecological zone and by ferias (or fairs) where goods were exchanged (Dillehay and Nuñez 1988: 611).

This historical model is of importance here because it highlights the limitations of a core-periphery focus for addressing certain regionally distributed processes like the emergence of control over regional exchange routes during the Formative in the Lake Titicaca Basin (Nielsen 2000: 88-92; Yacobaccio et al. 2002: 171-172). In models of Late Formative complexity in the Titicaca Basin presented by Browman (1981a) and, to a lesser extent, Kolata (1993: 274), caravans and long distance trade play a prominent role. In Browman’s formulation, the core areas of regional centers became increasingly powerful due to craft specialization guilds and other institutions that reached their apex at Tiwanaku, albeit many of these expectations for guilds have not been borne out in more recent research (Isbell 2004: 216; Rivera Casanovas 2003). Kolata holds it was the productivity of raised-field agriculture that formed the principal economic mechanism behind Tiwanaku’s florescence, with caravan based articulation being a secondary component. Both scholars emphasize the dominant position of the core areas of regional centers, a position that on a regional scale was ultimately attained by the Tiwanaku state. In contrast to these models that emphasize centralization, the Nunez and Dillehay model holds that it is integration by way of caravan trade routes themselves, and that these routes developed into “leading circuits” when they served to connect important centers. Further, as traditions became established, the relationships between circuits and principal settlements along these routes provided temporal continuity and stability to a system that is otherwise fluid and mobile. Their model gives more autonomy and influence to this integrating, caravan-based element in society such that “the sedentary (or axis) settlements of the population were maintained (and often created) and controlled by the mobile sectors.” (Dillehay and Nuñez 1988: 621).

This model also contains weaker points, such as an adaptationalist underpinning for the origins and incentives for participation in these caravan exchange networks, and the model ascribes the emerging dominance of Titicaca Basin centers as resulting from their environmental characteristics. The system is described as “harmonious and cohesive” (Dillehay and Nuñez 1988: 620) as caravans are used to efficiently spread patchy resources over a wider region. The adaptationalist interpretation of harmony is based on a lack of archaeological evidence for warfare in the Formative, with the Andean tradition of reciprocity serving as the cohesive force. Further, the system segregates discrete “highland” and “lowland” communities, while archaeological evidence supports a gradient with no clear demarcation.

A more current theoretical orientation for this model would focus on the motivations of traders, the influence of non-local goods in axis communities, and the status acquired by caravanners based on the importance of their role on a regional scale. The emergence of this distinctive, dispersed economic form that appears simulatenously with beginnings of social inequality during Terminal Archaic and

Formative may shed light on the underpinnings of social inequalities that developed during the Formative. Further, a greater exploration of the strategic relationship between aggrandizers in Titicaca Basin regional centers and these long distance traders may provide evidence for how the first elites in early polities were able to coordinate labor and garner resources from the region. Despite the historical and adaptationalist focus, the Nuñez and Dillehay model brought a focus on the role decentralized networks in connected emerging settlements that grew to have regional influence. This emphasis on the mobile sector of society highlights the potential influence in both resources and political support that could come from second-tier communities dispersed across the large expanses of the altiplano in the political strategies of early elites in Titicaca Basin centers.

3.2.7. Compadrazgo relationships and commerce

A trade relationship termed *compadrazgo,* or simply *conocidos,* is reported between regular trade partners; typically between those who live in complementary ecological areas (Browman 1990: 404-405; Flores Ochoa 1968; Nielsen 2000: 437-438; 2001: 182-183; but see Love 1988: 95). For example, if a llama caravan driver from a particular area of the puna and a farmer in a mid-altitude valley with a variety of products have regularly exchanged goods over the years, and then they teach their children of the relationship using fictive-kin terms; a tradition of mutualism is established between herder and farmer that can potentially last for generations. The relationship offers stability and predictability to both sides of the exchange in barter rates, types of goods, and quantities to be exchanged.

The nature of this encounter is critical to understanding Andean reciprocity relationships and the degree of alienability of goods being exchanged (Burchard 1974; Mayer 1971). As mentioned above, the caravan driver has mobility and choices in terms of travel routes and communities where to partake in exchange. The maintenance of long term exchange partners through *compadrazgo* is therefore a constraint on caravan autonomy. Two characteristics of *compadrazgo* relationships appear to underscore the embeddedness of the interaction:

(1) Patio exchange

Information exchange concerning the relative barter values for goods are subsumed by the intimacy of the exchange context. In ethnographic accounts of exchange the negations occur predominantly in the privacy of domestic patio areas, and not in a public forum, such as a marketplace, where prices and equivalencies are public knowledge (Humphrey and Hugh-Jones 1992).

(2) Temporality of caravan travel

Caravan travel involves negotiating long distances with unforeseen delays. Due to the difficulty in scheduling encounters between caravans as highly mobile segments of the population, settled villages probably served as important nodes in the fluid regional interaction network (Dillehay and Nuñez 1988). The manner in which these temporal factors intersect with the diachronic nature of reciprocal exchange is counter to the synchronic expectations of establishing immediate, market-based equivalences for goods.

When caravan drivers do not have established trade partners in a settlement they may initiate a new trade relationship with unknown partners upon entering the community. Casaverde Rojas (1977: 177) describes how women in Cabanaconde, in the lower Colca valley, would besiege the first caravans to arrive seasonally at the village entrance with offers. The women would attempt to establish trade partner relationships by negotiating favorable terms for agricultural goods and a place to corral the caravan animals in exchange for labor and pastoral products. Nielsen (2001: 183) states that when market prices fluctuate then contemporary caravanners in Oruro, Bolivia, will sometimes avoid established trade partners in order to better pursue profit opportunities with the greater variety offered by modern market forces; the *compadrazgo* institution seems to be waning. As Danby (2002) and M. E. Smith (2004) both argue, commercialization and alienability of products in all ancient economies should perhaps best be considered in terms of degrees and not in absolutes.

Yapa and over-reciprocation

Barter relationships are often cemented with a *yapa:* a little bonus given to the buyer that takes the form of an over-reciprocation to assure future transactions (Browman 1990: 421; Sahlins 1972: 303). The magical powers attributed to the *yapa* notwithstanding, Sahlins' (1972: 308-314) develops a functional economic explanation for over-reciprocation where it serves a similar mechanism to price fluctuations in market-based societies. When an over abundance of product A relative to product B exists in a barter situation based on traditional equivalencies (hence, a lower value for A may result, in a market system), the provider of product

A may over-reciprocate and thus, based on the morality of reciprocal arrangements, guarantee future compensation from the trade partner.

> The primitive trade partnership is a functional counterpart of the market's price mechanism. A current supply-demand imbalance is resolved by pressure on trade partners rather than exchange rates. Where in the market this equilibrium is effected by a change in price, here the social side of the transaction, the partnership, absorbs the economic pressure. The rate of exchange remains undisturbed – although the temporal rate of certain transactions may be retarded (Sahlins 1972: 311).

The discrepancy that must be resolved synchronically in neoclassical market economics is resolved diachronically in reciprocal arrangements (Danby 2002). Browman (1990: 421) does not believe the over-reciprocation device described by Sahlins is in evidence in the Andes. As Browman observes, there is ethnographic evidence that suggests that barter rates do, in fact, fluctuate in response to supply and demand. The arrangement described above is one possible configuration that occurred in prehistoric circumstances, however, and it is a possible means of assuring the long term persistence of exchange relationships (Burchard 1974; Mayer 1971).

Seasonal fairs and the temporality of caravans

If seasonal fairs and aggregations were a feature of the prehispanic altiplano, as discussed by Browman (1990), interactions may have taken notably different forms in those contexts. Seasonal fairs may have had the significance of religious festivals in the contemporary Andes where the devout sometimes travel for weeks in order to arrive at auspicious times. Fairs and cultural occasions may, then, have been blended with economic transactions.

Scheduled festivals with elaborate dances, music, and costumes are a major cultural contribution in contemporary altiplano communities like Paratía (Flores

Ochoa 1968) and despite the lack of simple material correlates for archaeological study, cultural items like song and dance were probably significant features in a variety of prehispanic reciprocal exchange contexts (J. Flores Ochoa 2005, pers. comm. July 2005). Despite the relative marginalization of altiplano cities in the modern economy (or perhaps a reflection of this marginalization), traditional festivals endure as important cultural features in the Titicaca Basin. Citing early twentieth-century sources, Browman (1990: 409) reports that at major shrine at Copacabana, Bolivia, between 40,000 and 50,000 "traders" would converge at times scheduled to coincide with ceremonies at the shrine.

If economic transactions occurred in association with these festivals in prehispanic times, either as a central feature or relegated to the periphery of the cultural events, the transactions may have assumed certain characteristics of marketplace exchange. These characteristics would have included public knowledge of barter equivalences and perhaps more immediate, synchronic exchange due to the short time period of convergence at the festival. As mentioned, however, marketplace concentrations do not necessarily imply true "market economies" with fluctuating prices reflecting supply and demand (LaLone 1982). Assuming that economic transactions that may have occurred at these fairs did not create moral conflict (by debasing sacred ceremonies with lowly economic transactions, in a Euro-American perspective) they would have created an excellent context for the transfer of both cultural goods and prestige items, and for the control of certain exchange practices by administrators or elites. Nevertheless the problem remains that dedicated agriculturalists with harvest goods for exchange would have been absent from these fairs on the altiplano because dedicated agriculturalists would not have the schedule or the herd demographics that would have permitted them to initiate long distance caravans. Therefore a variety of strategies probably developed to allow the transfer of products with the emergence of caravans that traveled, on the large scale, according to schedules dictated by seasonal gatherings, harvest schedules, and other economic and cultural circumstances. These developments imply the emergence of something of a continuum between the more alienable exchange that occurred in seasonal gatherings, and more inalienable barter that occurred in the intimate exchange context of *compadrazgo* relationships.

3.2.8. Discussion

The environmental and cultural context of the south-central Andean highlands framed the circumstances in which emerged the long distance traffic in various products during the prehispanic period. The domestication of camelids sometime in the past 6000 years allowed for more efficient transport of bulky goods. There remain many unknown aspects to the network that articulated dedicated agriculturalists with pastoralists in the prehispanic past, however archaeological and ethnographic evidence allows for inference regarding the following major points:

(1) *Network configuration.* Products available by ecozone were transported in numerous, segmentary articulations between ecozones while other products, only available in a few locations, were apparently conveyed diffusively and were between transported ecozones and across homogeneous terrain like the altiplano (Figure 3-4).

(2) *Motivations for change in mode of interaction.* The domestication of animals and plants, changes in sedentism, and the development of social inequalities were

some of the factors that contributed to development of long distance caravans. It is evident that the original modes of interaction: Direct acquisition and down-the-line exchange, were supplemented by household organized caravan trade, and finally administered caravan trade, but the timing of these changes is difficult to establish with precision.

(3) *Means of trade.* Features of the Andean barter economy such as enduring trade relationships between households in complementary zones cemented by institutions like over-reciprocation and fictive kinship, are well demonstrated ethnographically in the region. However, seasonal market-like gatherings are also reported in the region and exchange of goods in those contexts may have been more alienable, and transactions may have been more synchronic in nature. Such gatherings may also have had evolutionary significance because they potentially relate to the development of early leadership in regional centers including ceremony, feasting, the use of monumental architecture, and centralized control of trade in certain goods.

The persistent themes in mountain agropastoral settings of non-autarkic economies and risk reduction through mixed subsistence strategies serve as a reminder that variability was probably the rule in exchange relations as well. Absolutes in exchange patterns were probably rare, and a degree of both self-interested trade and elements of embedded, social and symbolic fraternity likely existed between trade partners since early antiquity. While a number of plausible models have been proposed for the later Prehispanic periods where both household-level and elites-administered trade caravans appear to have transported a variety of goods in the region, the initial contexts for caravan trade remain largely unexplained. These initial contexts are particularly important because this mode of organization contributed to the regional context and institutional base in which early leaders in the Titicaca Basin had to operate in order to begin the process of expanding their influence in access to labor, resources, and ideology of their communities.

If enduring regional interaction had persisted since the early days of the pastoral economy during the preceramic, this may be connected to the factors that lead to an increasing consolidation of power in the Titicaca Basin during the Formative Period. These questions are central to understanding the foundations of regional integration that emerged in the Lake Titicaca Basin during the Middle and Late Formative Periods. The above discussion has sought to elaborate upon a possible context for early household-level caravan organization that is principally based on the "circuit mobility" model of Nunez and Dillehay (1995 [1979]; Dillehay and Nuñez 1988) but without following the adaptationalist approach, and with more specific empirical contexts for early caravans. In the ensuing discussion of obsidian procurement and circulation in the south-central Andes existing evidence from obsidian circulation in the region is presented that provides the context for examining obsidian production in more detail.

3.3. Regional patterns and major sources of obsidian

Sources of tool-quality obsidian occur in discrete locations along the Western Cordillera in the south-central Andes. The spatial pattern of obsidian sources in southern Peru, spaced at an interval of approximately 100-300 km along an arc trending north-west to south-east, is evident from maps of these source distributions.

It is volcanic processes at a continental scale that have resulted in emplacement of obsidian at 3000 and 5000 meters above sea level. As will be discussed in more detail in Chapter 4, obsidian sources appear to be regularly spaced paralleling the spine of the Western Cordillera, however geologists believe that "the complex tectonic and lithospheric variables at continental subduction zones preclude the development of any regular pattern of volcano spacing" (Clapperton 1993: 77-80). Nevertheless, volcanoes do occur at major crustal fractures and at fracture intersections.

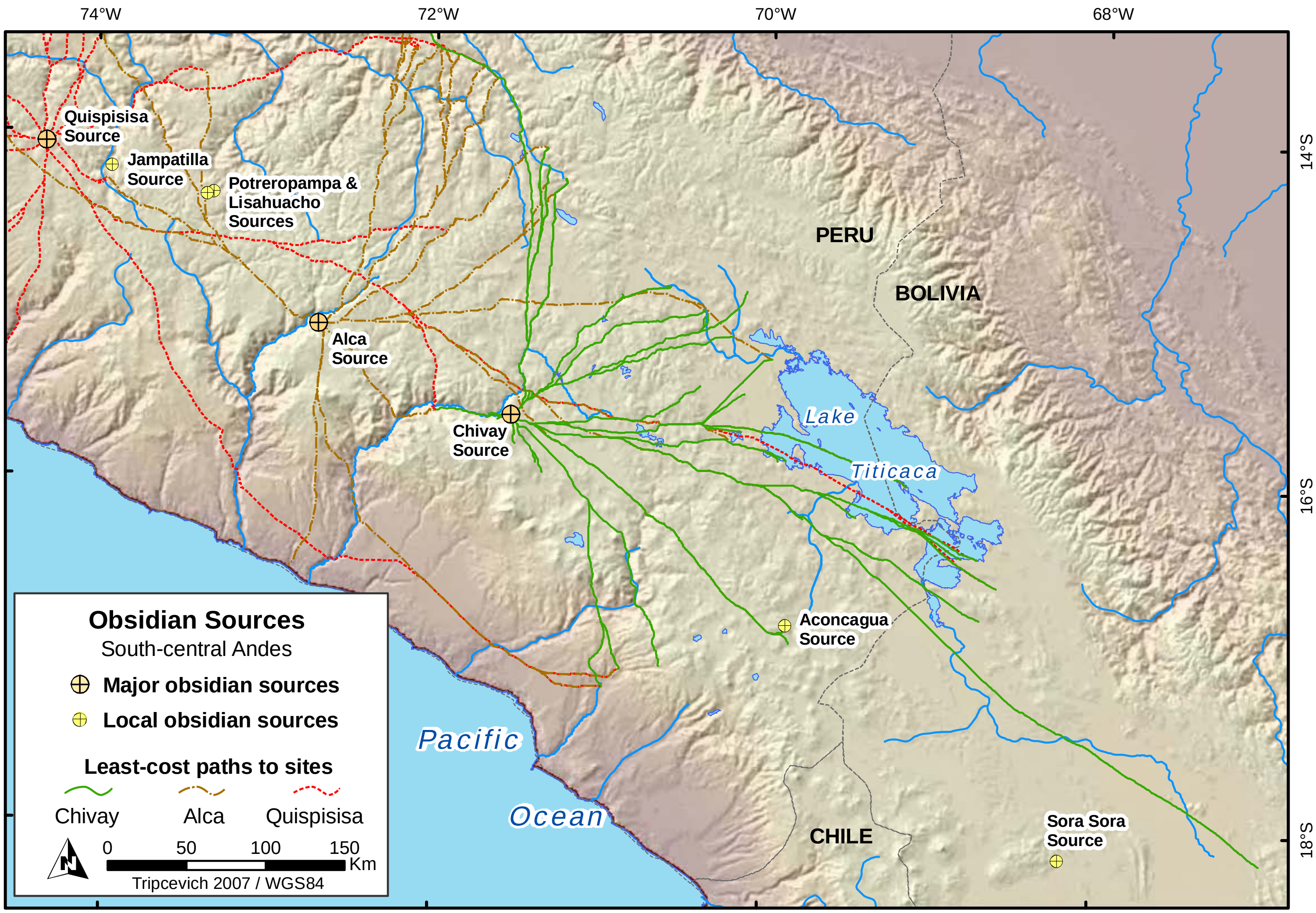


Figure 3-5. Known south-central Andean obsidian sources used in prehistory with least cost paths (Tobler's function on SRTM DEM data) from the three major sources to sites in the region.

In the prehispanic central and south-central Andes obsidian from three sources dominated the archaeological use of this material, followed by obsidian from a number of minor, local sources that were only used for tool production in the area of geological origin (Figure 3-5). Finally, there were countless sources of geological obsidian that were used negligibly, or not at all, by humans apparently due to the undesirable attributes of the glass. Outside of the study region, additional major Andean obsidian sources have been studied to the south in northern Argentina and surrounding terrain (Yacobaccio et al. 2002; Yacobaccio et al. 2004) and to the north in Ecuador (Burger et al. 1994; Burger 2003).

The three most widely-circulated obsidian sources in Peru and north-west Bolivia are the Quispisisa, Alca, and Chivay types, and these three types will be investigated here in more detail. Burger et al. (2000: 348) argue that it is the large nodule size and the homogeneity of the glass that is the primary determinant of how widely obsidian was circulated in prehistory and by these criteria these three sources are exceptional in the Andes.

In the course of this research a relational GIS database has been assembled using published data on obsidian sourcing in the south-central Andes (primarily from evidence in Burger et al. 2000; Craig 2005: 908-916; Frye et al. 1998; Giesso 2000) and using these data a few summaries have been generated for the purposes of this study. The trends in these data show broad patterns in the use of obsidian by chemical type, but given the early stages of this kind of research, these values also reflect a sampling bias based in the history of research and the collections available for sampling. With further development of sourcing technologies, including the more widespread use of portable XRF units, obsidian from a wider variety of sites will be characterized in coming years.

Type	Samples	Sites	Ave. Distance (Km) *	Ave. Time (Hrs) **	Max. Distance (Km) *	Max. Time (Hrs)**
Chivay	531	48	171.0	40.0	553.6	120.8
Alca	305	50	249.6	66.0	988.7	260.7
Quispisisa	525	63	260.3	66.7	846.7	208.5

Table 3-2. Three major Peruvian obsidian sources showing average and maximum distances and times. * based on straight-line distance measure, ** Least-cost path walking time based on Tobler's (1993) hiking function.

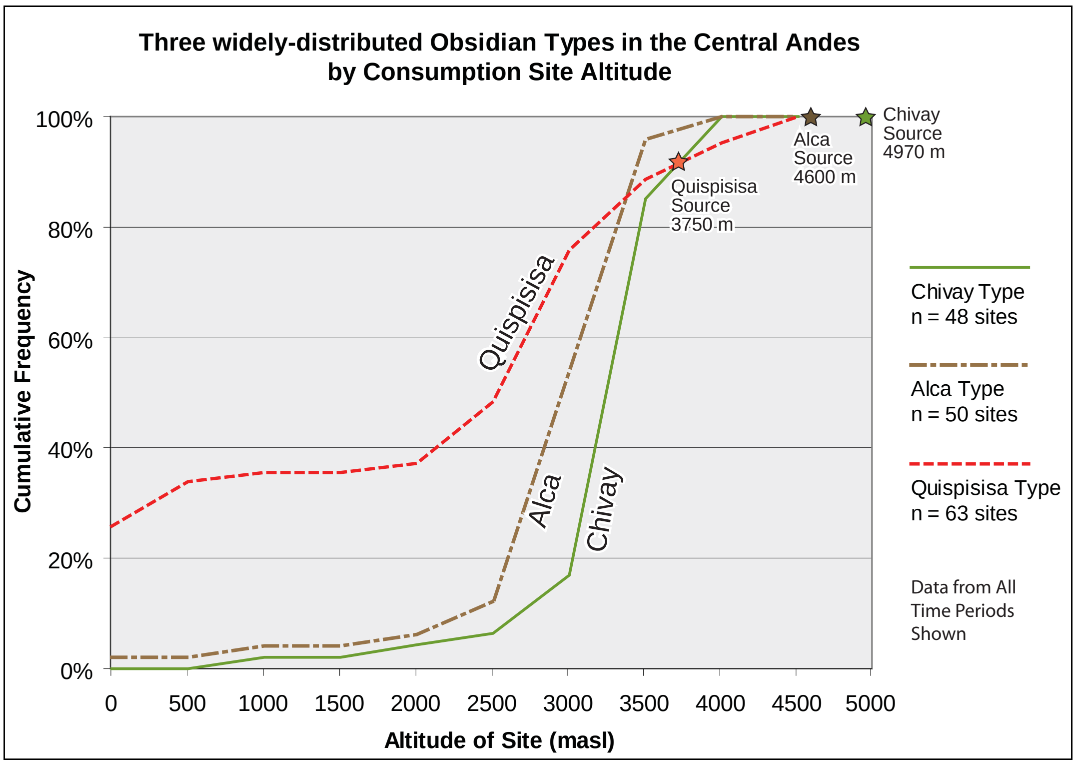


Figure 3-6. Cumulative frequency graph showing three major Peruvian obsidian sources by consumption site altitude.

As will be discussed below, the dominant pattern that has emerged for both the Chivay and the Alca obsidian types is one of highland interaction. Throughout the prehispanic period, artifacts of Chivay obsidian have never been found below an altitude of 1280 masl, and that was in the context of a Tiwanaku colony, at the site of Omo in Moquegua (Burger et al. 2000: 338; P. S. Goldstein 1989). Alca type obsidian artifacts are similarly found mostly at high altitude; the coastal Quebrada Jaguay paleoindian finds are anomalous for Alca distributions. The next lowest altitude context for Alca is also at Middle Horizon Omo. Quispisisa, on the other hand, is commonly found at coastal sites from the Nasca area and northward, beginning with a strong representation at the cotton preceramic site of San Nicolas (Burger and Asaro 1978; Vaughn 2005a).

One possible explanation for the lack of Chivay and Alca obsidian in low elevation contexts is that camelid caravans were less common in the low elevation coastal areas of southern Peru and northern Chile. While there is strong evidence of camelid corrals in northern coastal Peru (Shimada 1982), the examples of pastoral sites in the coastal areas of the south-central Andes are rare. Stanish (1992: 57) states that there no sites with corrals below 1,500 masl in the Moquegua drainage, and he presents other evidence for the scarcity of pastoral sites in southern coastal Peru. However, Wheeler et al. (1995) examine the remains of 26 camelids, both llamas and alpacas, at the Chiribaya site of El Yaral at 1000 masl in Moquegua. Moving northward in the Pacific coastal drainages, both Christina Conlee (2000) and Kevin Vaughn (2005b) report evidence of domesticated camelids at low altitude in the Nasca area. Vaughn (2005b: 92) describes a corral-like structure at the site of Marcaya at 1000 masl. As mentioned, the Nasca zone is rich in Quispisisa obsidian. A variety of factors may have contributed to the pattern of Quispisisa obsidian consumption on the coast and Alca and Chivay consumption in the highlands including the greater breadth of the altiplano in the Titicaca Area, the position of geological source relative to the coast, and the severe aridity in the Atacama area of southern Peru and northern Chile.

3.3.1. Obsidian and larger geographical associations

The specific cultural and temporal associations of these distributions are explored in a series of publications by Richard Burger, particularly in Burger et al. (2000). There appear to have been two overarching geographical associations that cut across the various distributions of obsidian in space and time.

Availability, demand, and mobility

Chivay was largely conveyed into the Lake Titicaca area by Titicaca Basin communities and polities that were organized around the lake and the adjacent broad altiplano. For sites in the Lake Titicaca Basin, the database shows that 453 obsidian artifacts have been sampled from all time periods, and 408 (90%) of the samples were of the Chivay obsidian type. Another interesting aspect to this pattern is that the proportion of Chivay obsidian holds true for the north Titicaca Basin as well as the south when the two areas are considered separately. Using Bandy's (2005: 92) division of the Titicaca Basin where the site of Camata and northward are considered the North Basin, and with the South Basin extending as far south as Khonkho Wankane and south-west to Qillqatani, all obsidian samples in the region were aggregated from the entire prehispanic period. The LIP site of Cutimbo, though slightly south of Camata, was joined with the North Basin sites while Incatunahuiri and the Ilave valley sites were counted with the South Basin.

	Samples	Sites	Chivay Type		Alca Type		Other Types	
North Titicaca Basin	284	16	261	91.9%	20	7.0%	3	1.1%
South Titicaca Basin	231	13	205	88.7%	5	2.2%	21	9.1%
Total	515	29	466	90.5%	25	4.9%	24	4.7%

Table 3-3. Obsidian in the north and south Titicaca Basin by counts and percents.

These patterns reveal that Chivay obsidian accounts for approximately 90% of obsidian from the Titicaca Basin, with a greater presence of Alca obsidian in the North Basin. It seems that the presence of obsidian from alternative sources, whether it was the Tumuku source (still unlocated) or other obsidian sources further to the south, counter balances the access to Alca type in the North Basin. This pattern, with heavy use of Chivay obsidian in the South Basin, reflects overall integration in the Titicaca Basin through prehistory as well as the lack of high quality obsidian sources with large nodules south of the Chivay source, until one arrives at the Zapaleri source close to the frontier of Bolivia, Argentina and Chile, located 700 km to the south of Lake Titicaca (Yacobaccio et al. 2004: Fig. 1). It has been noted that, in cultural terms, the Chivay distributions are especially linked to areas integrated by the Tiwanaku state, the Pukara polity, and with their predecessors: the Middle Formative communities linked by Yaya-Mama stylistic features (Burger et al. 2000). However, what is particularly compelling about the evidence from obsidian is that these social and economic links in obsidian exchange appear to predate the cultural-stylistic links and become defined in the Terminal Archaic roughly 1000 years earlier than regional evidence of the Yaya-Mama stylistic attributes that first appear at Chiripa in the southern Lake Titicaca Basin.

The distribution of Alca material is confined by the availability of Quispisisa on one side and Chivay on the other, but nevertheless Alca obsidian was transported the furthest with material during the Middle Horizon being conveyed as far as the Wari sites of Huamachuco and Marca Huamachuco near Cajamarca (Burger et al. 2000: 336). Alca material was also transported the furthest distance at an early date, as it was conveyed 769 km to Chavín de Huantar during the Early Horizon where it was found in both elite and commoner contexts (Burger et al. 2000: 313-314). Quispisisa predominates in Wari assemblages but it also circulated widely before the Middle Horizon, such as the 589 km to Chavín de Huantar during the Early Horizon.

Terrain adjacent to source

The altitudes of obsidian consumption sites (Figure 3-6) also reflect the terrain adjacent to each of the sources. The Quispisisa source is in an area with deep river valleys and a number of the sites sampled are from lower elevation or coastal contexts. The Alca source is similarly close to deep river valleys, but it also borders the altiplano and the much of the Alca samples came from the highlands of the Department of Cusco. The Chivay source is on the periphery of the broad altiplano and with no major altitude loss it was possible to transport material to a variety of sites that include Pikicallepata to the northeast and Qillqatani to the southeast. Further detail on these obsidian distributions are described below, and are published elsewhere (see articles by Burger, especially Burger et al. 2000; as well as Craig 2005: 908-916; Frye et al. 1998; Giesso 2000).

3.4. Chivay Obsidian Consumption Contexts

Archaeological research conducted at four sites in the south-central Andean highlands, the consumption zone for Chivay obsidian, provide evidence for the changing use of Chivay obsidian over long time periods. This section will begin by focusing on the four sites because they important here as the sites have provided stratified evidence of obsidian consumption during the Archaic and Formative in well-dated archaeological contexts. This review of the sites will be relevant in subsequent discussions of change in obsidian use over time in the region, and for interpreting activities at the Chivay source.

3.4.1. Asana

The site of Asana is at 3435 masl in the Osmore drainage of Moquegua, and it lies 185 km or 50 hours by the hiking model to the south-east of the Chivay source. Excavations at Asana were directed by Aldenderfer (1998b: 76-80) between 1986 and 1991 and in the lower levels of the deeply-stratified site obsidian was found in low concentrations.

Titicaca Chronology (BCE)	^{14}C yr bp	Lab Code (Beta-)	Cal. BCE	^{14}C Sample Provenience	Obsidian Provenience	Obsidian Type	Obsidian Artifacts
Early Form. 2000-1300	3640±80	23364	2300-1750	II (sup), TU1	II	Aconcahua (visual ID)	n=3, 0.4%
Late Archaic 5000-3300	6040±90	24634	5210-4720	XIVb, I25b	XIV		n=1, 2%
Middle Archaic 7000-5000	6550±110	24629	5680-5300	XVIIa, G24b	KF4a: J29D-8; XVIIA	Chivay	
	6550±110	24629	5680-5300	XVIIa, G24b	KF4b: J29D-8; XVIIA	Chivay	
Early Archaic 9000-7000	8620±110	47057	8200-7450	PXIX, P38b			
	8780±90	43920	8250-7600	PXX, V51a	KF5: F28D-5; PXXi	Chivay	
	8720±110	33303	8250-7550	PXXI, R43c	KF6: P38D-W; PXXI	Chivay	
	8720±110	33303	8250-7550	PXXI, R43c	KF2: W41A-4; PXXII	Chivay	
	8720±120	43922	8250-7550	PXXIII, X36c			
	8720±110	35599	8250-7550	PXXIV, T34a			n=11, 0.36%
					KF3: T42B-7;F28D-5	Chivay	n=1, 0.08%
					KF1: U41D-6; PXXV	Chivay	
	9820±150	40063	9900-8700	PXXXIII, S38c			

Table 3-4. Asana obsidian samples, collections, and associated ^{14}C samples by level (from Aldenderfer 1998b: 131, 157, 163, 209, 268; Frye et al. 1998).

These data from Asana show that low frequencies of Chivay obsidian occurred regularly through Early and Middle Archaic levels at the site despite the presence of high quality cherts nearby, and low quality obsidian from the Aconcahua source located about 50 km away. During the Late Archaic, obsidian disappears from the site and in a level that is transitional between the Terminal Archaic and Early Formative, obsidian returns in the form of lower-quality Aconcahua material. These data will be discussed in more detail below as obsidian use is explored by time period.

3.4.2. Qillqatani rock shelter

The rock shelter of Qillqatani[3] is at 4400 masl along the Río Chila to the southwest of Mazo Cruz, and it is 221 km or 50.3 hours walking time, by the hiking model, across the puna from the Chivay obsidian source. Qillqatani lies on the southwestern perimeter of the Lake Titicaca Basin in the headwaters of the *río*Huenque drainage in the Department of Puno, and it is not far from the headwaters of the Osmore drainage on the western slope in the Department of Moquegua. The shelter has a strong pastoral component, but excavations revealed occupations dating back to the Middle Archaic. The shelter is also known for elaborate rock art panels. Qillqatani was excavated in 1990 by Aldenderfer in two adjacent blocks, labeled East Block and West Block (1999c; 2005; in press). The East Block measured 20 m^2 in horizontal extent, while the West Block measured 60 m^2.

[3] Also known as "Quelcatani"

(a) Titicaca chronology, calibrated dates	(b) Qillqatani periods, calibrated dates	(c) Uncalibrated ^{14}C dates in r.c.y.b.p.	(d) Qillqatani provenience of obsidian	(e) Obsidian sample	(f) Block
LH AD1476 – 1532	LH 1476 – 1532 WIII / EIII	Level D11d-507/WIII: 400±50bp (B118156)			
LIP AD1100 – 1476	LIP 1100 – 1476 WIV – WV / EIV		H12C-3; WV; LIP	Chivay	West
Tiwanaku Horizon AD400 – 1100	Tiwanaku AD 500 – 1100 WVI – WVII / EVI	Level D9a/F7/WVIII: 2210±60bp (B93354)	E9A-5; WVII; F-3	Aconc.	West
			E6A-4; WVII	Chivay	West
	Late Formative 400 BCE – AD500 WVIII – WIX / EVII – EVIII		D6C-8; WX; F-5; 1.45	Chivay	West
Late Formative 500 BCE – AD 400			D9A-8; WX; F-5; 1.45	Chivay	West
			G13A-10; WX	Chivay	West
			G13A-10; WX	Chivay	West
			D6C-9; WXI; F-6; 1.6	Chivay	West
			H12D-10; WXI; F-12; .75	Chivay	West
			H12D-10; WXI; F-12; .75	Chivay	West
			I12D-8; WXI; F-13; 2.00	Tumuku	West
	Formative C 900 – 400 BCE WXII – WXIV / EIX – EXIV	*East Block dates* Level D25d/F10/EVI: 2210±50bp (B93355) Level F23a/F4/EXI: 2620±60bp (B93357) *West Block date* Level G7c-513/WXII: 2550±80bp (B43924)	E25B-10; EIX; F-7	Chivay	East
Middle Formative 1300 – 500 BCE			D25D-6; EIX; F-7	Chivay	East
			D26B-10; EXI; F-12	Alca	East
			F23B-11; EXI; F-3	Chivay	East
			F24B-9; EXI; F-13	Aconc.	East
			D6D-11; WXIII; F-8; .75	Chivay	West
			F11A-3; WXIII; 1.65	Chivay	West
			D26D-13; EXIV; F-10	Tumuku	East
			D26C-13; EXIV	Chivay	East
			D26C-13; EXIV	Tumuku	East
	Formative B 1500 – 900 BCE WXV – WXIX		D8C-12; WXVIII; F-11	Chivay	West
			D8C-12; WXVIII; F-11	Chivay	West
			G7D-11; WXVIII; 5.5	Chivay	West
Early Formative 2000 - 1300 BCE		Level D6/F7/WXVI: 3000±70bp (B43929)	E9D-12; WXVIII; F-9	Chivay	West
	Formative A 2000 – 1500 BCE WXX – WXXIII	Level D6a-522/WXIX: 2940±70bp (B43925)	E6C-14; WXX; F-7; 1.4	Chivay	West
			E9A-15; WXX; 2.4	Chivay	West
			H13A-15; WXX; 4.6	Chivay	West
Terminal Archaic 3300 - 2000 BCE	Terminal Archaic 3300 – 2000 BCE WXXIV	Level F9a-532/WXXIV: 3660±60bp (B43926)	F28B-19; WXXIV; HF-1	Chivay	West
			F28B-19; WXXIV; HF-1	Chivay	West
			F28B-19; WXXIV; HF-1	Chivay	West
			G9E-19; WXXIV; 98.70	Chivay	West
			G9E-19; WXXIV; 98.20	Chivay	West
			G10B-20; WXXIV; HF-2	Chivay	West
Late Archaic 5000 - 3300 BCE	Late Archaic 5000–3300 B.C.E WXXV–WXXIX	Level E9d-541/WXXX: 5620±120bp (B43927)	E9D-18; WXXX	Chivay	West
Middle Archaic 7000 - 5000 BCE	Middle Archaic 7000–5000 B.C.E WXXX – WXXXVI	Below level WXXX: 7100±130bp (B18926) 7250±170bp (B18927)	FAC-25; WXXXIV	Source unknown	West

Table 3-5. Qillqatani excavation levels, radiocarbon dates, and obsidian samples. (a) Titicaca chronology, (b-c) levels and ^{14}C dates from Qillqatani, all dates are on charcoal and were analyzed by Beta Analytic, from Aldenderfer (1999c). (d-f) Obsidian from Qillqatani chemically provenienced at MURR from data presented by Frye, Aldenderfer, and Glascock (1998), with "Tumuku" type replacing reference to "possible Alca-2", and Aconcahua type abbreviated to "Aconc."

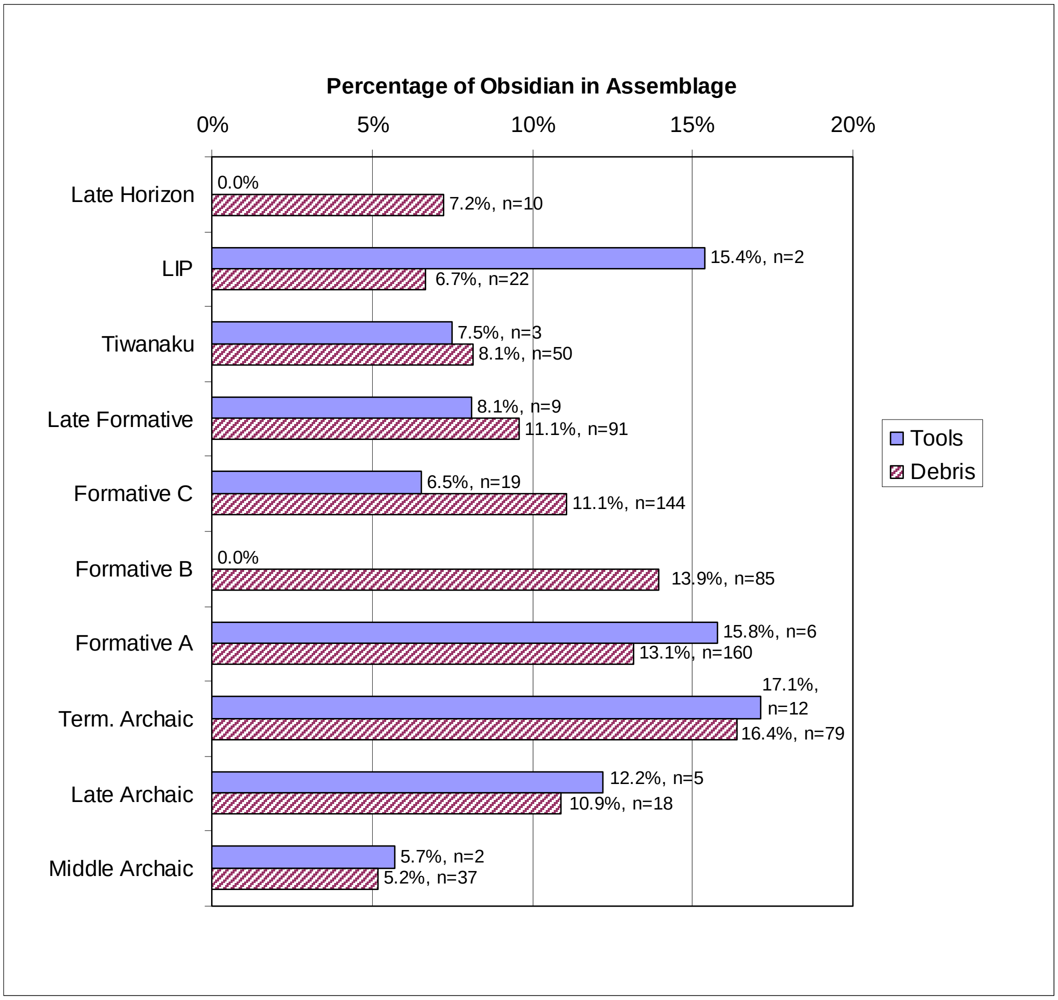


Figure 3-7. Qillqatani data showing percentage of bifacially flaked tools and percentages of debris made from obsidian per assemblage by count (from Aldenderfer 1999c, in press).

	TOOLS					DEBRIS				
	Obsidian		Non-Obsidian			Obsidian		Non-Obsidian		
Qillqatani Period	*No.*	*Ave Wt.*	*No.*	*Ave Wt.*	*Total*	*No.*	*Ave Wt.*	*No.*	*Ave Wt.*	*Total*
Late Horizon AD1476–1532			13	0.84	13	10	0.68	128	1.57	138
LIP AD1100–1476	2	0.75	11	3.35	13	22	0.46	308	1.81	330
Tiwanaku AD500–1100	3	0.80	37	1.49	40	50	0.54	565	2.23	615
Late Formative 400BCE–AD500	9	0.84	102	2.19	111	91	0.47	859	2.19	950
Formative C 900–400 BCE	19	1.21	272	2.44	291	144	0.46	1157	1.39	1301
Formative B 1500–900 BCE			2		2	85	0.58	525	1.73	610
Formative A 2000–1500 BCE	6	0.93	32	1.49	38	160	0.53	1057	1.37	1217
Term. Archaic 3300–2000 BCE	12	0.99	58	3.00	70	79	0.79	403	1.79	482
Late Archaic 5000–3300 BCE	5	1.57	36	3.57	41	18	0.56	147	1.78	165
Middle Archaic 7000–5000 BCE	2	0.20	33	7.26	35	37	0.60	674	2.76	711
Total	58	1.05	596	2.87	654	696	0.55	5823	1.84	6519

Table 3-6. Qillqatani periods by tools (bifacially flaked) and debitage (all other lithics), in obsidian and non-obsidian categories.

Excavations in the two blocks at Qillqatani revealed a switch from hunting and gathering to a predominantly pastoral economy between the occupation in level 25, and that of level 24 that was stratigraphically superior (Aldenderfer 2005: 20; Craig 2005: 179-180). The occupation in Level 24 appears to have been the first residential occupation, and it is considerably thicker than were previous levels that appeared to have been logistical in nature. The ovoid structures of Level 24 are slightly larger and are free standing, while in the preceding levels the structures are against the rear wall of the rock shelter. Level 24 is the first level with ceramics, but it is being considered Terminal Archaic in this analysis due to economic evidence and the exceptionally early ceramics at Qillqatani.

Qillqatani Period	Weight in Grams					Total Count
	0 – 1 g	*1 – 2 g*	*2 – 3 g*	*3 – 4 g*	*4 – 5 g*	
Late Horizon	9		1			10
LIP	22					22
Tiwanaku	44	5	1			50
Late Formative	79	8	4			91
Formative C	129	11	2	2		144
Formative B	71	8	4	1	1	85
Formative A	135	17	5	1	2	160
Terminal Archaic	58	12	5	4		79
Late Archaic	13	4	1			18
Middle Archaic	29	4	2	2		37
Total Count	589	69	25	10	3	696

Table 3-7. Counts of obsidian debitage at Qillqatani by weight (g).

The earliest obsidian at Qillqatani is a Middle Archaic sample from an unknown source. In the Late Archaic, Chivay obsidian begins to appear at the rock shelter. Subsequently, during the Terminal Archaic obsidian from Chivay occurs in relatively large numbers and it persists until the end of the Early Formative (the Qillqatani *Formative C* period) where chemical testing of ten obsidian samples reveals there is greater heterogeneity in obsidian procurement. In this period, Chivay obsidian makes up 60% of the obsidian tested by the Missouri University Research Reactor (MURR), the Tumuku type makes up 20%, and the Aconcahua type and Alca type make up the remaining 10% (one sample of each).

Three obsidian artifacts from two proveniences at Qillqatani, West level XI and East level XIV, were found to belong to the Tumuku chemical group, a group that derives from an as-yet-unlocated source that probably lies in the southern department of Puno. This chemical group has not yet been well characterized, as no source samples are available and the samples analyzed by NAA in the 1970s at Lawrence Berkeley Labs (Browman 1998: 309-311; Burger and Asaro 1977) are not easily comparable with more recent NAA results from MURR. As a consequence, in initial studies of these three Qillqatani artifacts it was proposed that the artifacts belong to a subgroup from the Alca obsidian source in northern Arequipa, a subgroup that was referred to as “Alca-2” (Frye et al. 1998) and “Alca-Z” (Jennings and Glascock 2002: 111). More recently, Michael Glascock at MURR has stated that these three Qillqatani samples probably derive from the Tumuku source (M. Glascock, March 2006, pers. comm.).

Flake sizes at Qillqatani indicate that relatively large flakes were being discarded (Table 3-7), particularly during the Terminal Archaic and Early to Middle Formative. A central question concerning obsidian circulation is to what degree were flakes used for shearing and butchering tasks? Were flakes sufficiently large to be hand-held for these activities? Length measurements from these flakes from Qillqatani are not available, but an estimate of the size of those flakes based on their weight is provided by comparing similar obsidian flakes from the Chivay source dataset. An obsidian flake weighing 4g from the Chivay dataset had the following dimensions: 45 x 13 x 7mm. A smaller obsidian flake weighing 3g measured 31 x 14 x 6mm. These flakes appear to have been sufficiently large for shearing and butchering tasks. Further technical studies, as well as use wear and residue analysis, may shed more light on the use of large obsidian flakes in the regional consumption zone.

Small quantities of material and regional models of exchange

The actual volume or weight of obsidian at Qillqatani is relatively small. Obsidian from the Chivay source appears in small quantities in nearly every stratum in the approximately 8000 year sequence. The most informative data on long distance exchange come not from the total mass of obsidian, but from the variability in the relative percentage of obsidian flaked and obsidian tools in each lithic assemblage through the sequence. Nevertheless, the weight of obsidian tools at Qillqatani totals 43 g, and the sum of the weight of obsidian flakes is 382 g out of a total of 11,085 g of lithic material. Thus, the entire quantity of obsidian excavated at Qillqatani is only about 1.5% of the cargo that could be carried by a single llama.

These figures are meant to highlight a central issue with obsidian studies overall: the actual quantities of obsidian encountered and evaluated from the consumption sites throughout the south-central Andes are relatively low. The significance of obsidian circulation over the larger region is not matter of weight or volume, but rather a question of consistency and changes in the proportions of particular sources utilized over time. These data from Qillqatani underscore this issue. A comparison of the persistence of non-local obsidian at Qillqatani as of level 24 (Table 3-6 and Table 3-7) with the non-local obsidian at Asana (Table 3-4) during earlier periods of the Archaic, suggests that on a regional scale mechanisms of exchange, or direct acquisition, were more intermittent during the earlier Asana phases. In contrast, Qillqatani has high quality cherts and low quality Aconcahua type obsidian available in the immediate proximity of the rock shelter. Thus, the question becomes: why transport Chivay obsidian 200 km when alternative materials are locally available? Further, why was the transmission of Chivay obsidian so consistent through time? In this perspective the low but consistent quantities of Chivay obsidian that were conveyed throughout the south-central Andean highlands during the prehispanic period can be seen as a gauge of highland interaction and horizontal complementarity, with wider implications for exchange.

3.4.3. Sumbay

The work of Máximo Neira Avendaño (1968; 1990) is distinguished as being the earliest systematic Archaic Period excavations in the Arequipa highlands. In the mid-1960s Neira excavated at seven preceramic sites close to the Sumbay train station, including several rock shelters, known as Sumbay-1 through Sumbay-7. The sites were later renamed "Ccollpa-Sumbay" by Eloy Linâres Malaga in 1984 (1990; 1992) as part of the CONCYTEC survey.

The Sumbay area lies 42 km to the south-east of the Chivay source across the pampa and it is 9.3 hours from the obsidian source area by the hiking model. The main cavern, SU-3, is a rock shelter that is concealed in narrow canyon that cuts through the puna. This rock shelter measuring 15m across, 11m deep, and 6m in height at the dripline, was badly looted in the 1930s, and Neira's excavations focused on the remaining intact portions of the cave. The cave is known for exceptional rock art panels featuring both petroglyphs, ochre pictographs, and a variety of animal species including elongated camelids, a hunting puma, humanoid figures, and *suri* the Andean ostrich.

Seven excavation pits were placed in the main shelter, SU-3. Pit 5 produced obsidian samples in every level along with a large number of tools made from pitchstone, a dull vitreous material formed from weathered obsidian that has absorbed water from the environment. Pitchstone has 4-10% water while obsidian has 0.1 - 0.5% water (M. Glascock, 2006 pers. comm.). The source of this pitchstone is probably somewhere near Sumbay and further study of this pitchstone may provide an interesting complement to the chemical characterization of obsidian.

Figure 3-8. Sumbay pitchstone projectile points.

Titicaca Chronology	Sumbay Stratum	^{14}C yr bp	Lab # (Bonn)	Cal. BCE	Obsidian Type	Artifacts
	1	None				Many very small flakes.
Late Archaic 5000-3300 BCE	2	5350±90	1559	4350-3980		One pitchstone knife, 5 broken pitchstone points, 1 quartzite scraper, 100 flakes.
	3	6160±120	1558	5400-4750	Two obsidian samples (Chivay)	One pitchstone foliate point with concave base, 4 pitchstone scrapers, 6 broken pitchstone points, 1 broken obsidian point, 62 flakes.
Middle Archaic 7000-5000 BCE	4	None			One obsidian sample (Chivay)	Six pitchstone points: 2 incomplete stemmed with concave base, 1 almost complete, 3 foliate points, one with broken tip and broken base. Seven incomplete pitchstone points, 2 incomplete quartzite points. One pitchstone knife, 110 flakes, 1 worked bone, 5 bone concentration.

Table 3-8. Sumbay, SU-3 Pit 5. Strata with obsidian samples and associated artifacts (Máximo Neira Avendaño 1990: 32-33).

Twenty-five obsidian samples were analyzed from the Sumbay area. Twenty samples from the surface and terreplain of the rock shelter SU-2, two from the surface of the rock shelter SU-3, and 3 from excavations in SU-3, Pit 5 (Burger et al. 1998a: 209; Burger et al. 2000: 278). All samples turned out to be of the Chivay type. Since stratum 3 was dated to the Middle – Late Archaic transition, the stratum 4 obsidian sample is stratigraphically below than that, so it is probably Middle Archaic in date.

3.4.4. The Ilave Valley and Jiskairumoko

Located in the Department of Puno in the western Lake Titicaca Basin, the Ilave river valley is an open, terraced river valley and it forms the highest volume river drainage to flow into Lake Titicaca from the west. Jiskairumoko (95-189) is the largest multicomponent Archaic/Formative site identified during survey and it lies

200 km from the Chivay obsidian source or 44 hours travel time across the expansive puna grasslands. Mark Aldenderfer conducted research in the Ilave valley from 1994 to 2002 including a pedestrian survey, a testing program, and excavation work (Aldenderfer 1997, 1998a). In 1997 and 1998 Cindy Klink conducted research in the Huenque drainage, a principal tributary that joins the Ilave from the south (Klink and Aldenderfer 1996; Klink 2005, 2006). Nathan Craig excavated at the site of Jiskairumoko and tested at numerous other sites between 1999 and 2002 (Craig 1999; Craig and Aldenderfer 2002; Craig 2005; Craig and Aldenderfer in press). Tripcevich conducted a viewshed analysis of sites in the Ilave drainage using data from the 1994 and 1995 Ilave valley survey (Tripcevich 2002).

Ilave Valley

In the Ilave valley, obsidian was scarce prior to 3300 BCE, but it appears in a number of Terminal Archaic and Formative contexts after that date. Diagnostic projectile points from the Ilave area reveal a dramatic change in material type with the Terminal Archaic.

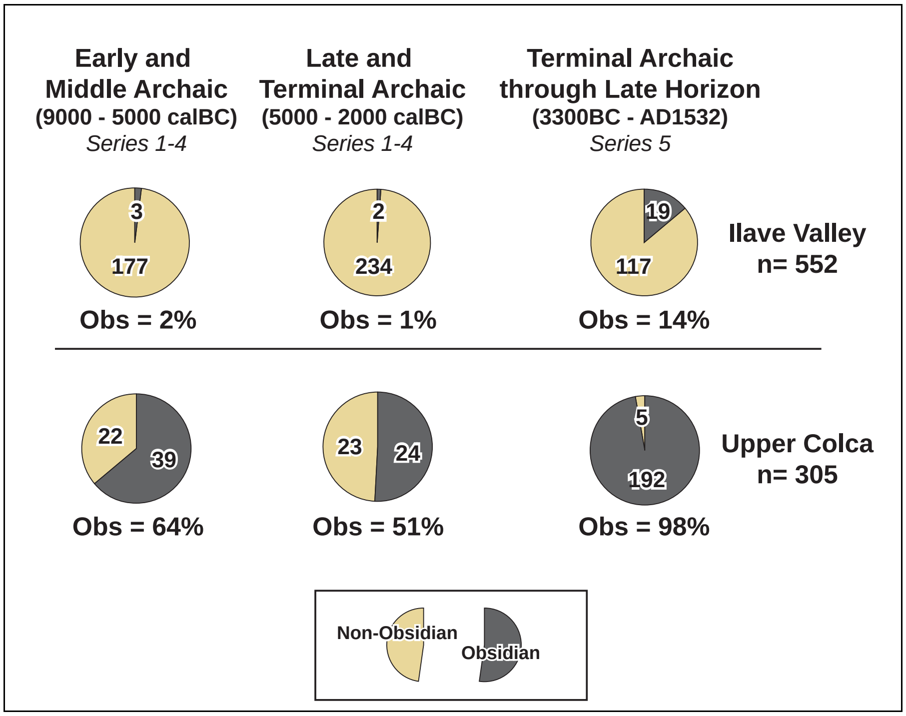


Figure 3-9. Comparison of projectile point counts in the Ilave Valley and the Upper Colca.

Using only diagnostic projectile points from the Klink and Aldenderfer (2005) point typology, these data reveal a shift to greater use of obsidian with series 5 projectile points. Following the point typology, all series 1 through 4 points are diagnostic to the Terminal Archaic or earlier, except for types 4C and 4E which have been excluded from this analysis. The lower part of Figure 3-9 reveals data classified into the same three groups, but with data from the Chivay obsidian source area resulting from the 2003 Upper Colca project. Comparing these two datasets reveals that with the advent of Series 5 points in the Terminal Archaic after 3300 BCE there is a sudden upswing in obsidian use in the Ilave consumption zone that corresponds perfectly with a dramatic shift in projectile point production at the Chivay source area itself. There appear to have been pan-regional changes occurring with the widespread adoption of series 5 style projectile points, the use of obsidian, and these changes are possibly related to the greater use of the bow and arrow.

Jiskairumoko (95-189)

The site of Jiskairumoko was excavated using a broad, horizontal décapage technique between the years 1999 and 2002, and Craig's (2005) dissertation forms the site archive. Radiocarbon dates from excavation work at Jiskairumoko range from the Late-Terminal Archaic transition with a date of 4562±73bp (AA58476; 3520–3020 BCE) through to the end of the Early Formative, with a date of 3240±70bp (Beta-97321; 1690-1390 BCE). Note that Craig (2005) has the Terminal Archaic dating to 3000-1500 BCE, while in the Upper Colca Project and in this dissertation the period dates to 3300 – 2000 BCE All references to the "Terminal Archaic" have been adjusted to the latter time range in this document unless otherwise noted.

Craig and Aldenderfer chemically characterized 68 bifacially-flaked obsidian tools from excavated contexts at Jiskairumoko (96% of all obsidian tools from Jiskairumoko) by sending these items to M. Steven Shackley at the UC Berkeley Archaeological XRF Lab (Craig 2005: 513, 908-916). The samples were compared with four geological samples that provided to Shackley from nodules that I had collected from Chivay source in 2003. Three of the nodules provided to Shackley were from the Maymeja area and one was from east of Cerro Hornillo. The XRF results showed that 97% of the Jiskairumoko obsidian tools (n = 66) were from the Chivay source and 3% (n = 2) were from the Alca source. These values diverge slightly from obsidian type distributions in the Titicaca Basin more generally (Table

3-3), where 90.5% (n = 466) of all of the obsidian artifacts tested to date from the Titicaca Basin are Chivay type. These data indicate that the people at Jiskairumoko were more intensively using Chivay obsidian in the Terminal Archaic and Early Formative than were Titicaca Basin residents over all, especially in contrast to the variety in obsidian types that emerge from samples dating to later times.

Obsidian artifacts from excavations at Jiskairumoko reveal that obsidian was used in similar proportions for projectile points from excavated contexts as for points from surface contexts in the Ilave valley. Craig (2005: 685) observes that 18% (n = 54) of the excavated Jiskairumoko projectile points are made from obsidian. He also notes that 50% of these have edge modification in the form of serration or denticulation while only 15% of non-obsidian points have edge treatment, a statistically very significant pattern that he attributes to the symbolic importance of this material. Obsidian was found, along with other lithics and a carved camelid effigy, in Burial 1 at Jiskairumoko in the grave of an elderly adult female with cranial deformation, a primary deposit dating to the Terminal Archaic or 3019-2859 cal BCE (Craig 2005: 680-682). Graves excavated in the Ilave valley area also contain a variety of non-local grave goods including obsidian, lapis, and gold, but non-local grave goods only occur in contexts dating to the Terminal Archaic and later.

3.5. Andean Obsidian Distributions through Time

While obsidian spatial distributions are well demonstrated, it is more difficult to ascertain the temporal patterns because many of the obsidian artifacts from the south-central Andes that have been sourced are from an uncertain temporal provenience.

The Andean obsidian sourcing literature, organized and published primarily by Richard Burger, has provided a temporal context for obsidian samples wherever possible. Temporal control for obsidian artifacts fall into three categories

(1) excavated contexts with a temporal association.

(2) surface materials spatially associated with temporally diagnostic artifacts.

(3) direct chemical sourcing of temporally-sensitive diagnostic projectile points.

Good temporal control from excavated contexts is preferred, but a number of the samples are from the *number 2* group, above, because the samples have weak temporal control and are from sites that are assumed to be single component based solely on diagnostic artifacts. Finally, a fourth method, obsidian hydration dating, has been used in the Andes but with mixed results. The high diurnal and seasonal temperature variation in the Andean highlands suggests that hydration dating can only be reliably used as a relative dating method in conjunction with ^{14}C dates (Ridings 1996).

Chronologies based on stages on the one hand, and periods or horizons on the other, are used in Andean archaeology. Some pan-Andean research, such as studies of regional obsidian exchange, have used the horizons absolute chronology developed by John H. Rowe (1967) in collaboration with Dorothy Menzel and based on the Ica ceramic “master sequence”. This approach allows for a maximum of compatibility between regional datasets and it has been used widely, and even extended into the Titicaca Basin (e.g., Burger et al. 2000). However, archaeological research conducted in the Lake Titicaca Basin has largely followed a chronology based on evolutionary stages that differs from the horizon chronology primarily during the Formative Period and the Tiwanaku Period (Hastorf 1999; Kolata 2003; Stanish 2003: 85-90). As the bulk of Chivay type obsidian artifacts are found in the Lake Titicaca Basin, this dissertation will review Andean obsidian distributions using a Titicaca Basin chronology, and it will follow the Formative Period temporal divisions used by Stanish (2003). These regional data will be presented in terms of three major temporal periods in order to be consistent with the framework adopted with the new data reported for this dissertation.

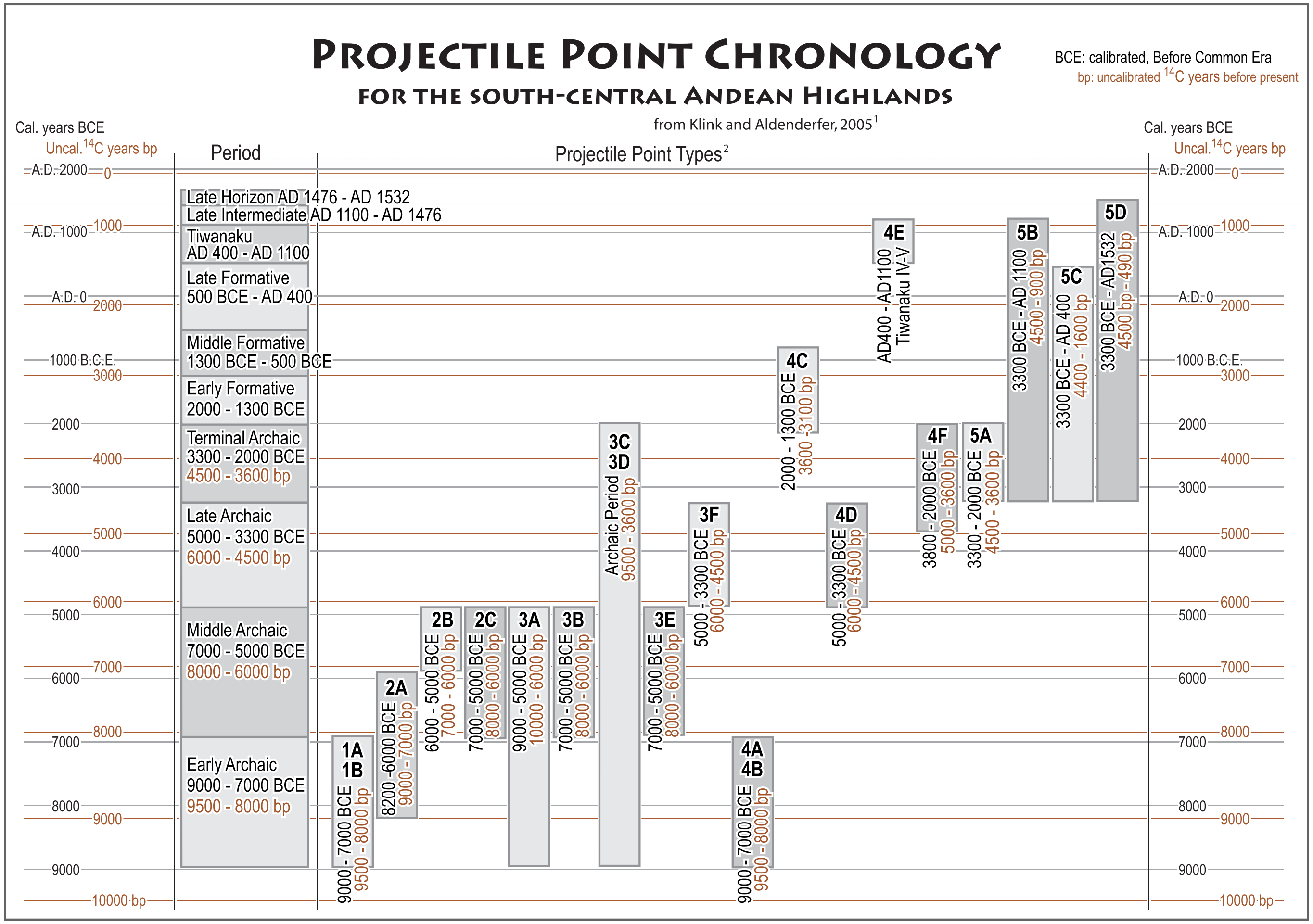
	Titicaca Chronology	Years cal. AD/BCE
Late Prehispanic	Late Horizon	A.D. 1476 – 1532
	Late Intermediate	A.D. 1100 – 1476
	Tiwanaku	A.D. 400 – 1100
Early Agropastoralists	Late Formative	500 BCE – AD400
	Middle Formative	1300 – 500 BCE
	Early Formative	2000 – 1300 BCE
	Terminal Archaic	3300 – 2000 BCE
Archaic Foragers	Late Archaic	5000 – 3300 BCE
	Middle Archaic	7000 – 5000 BCE
	Early Archaic	9000 – 7000 BCE

Table 3-9. Temporal organization of data.

These three major temporal divisions serve to differentiate the major forces that appear to have structured obsidian procurement and distribution. Rather than focusing on the “preceramic” and “ceramic” dichotomy, which is only peripherally related to obsidian use, a decision was made to present data in terms of these three major divisions. Furthermore, socio-political changes that accompanied obsidian circulation in the Terminal Archaic are better considered in conjunction with the later developments in the Formative than together with the earlier periods of the Archaic.

The use of the term “Archaic Foragers” is not meant to suggest that no pastoralism occurred prior to 3300 BCE Many scholars place the initial domestication sometime between the Middle and the Late Archaic in the chronological terms used here (Browman 1989; Kadwell et al. 2001; J. Wheeler 1983; Wing 1986). However, initial domestication and adoption of a dedicated pastoralist economy are distinct events, and the evidence from a number of sites in the south-central Andean highlands suggests that the process of shifting to a food producing economy in the Andean highlands featuring camelid pastoralism and agriculture based largely on seed-plant and tuber cultivation was complete by circa 3300 BCE in the Upper Colca region. Likewise, these divisions between “forager” and “pastoralist” are not meant to suggest that foraging activities ceased in the Terminal Archaic, merely that foraging diminished in importance in terms of caloric intake and food security.

The Early, Middle, and Late Archaic Periods have the additional benefit of being differentiated by relatively consistent changes in projectile point morphology through prehistory. A projectile point typology has recently been developed by Klink and Aldenderfer (2005) that synthesizes data from previously developed point typologies with new evidence from stratified Archaic and Formative excavations in the region. This typology has proven to be extremely useful for investigating surface distributions of projectile points, and it will was used throughout this dissertation both for assessing the age of obsidian points on a regional scale, and for assigning temporal categories to surface sites identified in the course of our 2003 survey work.



[1] Klink, C. and M. Aldenderfer, 2005. A Projectile Point Chronology for the South-Central Andean Highlands. In *Advances in Titicaca Basin Archaeology-1*, edited by C. Stanish, A. Cohen and M. Aldenderfer, pp. 25-54. Cotsen Institute of Archaeology, Los Angeles, California.

N. Tripcevich, 2006

[2] Date ranges of projectile point types are from the uncalibrated before present dates reported by Klink and Aldenderfer. They were calibrated using Oxcal v3.9 (C. Bronk Ramsey, 2003), and then the mean of the 2σ BCE range was rounded to the nearest 100. The point types are plotted on two reference scales that were derived from dates calibrated in 500 year increments. Errors of ±50 years were used for dates <5000 bp and errors of ±100 years were used for dates ≥5000 bp. These dates and period definitions are not precise; they are meant only for convenient reference.

Figure 3-10. Projectile Point Typology with Titicaca Basin chronology (from data in Klink and Aldenderfer 2005)

The temporal groups shown in Figure 3-10 visibly depict the changes in temporal control provided by projectile point evidence between the "Archaic Foragers" and the "Early Agropastoralists". With the advent of series 5 projectile point styles in the Early Agropastoralists time, the forms of projectile points became a far less effective means of differentiating time periods because projectiles do not change with as much regularity. Series 5 projectile points, except for type 5a, are diagnostic only to the time after the domestication of camelids and the dominance of food producing, pastoral economy. The following review will examine only a few of the most significant aspects of these distributions by time period, with a focus on insights from obsidian exchange on the preceramic and Early Agropastoralist stages of Andean prehistory.

3.5.1. Archaic Foragers in the South-Central Andes

To date, relatively few Archaic archaeological sites have been excavated in the area of the south-central Andean highlands, and therefore the regional knowledge of this important time period is limited. A brief overview of each period will be provided here, with an emphasis on archaeological sites containing Chivay type obsidian, in order to contextualize the regional relationships and interactions that were occurring during these preceramic periods. This review will focus on the western slope of the Andes and the Lake Titicaca Basin, the region where Chivay type obsidian abounds. Much of the Archaic Foragers obsidian in the literature that has been sourced was derived from undated, surface contexts from sites that are assumed to date to the Archaic based on projectile point styles or other inference by archaeologists. Klink and Aldenderfer's (2005) projectile point typology permits the classification of site occupations by time period with greater certainty during the Archaic when projectile point styles change with regularity. In some cases, the projectile point typology can be used to assign a date range to temporally diagnostic obsidian projectile points that have been directly analyzed for chemical provenience.

In Burger et al.'s (2000: 275-288) review, procurement and exchange during the preceramic is evaluated through chemical provenancing data from 87 obsidian samples, 70 of which are from the Chivay source. Unfortunately, of the thirteen sites where the samples were collected in the south-central highlands, only three sites (Chamaqta, Asana, and Sumbay) contain excavated contexts placing the samples in preceramic levels. The other samples are assigned to the preceramic group through inference from projectile points, or because they are from a-ceramic sites. The difficulty in this arises from the fact that obsidian was used with much greater frequency in the beginning of the pastoralist periods, as was mentioned above in the case of the Ilave valley (Section 3.4.4).

Obsidian materials from both the Chivay and Alca sources were transported relatively long distances from the Early Archaic onward, indicating that material from these obsidian sources has properties that were prized at a relatively early date. Sites such as Asana and Qillqatani, both over 200 linear km from the Chivay source, contain non-local obsidian through much of the preceramic sequence despite the immediate availability of high quality cherts, as well as the lower-quality Aconcahua obsidian, in the local area. This evidence underscores the nature of obsidian provisioning in the Archaic Period. As compared with later pastoralist use of obsidian, Archaic foragers were relatively selective in their use of raw materials. This may reflect the priority placed on dependable hunting technology as compared with the shearing and butchering needs of pastoralists, or the different social and symbolic priorities attached to obsidian by hunters versus herders.

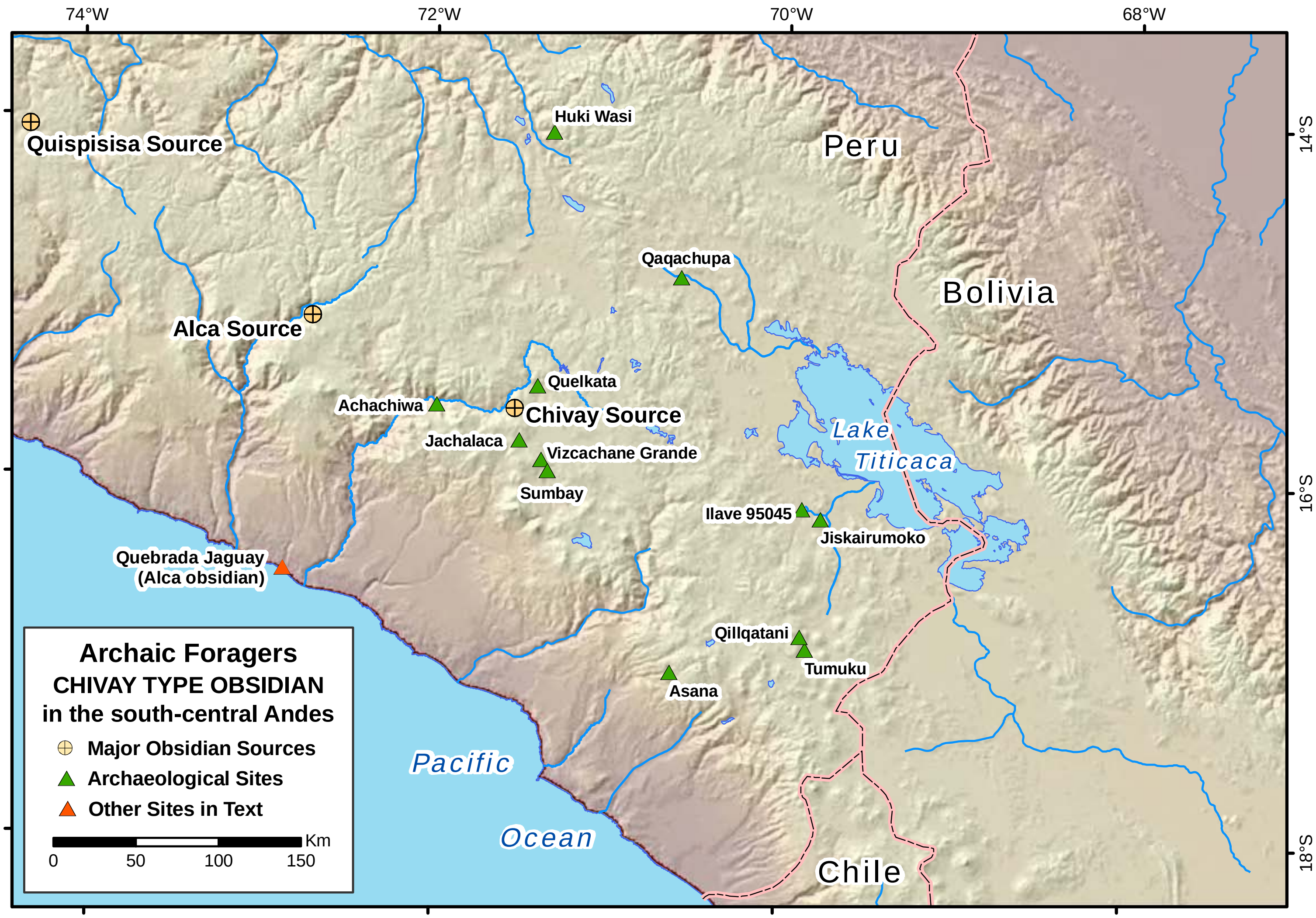


Figure 3-11. Chivay type obsidian distributions during the “Archaic Foragers” time (circa 10,000 – 3,300 BCE).

Early Archaic (circa 10,000 – 7,000 BCE)

Evidence from the Early Archaic in the south-central Andes is slim, but it is accumulating gradually. The available data suggest that during this time period human groups went from initial exploration of the highlands to more stable, year around occupation of the sierra and puna. The best evidence from the highlands comes from a handful of stratified sites in the region with Early Archaic components, as well as distributional evidence from archaeological survey work (Aldenderfer 1997; 1998b; 1999b; 2003; Craig 2005: 452-484; Klink 2005; Nuñez et al. 2002; Santoro and Núñez 1987; Tripcevich 2002).

A regional study of projectile points from excavated contexts by Klink and Aldenderfer (2005: 31, 53) noted that projectile point styles diagnostic to the Early Archaic (Series 1 and Types 4a, 4b) and the Early-Middle Archaic transition (Type 2a) have a broad geographical distribution. These types are found throughout a region that includes the littoral, western sierra, and puna areas of extreme northern Chile and southern Peru, and as far north as Pachamachay cave in the Junin puna (Rick 1980). Given the low population densities of that time period, this wide regional stylistic distribution suggests that a high degree of mobility was being practiced in the Early Archaic and first part of the Middle Archaic. Further to the north, in contrast, raw material types in the Junin puna of central Peru suggest to Rick (1980) that very low forager mobility was occurring throughout the early preceramic period. Early Archaic obsidian distribution data largely confirm with the model of high mobility and show that humans found good sources of lithic raw material in the sierra early, and then transported the material or exchanged it widely from a relatively early date.

Current paleoclimate evidence indicates that glaciers advanced during the late glacial between 11,280 and 10,990 ^{14}C yr bp, and then, despite cool temperatures, the glaciers receded rapidly, perhaps as a result of reduced precipitation (Rodbell and Seltzer 2000). Glaciers were in approximately modern positions in southern Peru by 10,900 ^{14}C yr bp (circa 11,000 cal BCE). The Early Archaic Period, with reference to diagnostic projectile point styles (Klink and Aldenderfer 2005), begins at circa 9000 cal BCE During the Early Holocene and the first part of the Early Archaic conditions were wetter and cooler than modern conditions. Subsequently, during the latter part of the Early Archaic, the climate began an episode of long-term aridity that lasted through the Late Archaic (Abbott et al. 1997a; Argollo and Mourguiart 2000: 43; Baied and Wheeler 1993; Paduano et al. 2003: 272). Opportunities in the highlands for human foraging groups were created by a number of new ecological niches for plants and animals that opened up during the Early Holocene. These niches represented a resource pull for mobile foragers that countered the increased difficulty of subsistence in the hypoxic, high altitude environment faced by the non-adapted early settlers in the highlands (Aldenderfer 1999b). A review of the evidence for forest cover on the altiplano during the Archaic, with deforestation occurring as a result of pastoral intensification, is provided by Gade (1999: 42-74).

During the Late Pleistocene lacustrine period, paleo-Lake Titicaca (Lake Tauca) was much larger but only a few meters higher than is modern Lake Titicaca

(Clapperton 1993: 498-501). Radiocarbon dates on shells show that Lake Tauca was probably still present as late as 10,080 ^{14}C yr bp (or 9900 cal BCE). Sediment cores from Lake Titicaca indicate that there was an increase in sub-puna vegetation and fire from vegetation prior to 9000 BP (Paduano et al. 2003: 272). Evidence from paleoclimate records and fluvial geomorphology point to a time of increased aridity and salinity in Lake Titicaca, with short, episodic moist spells beginning around 8000 cal BCE and continuing through the Middle Archaic and Late Archaic Periods (Rigsby et al. 2003; Wirrmann et al. 1992). The climatic data for this time suggest that with deglaciation in the Early Holocene a resource niche opened up that exerted a pull on plant and animal species towards the high altitude regions, and that early human groups responded to these opportunities by colonizing the high Andes.

Chivay obsidian in the Early Archaic

Evidence of human use of the Chivay Source beginning in the Early Archaic Period comes from survey work adjacent to the source and from excavations at the site of Asana, 200 km away in Moquegua. As will be discussed in Chapter 7, during the course of survey work in the area of the Chivay source in 2003 the Upper Colca team collected several dozen Early Archaic type projectile points, the majority of them made from obsidian. Evidence for the regional consumption of Chivay obsidian begins with the site of Asana that were described earlier in Section 3.4.1 and Table 3-4. Aldenderfer (1998b: 157, 163; 2000: 383-384) encountered small quantities of obsidian in two levels belonging to the Asana II/Khituña Phase, placing them in the Early Archaic Period. In level PXXIX just one obsidian flake from Chivay was identified in an assemblage consisting of 1,152 lithic artifacts weighing 746 g. This level could not be dated directly, but it is assessed at 9400 uncal bp as it lies stratigraphically above a ^{14}C sample from level XXXIII dating to 9820±150 ^{14}C yr bp (Beta-40063; 10,000–8700 BCE).

Obsidian from Chivay appeared in greater quantity in level PXXIV where eleven flakes of Chivay obsidian made up 0.36% of the lithic assemblage by count. These flakes were all small tertiary flakes, chunks, and shatter, suggesting to Aldenderfer (1998b: 163) that a bifacial core of Chivay material was reduced on site. A ^{14}C sample from level PXXIV dated to 8720±120 bp (Beta-35599; 8250–7550 BCE). The Khituña phase has been interpreted by Aldenderfer (1998b: 172-173) as representing a residential base in the high sierra and the beginnings of permanent settlement above 2500m in elevation. This interpretation is based on the presence of high sierra and puna lithic raw materials, but no coastal materials.

In surface contexts in the Ilave valley, surveys directed by Aldenderfer (1997) located three obsidian projectile points in forms that are possibly diagnostic to the Early and Early-Middle Archaic transitional period (types 1A, 3A, 3B). These three points were analyzed using a portable XRF unit in 2005 and all three were found to be of the Chivay type (Craig and Aldenderfer, in press).

Alca obsidian at Quebrada Jaguay

The earliest obsidian identified in the south-central Andes comes from one of the oldest confirmed sites in South America, the Paleo-Indian site of Quebrada Jaguay 280 near the coast north of Camaná, Arequipa. Sandweiss et al. (1998b) report that

Alca type obsidian was the dominant lithic material at the site in the Terminal Pleistocene and Early Holocene phases that were identified. Twenty-six Alca type obsidian flakes came from the older occupation that occurred during the Terminal Pleistocene and the context is dated by twelve ^{14}C dates on charcoal falling between 11,105±260 bp (BGS-1942; 11,700–10,400 BCE) and 9850±170 bp (BGS-1956; 10,100–8700 BCE). A later occupation contained one flake of Alca obsidian and it belonged to the Early Holocene II phase dated by four ^{14}C samples falling between 8053±115 (BGS-1944; 7350–6650 BCE) and 7500±130 (BGS-1700; 6600–6050 BCE). Three other obsidian flakes from the Alca source were collected but they could not be assigned to a temporal context.

Sandweiss et al. observe that the Chivay source is "less than 20 km further; the absence of Chivay obsidian at QJ-280 may indicate that this source was covered by glacial readvance during the Younger Dryas (circa 11,000 to 10,000 ^{14}C yr B.P.)" (Sandweiss et al. 1998b: 1832). The Maymeja volcanic depression of the Chivay obsidian source indeed shows notable evidence of recent glaciation, but obsidian matching the "Chivay Type" is also found in smaller nodules on adjacent slopes outside the Maymeja zone as well as in the streambed below Maymeja having eroded through alluvial erosion (see Section 4.5.1 for maps and a discussion of the Chivay obsidian source geography). Procurement of obsidian from Chivay did not necessarily require entering the Maymeja area, however better source material can be obtained from the within the area.

Regional scale GIS analyses show Quebrada Jaguay to be 154 linear km from the Alca source, or 35.7 hours by the hiking function. In contrast, the trip to Quebrada

Jaguay from the Chivay source is 170 linear km and 41.5 hours by the hiking function. Despite this relatively difference in distance, no Chivay obsidian was found at Quebrada Jaguay. It is worth noting that, despite this early find of Alca obsidian on coast, both the Alca and the Chivay obsidian types were predominantly found at high altitude throughout prehistory based on current evidence from obsidian sourcing studies. In the bigger picture, the coastal Quebrada Jaguay paleoindian finds are anomalous for Alca distributions. The next lowest altitude context for Alca to date is at the site of Omo in Moquegua, a Tiwanaku colony site at 1250 masl dating to the Middle Horizon.

Recent work by Kurt Rademaker and colleagues at the Alca source has shown that bedrock outcrops of obsidian are found as high as 4800 masl, and there are large pieces found at 3,800 masl that appear to have been transported downslope by glacial action and colluviation (K. Rademaker 2005, pers. comm.). Deposits of Alca obsidian at much lower elevations have been reported that are probably the result of pyroclastic flows (Burger et al. 1998b; Jennings and Glascock 2002). These deposits found close to the floor of the Cotahuasi valley at 2500 masl were probably available throughout the Younger Dryas and perhaps further sub-sourcing of Alca obsidian will better answer the question of which Alca deposits were being consumed during the Terminal Pleistocene by the occupants of Quebrada Jaguay.

Quispisisa Obsidian in the Early Archaic

Another early use of obsidian in the Andes is the evidence of Quispisisa obsidian in levels dated to ~9000 uncalBP or 8500–7750 cal BCE (Burger and Asaro 1977, 1978; Burger and Glascock 2000; MacNeish et al. 1980) from Jaywamachay a.k.a. "Pepper cave" (Ac335) located at 3300 masl in Ayacucho in the central Peruvian highlands. As was recently explained by Burger and Glascock (2000; 2002), for nearly three decades the Quispisisa obsidian source was mistakenly believed to have been located in the Department of Huancavelica, but in the late 1990s the true Quispisisa source was finally discovered in the Department of Ayacucho. Jaywamachay is the closest of the sites excavated by MacNeish's team to the newly located Quispisisa source. It is 81.3 linear km or 22.0 hours walking calculated using the hiking function, while the bulk of the sites excavated by MacNeish were in the Ayacucho valley approximately 120 km from the relocated Quispisisa source. The Puzolana (Ayacucho) obsidian source is located close to the Ayacucho valley and high-quality, knappable obsidian is available at this source, but the maximum size for these nodules is 3-4 cm, significantly limiting the potential artifact size for pieces made from this source (Burger and Glascock 2001). It is interesting to note that, in several cases in the south-central Andes, the Archaic Period foragers seem to have ignored small sized or low-quality obsidian sources that later pastoralists ended up exploiting. The Aconcahua source near Mazo Cruz, Puno, previously described, was not used at the adjacent Qillqatani rock shelter until the Middle Formative (Frye et al. 1998), and it was not used at Asana until the Terminal Archaic (Aldenderfer 2000: 383-384).

Burger and Asaro (1977: 22; 1978: 64-65) chemically analyzed a projectile point of Quispisisa obsidian found at La Cumbre in the Moche Valley that was reportedly from a context dated to 8585±280 bp or 8500–6800 cal BCE (Ossa and Moseley

1971). The investigator, Paul Ossa, now doubts the Early Archaic context and instead believes the point may be Middle Horizon in date (Richard Burger, 11 March 2006, personal communication), but it is still a noteworthy case of long distance transport within the Wari Empire, and it perhaps involved the use of coastal maritime transport. Using the relocated Quispisisa source in the Department of Ayacucho the linear distance is 846.7 km and by the hiking function the distance is calculated as 199.8 hours, primarily confined to the coast.

Discussion

Regional relationships indicated by both stylistic criteria and obsidian distributions point to high mobility during the Early Archaic Period. Recent evidence of projectile point similarities from northern Chile suggest that mobility was high along the Pacific littoral, and between the sierra and puna during the Terminal Pleistocene and Early Holocene around 25° S latitude (Grosjean et al. 2005; Nuñez et al. 2002). During the Early Holocene, foraging groups resided around high altitude paleo-lakes on the altiplano of northern Chile between 20° S and 25° S latitude that persisted longer than did the paleo-lakes at the latitude of Lake Titicaca. These lakes subsequently dried up during the Middle Archaic Period and occupations declined until the end of the Late Archaic Period but this distributions point to the mobility and early high altitude occupation of the adjacent puna of Atacama.

On the whole, obsidian proveniencing and analysis has shed light on human activities during the Paleoindian period and Early Archaic at a regional scale. Chemical analysis techniques, non-destructive XRF analysis in particular, are becoming more pervasive because the methods are being refined and the equipment is becoming more portable. Further field research will provide a greater understanding of this time period, but evidence will also likely to emerge from existing collections as obsidian projectile points diagnostic to the Early Archaic are systematically provenienced.

Middle Archaic (7000 – 5000 BCE)

The Middle Archaic Period, as with the preceding period, is still poorly understood in the region as very few highland sites containing stratified deposits have been studied from this period. In the Lake Titicaca Basin paleo-climatic evidence points to significant aridity, a lake level approximately 15m below the current stand, and high salinity in Lake Titicaca that is comparable to that of modern day Lake Poopó (Abbott et al. 1997b; Wirrmann and Mourguiart 1995). Human occupation during the Middle Archaic in the Lake Titicaca Basin was notably higher than in the preceding period, but research shows that settlement continued to occur in the upper reaches of the tributary rivers and not adjacent to the shores of the saline Lake Titicaca (Aldenderfer 1997; Klink 2005).

Obsidian distributions during the Middle Archaic

At the site of Asana on the western slope of the Andes, Aldenderfer (1998b: 223) observed architectural features that suggest that a longer residential occupation of the site by entire coresidential groups was occurring in the latter part of the Middle Archaic Muruq'uta phase. One flake of obsidian from the Chivay source was found in the upper levels of the Muruq'uta phase (Table 3-4). This occupation dates to the

Middle Archaic - Late Archaic transition as the flake was stratigraphically above a ^{14}C sample that dated to 6040 ± 90 bp (Beta-24634; 5210–4720 BCE).

At the rock shelter of Sumbay SU-3 obsidian was recovered from excavation levels that date to as far back as the transition between the Middle and Late Archaic (Section 3.4.3).

Discussion

Relatively little is known about the Middle Archaic in the south-central Andean highlands. Elsewhere in the south-central Andes, archaeologists have noted an absence of settlement during the mid-Holocene timeframe corresponding to the Middle and Late Archaic Periods. In the dry and salt puna areas of northern Chile, and along the south coast of Peru, a significant decline or absence of mid-Holocene sites has led investigators to refer to this period as the *silencio arqueológico* (Núñez and Santoro 1988; Nuñez et al. 2002; Sandweiss et al. 1998a; Sandweiss 2003). This designation apparently does not apply to the Titicaca Basin or to the sierra areas of the Osmore drainage where no Middle Archaic occupation hiatus has been observed.

With gradual population increases and adaptation to the puna, social networks extending across the altiplano and connecting communities and their resources residing in lower elevations with puna dwellers, were probably beginning to take form. Exchange of resources, including obsidian, between neighboring groups may have been in the context of both maintaining access to resources and risk reduction. From a subsistence perspective, Spielmann (1986: 281) describes these as *buffering,* a means of alleviating period food shortages by physically accessing them directly in neighboring areas, and *mutualism,* where complementary foods that are procured or produced are exchanged on a regular basis. Another likely context for obsidian distribution during the Archaic Period is at periodic aggregations. Seasonal aggregations have been well-documented among foragers living in low population densities, where gatherings are the occasion for trade, consumption of surplus food, encountering mates, and the maintenance of social ties and ceremonial obligations (Birdsell 1970: 120; Julian Haynes Steward 1938). If analogous gatherings occurred among early foragers in the south-central Andes it have would created an excellent context for the distribution of raw materials, particularly a highly visible material like obsidian that was irregularly available in the landscape.

Late Archaic (5000 – 3300 BCE)

The Late Archaic in the south-central Andes signals the beginning of economic changes in the lead-up to food production, and furthermore the first signs of incipient social and political differentiation are evident in a few archaeological contexts. Some of the obsidian samples reported by Burger et al (2000: 275-288) with possible Late Archaic affiliations are from surface contexts at multicomponent sites and it is therefore difficult to confidently assign these samples to any particular period of the Archaic.

Chivay obsidian during the Late Archaic

Evidence of Late Archaic obsidian use comes from excavations at the previously discussed sites of Asana, Qillqatani, and Sumbay. Several obsidian samples in the Burger et al. (2000) study were of portions of diagnostic projectile points that resemble types in Klink and Aldenderfer's (2005) point chronology. From illustrations and text (Burger et al. 2000: 279, 281) the Qaqachupa sample appears to belong to the Late Archaic. Burger et al. describe this point as resembling a Type 7 point from Toquepala in Ravines' (1973) classification, and Klink and Aldenderfer (2005: 44) mention that their Type 4D point strongly resembles the Toquepala Type 7, making it diagnostic to the Late Archaic.

Asana

In excavated data from Asana, in Moquegua, one sample of Chivay obsidian was found in a Muruq'uta phase occupation in Level XIV–West lying above a palimpsest dated to 6040±90 (Beta-24634; 5210–4766 BCE) (Aldenderfer 1998b: 269), as shown above in Section 3.4.1. This level lies on the Middle Archaic / Late Archaic transition. Interestingly, Chivay obsidian disappears at Asana subsequent to this time period. Furthermore, evidence of lower raw material diversity in the Late Archaic lithic assemblage point to greater geographical circumscription.

Qillqatani

Chivay obsidian at Qillqatani is first found in the Late Archaic level WXXX dated to 5620±120 (Beta-43927; 4800–4200 BCE). The Chivay material is the second oldest obsidian fragment identified from Qillqatani (Section 3.4.2), the oldest obsidian is from an as-yet unknown source. Notably, the assemblages from the Qillqatani excavations do not begin to contain obsidian from the Chivay source until considerably later date than did the excavations from Asana. Figure 3-7 reveals that both obsidian tools and debris increase as a percentage of the assemblage in the Late Archaic. The counts of obsidian, however, are still relatively low.

Qillqatani is slightly further away than Asana than from the Chivay source, and it is at a higher altitude and further to the east. It has been suggested that perhaps the obsidian was transported via a coastal route at this early date (Frye et al. 1998). As mentioned, Alca obsidian was also found on the coast in the Terminal Pleistocene levels although, like Chivay, Alca obsidian distributions conform over the long term to a highlands orientation. As no Chivay obsidian as ever been found below the 1250 masl (at Omo), and all Archaic Period Chivay obsidian is found above 3000 masl, the littoral route between Chivay and Asana seems improbable.

Ilave Valley

Craig and Aldenderfer (in press) report that two obsidian projectile points from the Ilave valley in a type 3f form, diagnostic to the Late – Terminal Archaic were analyzed in 2005 with a portable XRF unit and were found to be of the Chivay type.

Sumbay

At Sumbay SU-3, three obsidian samples were analyzed from excavated contexts and all three turned out to be of the Chivay type (Burger et al. 1998a: 209; Burger et al. 2000: 278), as shown in Section 3.4.3. Two ^{14}C dates were run and returned dates from the early part of the Late Archaic (Ravines 1982: 180-181). One sample was from stratum 3 and it was dated to 6160±120 (BONN-1558; 5400–4750 BCE). Another sample was from above it in stratum 2 and it dated to 5350±90 (BONN-1559; 4350–3980 BCE). One of the three obsidian samples came from Stratum 4 of unit 5, while the other two samples came from higher levels. The Stratum 4 sample probably dates to the Middle Archaic.

Discussion

Obsidian from securely dated Late Archaic contexts show something of a reduction in regional distribution and a greater focus on locally available lithic material, suggesting a reduction in mobility or exchange in the Late Archaic. Similarly, projectile point styles became increasingly more limited in spatial distribution, with greater local variability during the Late Archaic implying reduced mobility (Klink and Aldenderfer 2005: 53). This is consistent with Aldenderfer's (1998b: 260-261) observations about reduced mobility during the Late Archaic Qhuna Phase occupation at Asana when the occupants ceased to use non-local lithic raw materials. During this phase, Aldenderfer also describes increasingly formalized use of space at Asana, evidence of a ceremonial complex, and greater investment in seed grinding. In short, during this time a circumscribed population with reduced mobility was probably living in higher densities and exhibiting signs of ceremonial activity that are consistent with the scalar stress model for the emergence of leadership (G. A. Johnson 1982).

It is also worth considering the impact that scarcity may have on valuation. The lack of discarded obsidian signifies that it was not being knapped or resharpened and it was probably not abundant, but that does not mean that obsidian was not known in the larger consumption zone during this period. In the subsequent time period, the Terminal Archaic, obsidian becomes abundant on a regional scale at the same time as a host of other social and economic changes were occurring. This period, and the previously discussed Middle Archaic, correspond with what was referred to as the *silencio arqueologico* (Núñez and Santoro 1988) due to a dearth of archaeological data observed by investigators working in Northern Chile. The reduced evidence of circulation of obsidian from Chivay appears to correlate with a reduction in archaeological evidence regionally.

There is strong representation of Chivay obsidian in Arequipa at Sumbay, and it is likely that Late Archaic projectile point forms are found in the North Titicaca Basin as reported by Burger et al. (2000). However, at Asana there is little obsidian from the Colca. Possibly these reduced distributions of obsidian reflect the reduced mobility and more complex architectural investment in Late Archaic contexts at Asana (Aldenderfer 1998b), and prior to the development of extensive, long distance exchange that were potentially initiated by early caravan networks during the Terminal Archaic. These conclusions, however, on not based on particularly robust data, as the sample of sites for this time period is relatively small.

Discussion and review of the Archaic Foragers period

The transport of obsidian from both the Chivay and Alca sources fluctuated during the Archaic Foragers period, and the distribution remained confined to the sierra and altiplano areas of the south-central Andes. The small and irregular quantities of obsidian consumed throughout the region could have been procured and transported by mobile foragers, or conveyed through down-the-line exchange networks. Conceivably exchange could have taken place a seasonal gatherings as well, based on analogy from other foraging groups worldwide, although there is no direct empirical support for such gatherings in the south-central Andean Archaic. At Asana, the most well-stratified highland Archaic site investigated to date, evidence of non-local obsidian was intermittent and consisted of very small quantities of material in a pattern that is perhaps exemplary of the discontinuous nature of regional exchange during this time.

Obsidian from the Quispisisa source (340 linear km to the north-west of the Chivay source), was likewise used primarily in highland contexts during the Archaic Foragers period, particularly in rock shelters excavated by MacNeish and colleagues in the central highlands. While Quispisisa material was circulated at a number of preceramic coastal sites (Burger and Asaro 1978), current evidence suggests that those contexts post-date 3300 cal BCE (i.e., cotton preceramic) and are therefore Terminal Archaic in the terms used here. It appears that while Quispisisa material was used widely on the coasts subsequent to the Archaic Foragers period, material from Chivay and Alca were virtually always confined in the highlands with the exception of the earliest obsidian evidence of all: Alca at Quebrada Jaguay. In the Archaic Foragers period, as in later periods, the evidence from obsidian is contrary to the widely-discussed Andean vertical complementarity models, because obsidian distributions suggest that the movement of people or products between ecologically complementary zones was not widespread.

3.5.2. Early Agropastoralist obsidian distributions

The “Early Agropastoralists” period (3,300 BCE – A.D. 400) begins with what appears to have been a shift to a chiefly pastoral lifeway, greater regional interaction, and a more intensive production and circulation of obsidian from the Chivay source area in the Terminal Archaic. In this discussion, the Early Agropastoralists period continues through the Late Formative and subsequently beginning AD400, with the ascendancy of Tiwanaku, the "Late Prehispanic" time block begins. The changes during the Terminal Archaic that mark the beginning of the Early Agropastoralist time include the growing importance of food production, the expanded production and circulation of obsidian, and socio-political differentiation that began to appear in the Terminal Archaic, phenomena of greater interest to this research than the presence or absence of pottery.

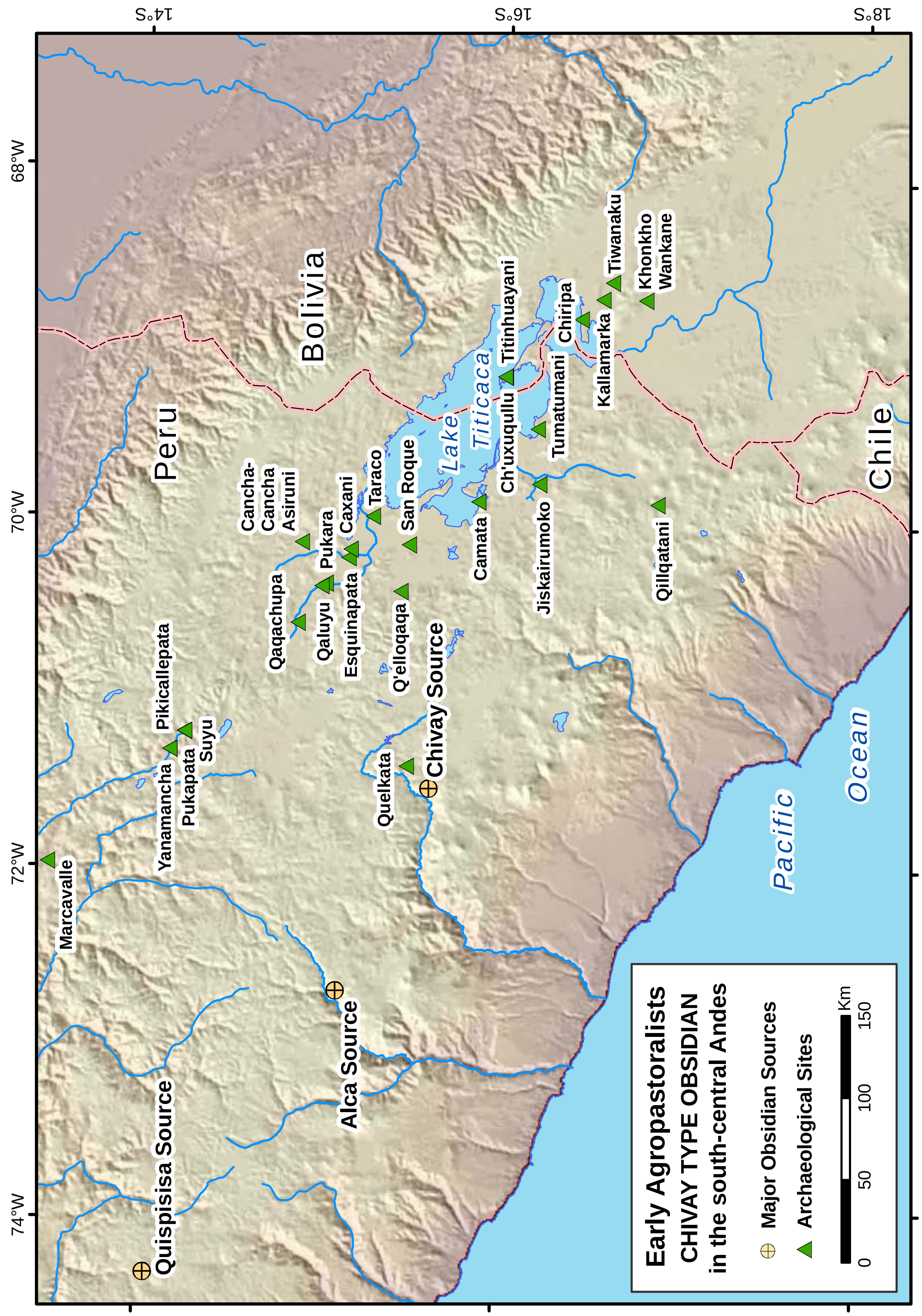


Figure 3-12. Chivay type obsidian distributions during the "Early Agropastoralists" time (3,300 BCE – AD 400).

Why an "Early Agropastoralists" time block?

In lieu of the traditional preceramic / ceramic divide in archaeology, the "Early Agropastoralist" time block was defined for this project because, in many ways, the conditions during the final millennium of the Archaic had more in common with events in the Formative than with the preceding Archaic Periods. Differentiating sites as "Early Agropastoralist" beginning in the Terminal Archaic requires that one delimits a firm boundary on a process that was millennia in the making. Considering the Terminal Archaic as the beginnings of agropastoralism, and thereby linking it to the attendant settlement distribution that includes series 5 projectile points, connects cultural and economic evidence from throughout the region with a generalized estimate of when food production took hold in terms of scheduling, mobility, and prioritizing the needs of agricultural planting and herding. As mentioned, the term "Early Pastoral" is not meant to imply that no food production occurred before this date and hunting and gathering did not persist after this date. Indeed the current evidence suggests that camelids were first domesticated sometime during the Middle or Late Archaic, probably after 5000 BCE (Browman 1989; Kadwell et al. 2001; J. Wheeler 1983; Wing 1986). The "Early Agropastoralist" period refers to a period after 3300 BCE that features a predominantly food producing economy in the highlands including intensive pastoralism, as well as seed-plant and tuber cultivation. These changes in food production may have been linked to the accumulating evidence of increased rainfall and shortening of the dry season beginning circa 2500 cal BCE (Baker et al. 2001; Marchant and Hooghiemstra 2004; Mourguiart 2000). These changes in economy are joined by evidence of increased sedentism, widening stylistic distributions pointing to long distance cultural integration, and the beginnings of social differentiation apparent in architecture and grave goods. The circulation of obsidian was linked to these phenomena because increased regional interaction was perhaps articulated through camelid caravans, although the presence of caravans in the Terminal Archaic is being explored, not assumed, in this study.

In the Titicaca Basin, the changes incurred between the Terminal Archaic and the Late Formative are monumental. However, from the perspective of the Chivay source the intensification revealed archaeologically, both at the source and in the consumption zone, is notable beginning in the Terminal Archaic, and the intensification does not change notably throughout the Formative Period. Defining the ending of the "Early Agropastoralist" period as the end of the Late Formative is similarly problematic. By the Late Formative, the economic influence of Pukara and other regional centers probably impacted the peoples of the Upper Colca, but direct evidence returning from Pukara, only 140 km away, is scarce in the Colca. In contrast, during the Tiwanaku times, regional states with socio-economic impacts over hundreds of kilometers dominated both the circulation of goods like obsidian, and regional settlement organization.

Terminal Archaic (3300 – 2000 BCE)

The Terminal Archaic ushers in a suite of social and economic changes in the south-central Andes and, consistent with these developments, obsidian begins to circulate in significantly greater quantities during this period. Obsidian is increasingly used for projectile points during the Terminal Archaic, a trend that continues into the Formative Period (Burger et al. 2000: 294).

Regional patterns in Terminal Archaic sites are somewhat difficult to assess from surface finds because the Terminal Archaic is lacking in exclusive diagnostic artifacts in both the lithic or ceramic artifact classes. As is shown in Figure 3-10, the most common projectile point styles that belong to the Terminal Archaic, such as Types 5B and 5D, also persist through the ceramic periods, leaving only type 5A and part of type 4F as diagnostic to exclusively the Terminal Archaic (Klink and Aldenderfer 2005: 48). Furthermore, by definition, the Terminal Archaic is a preceramic period, which precludes a ceramic means of assigning chronology. From site organization characteristics, a site might be considered to be a Terminal Archaic site if it has pastoralist attributes but it is aceramic and has series 5 projectile point types represented that belong, at least partially, to the Terminal Archaic.

The beginnings of the Andean agropastoral strategy are apparent during this period at sites like Asana where seasonal residential movement occurred between the high sierra and the puna (Aldenderfer 1998b: 261-275; Kuznar 1995). Another attribute of the Terminal Archaic at Asana is a disappearance of ceremonial features. Evidence for a shift from hunting to pastoralism comes primarily from evidence of corrals (Aldenderfer 1998b), from changes in the ratio of deer to camelid remains, and from the ratio of camelid neonate to adult remains. At sites where the process has been observed, the transition to full pastoralism at various sites in the Andes is usually perceived as a gradual process dating to sometime between 3300 to 1500 BCE At Qillqatani, however, the transition was relatively abrupt and it occurred in level WXXIV that dates to approximately 2210–1880 BCE (Table 3-1).

Chivay obsidian during the Terminal Archaic

While the number of excavated Terminal Archaic sites is relatively small, general processes are apparent from recent work at several sites in the south-central Andean highlands.

At Ch'uxuqullu on the Island of the Sun, Stanish et al. (2002) report three obsidian samples from the Chivay source in Preceramic levels. Eight obsidian flakes were found in aceramic levels and were described as being from a middle stage of manufacture, and three of these were sourced with NAA. Two samples came from levels with a ^{14}C date of 3780±100bp (Teledyne-I-18, 314; 2500–1900 BCE) and a third Chivay obsidian sample comes from an aceramic level that immediately predates the first ceramics level which occurred at 3110±45bp (AMS-NSF; 1460–1260 BCE). Citing paleoclimate data, the authors observe that boat travel was required to access the Island of the Sun at this time.

The Ilave Valley and Jiskairumoko

Terminal Archaic projectile points in the Ilave valley demonstrate the dramatic shift in the frequency and use of obsidian that occurred in this time period (Section 3.4.4). XRF analysis of 68 obsidian artifacts excavated from Jiskairumoko show that the Chivay source was used with particular intensity in this period. The XRF study found that 97% of obsidian bifaces from Terminal Archaic and Early Formative levels at Jiskairumoko were from the Chivay source, however published obsidian studies from all time periods show that typically 90% of all obsidian analyzed from Titicaca Basin sites are from the Chivay source (Table 3-3).

Qillqatani

The percentages of obsidian tools and debris remain generally similar to those in the Late Archaic level except that the counts are much higher (Figure 3-7). By count, obsidian tools are doubled, and obsidian debris is 4.3 times greater, and all the obsidian has visual characteristics of the Chivay type (Aldenderfer 1999c).

Based on the density of obsidian, the relationship with the Chivay source area 221 km away seems to be well-established by this time, and it is a relationship that becomes even more well-developed in the Early Formative. Six samples of obsidian were analyzed at the MURR facility from Terminal Archaic contexts that are associated with a radiocarbon date of 3660±120 (Beta-43926; 2210–1880 BCE). All six obsidian samples were from the Chivay source.

Asana

At the site of Asana, obsidian reappears at the end of the Terminal Archaic during the Awati Phase dated to 3640±80 (Beta-23364; 2300-1750 BCE) where it makes up

0.4% of lithic materials, but this obsidian was not from the Chivay source. It was judged from distinctive visual characteristics to have come from the Aconcagua obsidian source only 84 km to the east of Asana, near the town of Mazo Cruz (Aldenderfer 2000). Aconcahua type obsidian has characteristics that are less desirable for knapping due to fractures and perlitic veins that cross cut the material (see Appendix B.1), and while it was possible to derive sharp flakes for shearing and butchering functions, the material was probably not used for projectile point production (Frye et al. 1998).

The shift to Aconcahua obsidian in the Awati phase at Asana is particularly puzzling given the evidence for Chivay obsidian circulation at this time period. It is precisely at the end of the Terminal Archaic that a dramatic spike in the use of Chivay obsidian at Qillqatani (See Table 3-5 and Figure 3-7) took place. One may ask: Why is it that when the occupants of Qillqatani are importing Chivay obsidian in unprecedented quantities, the people of Asana are getting only small quantities of low-quality obsidian? In addition, this low-quality obsidian comes from Aconcahua, a source adjacent to Qillqatani?

Given the pattern of early Chivay obsidian at Asana, these Terminal Archaic distributions suggest that the high sierra residents at Asana were not participating in an altiplano-based circulation of goods as the Qillqatani residents. The residents of Asana never again participate in the circulation and consumption of Chivay obsidian, while at Qillqatani the consumption of Chivay material continues strongly for another one thousand years.

Other obsidian types during the Terminal Archaic

Obsidian from alternative sources in the circum-Titicaca region, including the unlocated sources of Tumuku and Chumbivilcas types, are used in greater quantity during the Terminal Archaic judging from associated projectile point evidence provided in Burger et al. (2000: 280-284).

Evidence from close to the Alca obsidian source provides new information about long distance interaction during Terminal Archaic. At the site of Waynuña at 3600 masl (Jennings 2002: 540-546) and less than one day's travel from the Alca obsidian source, recent investigations have uncovered a residential structure with evidence from starch grains resulting from the processing of corn as well as starch from arrowroot, a plant necessarily procured in the Amazon basin (Perry et al. 2006). Given the long distance transport of arrowroot, it is conceivable that the plant material arrived as a form of reciprocation or direct transport from travelers moving between the Amazon and the Alca obsidian source. The Cotahuasi valley also has major salt source and other minerals that would potentially draw people procuring such materials. The starch samples were found in a structure on a floor dated by two ^{14}C samples. One sample was dated to 3431±45 (BGS-2576) 1880–1620 BCE, and another was 3745±65 (BGS-2573) 2350–1950 BCE

Further north, the Quispisisa type obsidian was particularly abundant during the Terminal Archaic at the preceramic coastal shell mound site of San Nicolas, along the Nasca coast, in a context associated with early cotton (Burger and Asaro 1977; 1978: 63-65). Quantitative data on the consumption of obsidian at San Nicolas are unavailable and the temporal control is weak because the "cotton preceramic" date is derived from association with cotton and no ceramics, not from direct ^{14}C dating.

Discussion

The distribution of obsidian from all three major Andean obsidian sources: Chivay, Alca, and Quispisisa, expanded considerably during the Terminal Archaic. It is notable that both the Chivay and Alca sources expanded, but the distribution remained confined to the sierra and altiplano areas of the south-central Andes. In comparison, obsidian from the Quispisisa source (340 linear km to the north-west of the Chivay source), has been found in significant quantities in Ica on the coast of Peru. While many of the early coastal obsidian samples have weak chronological control, the quantities of Quispisisa obsidian found in possible Archaic contexts is noteworthy. The fact that Chivay obsidian has never been found in coastal areas, and Alca is not found on the coast after the Paleoindian period, is remarkable considering the extensive evidence of coastal use of Quispisisa obsidian beginning in the Terminal Archaic.

Early Formative Period (2000 – 1300 BCE)

In this time period, new socio-economic patterns became well established in the south-central Andes while the distribution of Chivay obsidian was at its maximum both in geographic extent and in variability of site types. During this time period, societies were characterized by sedentism, demographic growth, increased specialization, and early evidence of social ranking (Aldenderfer 1989; Craig 2005; Stanish 2003: 99-109).

At sites like Jiskairumoko in the Titicaca Basin, architecture from the Terminal Archaic consisted of pithouses with internal storage, ground-stone, and interments with grave goods that included non-local items (like obsidian) that were presumably of value (Craig 2005). During the Early Formative around 1500 BCE this architectural pattern gives way to larger, rectangular, above-ground structures that lacked internal storage.

As reviewed by Burger et al. (2000: 288-296) using the Ica "Master sequence" chronology under the roughly contemporaneous "Initial Period" (though the Early Formative ends 300 calendar years earlier), the distributions of obsidian are notable in their extension both north and south from the Chivay source, and in their concentrations at early centers like Qaluyu. Obsidian from Chivay also persists on the Island of the Sun in the Early Formative (Stanish et al. 2002).

Chivay obsidian distributions

At Qillqatani, obsidian flakes are available in quantity during this Titicaca time period which roughly overlap with the Formative A and B (Table 3-5). Seven obsidian samples were analyzed at MURR that all corresponded with the Chivay source. These samples were found in levels adjacent to a context that dated to 2940±70bp (Beta-43925; 1380–970 BCE).

It appears that obsidian was being obtained as nodules or blanks and being knapped down to projectile points. Obsidian flakes represent 15% by count (n = 160) of all the flakes in the period "Formative A", and obsidian projectile points represent 12% by count of all points in this level (Aldenderfer 1999c).

Obsidian is first found at Qaluyu dated to ~3250 uncal bp which calibrates to 1640–1420 BCE (Burger et al. 2000: 291-296), or the end of the Early Formative where Burger et al. report evidence of nodules or blanks arriving for further reduction at the source. Some of the Chivay obsidian found at Qaluyu were medium sized pebbles; one example Burger et al. analyzed had the dimensions 1.9 x 1.4 x 1.2 cm. Qaluyu is 140 linear km from the Chivay source, or 34.6 hours by the hiking model, so it is roughly 70% of the distance of Qillqatani from the source. There are substantial quantities of obsidian at Qaluyu during the subsequent Middle Formative.

Discussion

Paleoclimatic studies have documented a decline in abundance of arboreal species in the Lake Titicaca Basin and an increase in open-ground weed species reflecting disturbed soils after ca. 1150 cal BCE (Paduano et al. 2003: 274). This has been interpreted as reflecting intensification in food production and population that occurred during the Early Formative. Some argue that the grasslands of the altiplano are an anthropogenic artifact of a human induced lowering of the treeline due in part to the expansion of camelid pastoralism (Gade 1999: 42-74). The increasing sedentism, cultivated plants, expanding camelid herds and the growing influence of prominent settlements like Qaluyu in regional organization signify that significant socio-economic dynamism was underway by this period. The evidence of hierarchy takes the form of “very moderate social rank” acquired by certain individuals, such as religious specialists (Stanish 2003: 108). These traits are first suggested by jewelry, grave goods, and non-residential structures in the Terminal Archaic, but they become further elaborated during the Early Formative after 2000 BCE.

There is no evidence of political ranking in the structure of settlement distributions between Early Formative sites in the Lake Titicaca Basin, and all the sites are less than one hectare in size (Stanish 2003: 108), but the evidence of obsidian circulation from Qillqatani and other pastoral sites suggests of regional exchange system not yet focused around Lake Titicaca. Evidence acquired from the earliest occupational levels at Titicaca Basin regional centers suggest that regional interaction was low. At the site of Chiripa, in the southern Lake Titicaca Basin, Matthew Bandy describes traces of sodalite beads, obsidian, and sea shell in excavations from Early and Middle Formative contexts.

> It is clear, then, that long distance trade in mortuary and prestige items took place as early as the Early Chiripa phase [1500-1000 BCE]. Equally clear, however, is that this early exchange involved very small quantities of the objects in question. This trading would seem to have been very sporadic and infrequent. There is no evidence in the Early Formative Period for the sort of regular caravan trade postulated by Browman (his "altiplano mode"; see Browman 1981: 414-415) (Bandy 2001: 141).

However, the evidence for obsidian distributions at Qillqatani that are discussed here point to routine exchange, perhaps by caravan trade, along on the Western Cordillera in the Early Formative. It appears that future regional centers like Chiripa were not yet participants in these exchange networks.

The dynamic nature of interregional interaction that occurred during the Early Formative is evident from the diversity in obsidian types at sites, and the lack of geographical restrictions that appear to structure exchange during later periods. While settled communities were evident, the lack of hierarchy and centralization suggests that they were not integrated by supra-local organization. Yet the economic basis for long distance relationships appears to have taken form by the Early Formative. The decentralized and variable nature of exchange in this period, which is abundantly evident at Qillqatani and yet not evident at sites like Chiripa, implies that another form of integration was linking communities, like the residents of Qillqatani, with the Chivay source 221 km to the north-west.

Middle Formative Period (1300 – 500 BCE)

During the Middle Formative Period, social ranking became established in the Titicaca Basin. The changes are most evident in the settlement structure as some regional centers grew to become far larger than their neighbors and feature sunken courts, mounds, and specialized stone and ceramic traditions. Stanish (2003: 109-110) interprets these changes in terms of an ability of elites to mobilize labor beyond the household level.

The stylistic evidence suggests that during the Middle Formative the north and south Titicaca Basin were relatively separate spheres, with Qaluyu pottery in the north and fiber-tempered Chiripa ceramics in the south extending only as far north as the Ilave river. However, Chivay obsidian is encountered in both the North and South Basin. Christine Hastorf (2005: 75) suggests that by the end of this period (the Early Upper Formative) evidence of ethnic identity and ritual activity is supported by ritual architectural construction and non-local exchange goods. It is further inferred that "Plants such as coca (*Erythroxylum* sp.), Anadenanthera (*A. colubrine, A. peregrine*), and tobacco *(Nicotiana rustica)* surely would have been present in the Basin by this time, perhaps associated with snuff trays…" (Hastorf 2005: 75). An increase in long distance exchange is commonly found as part of a complex of features associated with ideological and social power during the Middle Formative in the region, and it appears that existing exchange routes, such as the one along the Western Cordillera connecting Chivay with Qillqatani, were increasingly routed towards the Titicaca Basin regional centers during this time.

Chivay obsidian distributions

Chivay obsidian occurs in small quantities at a number of Middle Formative sites in the southern Basin including Chiripa and Tumatumani, and it persists at Ch'uxuqullu on the Island of the Sun. At Tumatumani, 3% of the projectile points are made from obsidian (Stanish and Steadman 1994). Bandy (2001: 141) reports that at Chiripa they recovered only small quantities of obsidian in the time spanning 1500—200 BCE and these were in the form of finished bifaces. For the entire time span, after four excavation seasons, they report only 87.1g of obsidian. Tumuku type obsidian was identified in Chiripa in Condori 1B component circa 1500—1000 cal BCE levels (Browman 1998: 310, dates calibrated). At the site of Camata, on the lakeshore south of the modern city of Puno, four obsidian samples were analyzed from contexts that range from circa 1500 – 500 cal BCE and all four were of Chivay type obsidian (Frye et al. 1998; Steadman 1995).

The evidence from the North Titicaca Basin regional centers is even more intriguing as there is a significant presence of Alca type obsidian during the early part of the Middle Formative, and Chivay obsidian is found in the Cusco Basin during this time. Qaluyu, Pikicallepata, and Marcavalle all contain both Chivay and

Alca obsidian between approximately 1100 – 800 cal. BCE, the early part of the Middle Formative (Burger et al. 2000: 292; Karen L. Mohr Chávez 1980: 249-253). Subsequent to this overlap in obsidian use, there appears to have been significant overlap in other stylistic attributes as well. These similarities include common traits in ceramic vessel forms between Chanapata vessels in the Cusco area and Qaluyu vessels in the North Titicaca Basin (Burger et al. 2000: 292).

However, during the latter part of the Middle Formative after 800 BCE the Yaya-Mama religious tradition first emerges at the site of Chiripa (Bandy 2004: 330; Karen L. Mohr Chávez 1988), a tradition that eventually unifies the north and south areas of the Titicaca Basin during the Late Formative. As noted by Burger et al. (2000: 311-314), with the appearance of the Yaya-Mama tradition the Alca and Chivay obsidian distributions become more asymmetrical. Alca obsidian makes up 16% (n = 9) of the obsidian in a pre-Pukara context at the site of Taraco on the Titicaca lake edge in the North Basin, however while Chivay obsidian was found at Marcavalle and other Cusco sites previously during the Early Formative, obsidian from the Chivay source is absent during the Middle Formative and it does not re-appear in the Cusco region again until the Inka period. Alca obsidian, on the other hand, expands outward during this period as it is found in the Titicaca Basin to the south-east, and it is also is transported a great distance to Chavín de Huantar. Both of these examples of long distance transport have been attributed to religious pilgrimage (Burger et al. 2000: 314).

Qillqatani

At Qillqatani, the Middle Formative comprises the bulk of Formative B layers and all of the Formative C layers (see Qillqatani data in Section 3.4.2). In Formative B layers, Chivay obsidian is the only type represented in the four samples that were analyzed and the lithic assemblage suggests that formal tools were not being produced at the site as no evidence of obsidian tools were found in these levels. Obsidian flakes, however, persist as 18% of the lithic assemblage from that level. Subsequently, in the Formative C level that begins around 900 BCE and corresponds approximately with the latter half of the Middle Formative as well as the rise of the Yaya-Mama tradition in the south Titicaca Basin, there is a distinctive shift in the use of obsidian at Qillqatani. Whereas all prior obsidian samples from Qillqatani were Chivay after the initial Middle Archaic sample, the obsidian samples in Qillqatani Formative C levels are only 60% from the Chivay source.

The other samples come from Aconcahua, a source of lower-quality obsidian that is near the Qillqatani shelter, and from Tumuku, an as-yet undiscovered source that may be located close to the three-way border between Peru, Bolivia, and Chile, and finally Alca obsidian occurs for the first and only time at Qillqatani in these levels. Given that Alca obsidian also occurs at Pukara, Incatunahuiri (surface) and at Taraco in quantity (16% of assemblage, n = 9), the presence of Alca obsidian at Qillqatani is consistent with the abundance of Alca material in circulation in that time. A sample of Alca obsidian has also been found on the Island of the Sun (Frye et al. 1998), though it was from a surface context.

Table 3-6 shows that obsidian tools in Formative C levels at Qillqatani are abundant (n = 19) and relatively large on average (1.21 g), and the non-obsidian tools were also very abundant (n = 187) for this level.

Discussion

Middle Formative obsidian distributions appear to demonstrate the emergence of a distinctive Titicaca Basin exchange sphere. One could argue that the emerging elites that mobilized labor to build the initial mounds and courts, and sponsored specialized artistry in stone and ceramics, may have precipitated a demand for greater exotic exchange goods as a source of prestige. Stanish (2003: 162) believes that this is the process that occurs later, during the Late Formative, when he argues that this process is connected to wealth generation for sponsoring feasts and other activities, though he admits the data are sparse. Evidence of long distance exchange from contexts belonging to the Early Formative and first half of the Middle Formative (1500-1000 BCE) at sites like Chiripa are sparse, irregular, and generally involve very small, portable goods; however the evidence from Qillqatani supports other models of more regular interaction along established exchange routes.

Late Formative Period (500 BCE – AD 400)

During the Late Formative, significant social ranking developed and dominated the socio-political landscape in the Lake Titicaca Basin. The complex polities that emerged on either end of Lake Titicaca were distinguished by architecture, stoneworking, and ceramic traditions. A three-tiered site size hierarchy is evident in the Late Formative, and the construction of prominent terraced mounds with sunken courts occurred in a few major sites at this time. The elite ceramics and stoneworking, and the construction of elaborate mounds as a venue for large-scale feasts and human sacrifice at sites like Pukara and early Tiwanaku, can be interpreted as a means of demonstrating the large-scale organization of labor by elites (Stanish 2003: 143).

The patterns of obsidian circulation that emerged at the end of the Middle Formative became very well established in the Late Formative. Excavations at centers in the North Basin have found a reduction in the presence of Alca obsidian in the Titicaca Basin, but the Alca material is still present although it is found in minor quantities at the larger sites as compared with Chivay obsidian. The diversity of obsidian types in the Titicaca Basin samples reported by Burger et al. (2000: 306-308) for this time span is low, as compared with the diversity of types used in the Cusco area, because in the Titicaca Basin it is virtually all Chivay obsidian.

In recent excavation work at Pukara on the central pampa at the base of the Qalasaya, Elizabeth Klarich (2005: 255-256) found that obsidian was generally available and obsidian use was not associated with any intrasite status differences. Probable representations of obsidian points and knives appear in Pukara iconography, and small discs have been found at Pukara and Taraco that were possible ceramic inlays (Burger et al. 2000: 320-321). The Late Formative Period on the southern end of the Titicaca Basin has small amounts of Chivay obsidian at Chiripa and Kallamarka. In Giesso's (2000: 167-168) review of lithic evidence from several Formative Period sites he found no obsidian use in these collections except for samples from Khonkho Wankane which recent research directed by John Janusek has revealed to be principally a Late Formative center. The furthest confirmed examples of transport of Chivay obsidian are these examples encountered in southern Titicaca Basin sites. The two furthest confirmed contexts for Chivay obsidian transport are represented by two samples from a Late Formative context at Kallamarka (Burger et al. 2000: 308, 319, 323) and six samples found at Khonkho Wankane (Giesso 2000: 346), both about 325 km from the Chivay source, or 72 hours by the walking model.

At Qillqatani, the obsidian returns to being primarily Chivay type during the Late Formative although 1 out of the 9 obsidian artifacts analyzed from Late Formative levels was of the Tumuku type (Section 3.4.2). During the Late Formative there is a steady decline in the percentage of debitage made from obsidian at Qillqatani, a trend that continues in the Tiwanaku period.

In the Colca Valley, there are few traces of the Late Formative consumers of Chivay obsidian. As will be further explored in this research project, there is very little Qaluyu or Pukara material diagnostic to the Middle or Late Formative in the Chivay obsidian source region. Steven Wernke found a diagnostic classic Pukara sherd with a post-fire incised zoomorphic motif that resembles a camelid-foot from a Formative site above the town of Yanque in the Colca (Wernke 2003: 137-138).

Pukara materials are known to have circulated, probably through trade links, throughout the south-central Andes. Pukara sherds have been found in the valley of Arequipa in association with the local Formative Socabaya ceramics (Cardona Rosas 2002: 55). In the Moquegua valley, both Chiripa-related and Pukara pottery have been found (Feldman 1989), and a Pukara textile was found in a possible elite grave context in the Ica Valley (Conklin 1983).

Discussion

The decline in forest cover in the Lake Titicaca Basin beginning during the Early Formative intensified throughout the Formative Period. Between 2500 – 800 cal. BCE a decline in fine particulate charcoal was detected in a lake core drawn from the southern end of Lake Titicaca's *Lago Grande* (Paduano et al. 2003: 274). The pollen and charcoal record indicates that forest cover finally disappeared around AD0, coincident with population increases and resource pressure associated with Late Formative Period socio-economic intensification.

The obsidian circulation during the Late Formative shows distinct patterns in the Titicaca Basin and in Cusco. In the Titicaca Basin, the diversity of sources is reduced, with virtually all the material coming from Chivay and Alca, and the Alca samples are primarily affiliated with a single period at Taraco. Even at the site of Qillqatani, the diversity is reduced as compared with the previous Middle Formative level (Qillqatani *Formative C*). Current evidence suggests that the economic circulation was more integrated and that it was probably under some form of control by the dominant regional centers of this time. The furthest confirmed evidence of Chivay obsidian transport is from among Late Formative contexts at Kallamarka and Khonkho Wankane. Yet, diagnostic evidence from Titicaca Basin Late Formative polities in the Colca valley area is scarce. Part of the difficulty in understanding the

Formative at the Chivay obsidian source area is that the Formative ceramic sequence in the Arequipa highlands is still being refined.

Discussion and review of "Early Agropastoralists" obsidian

From the Terminal Archaic through the Formative Periods the circulation and consumption of obsidian expanded dramatically. Chivay and Alca obsidian is found in a wide variety of sites from isolated rock shelters to early regional centers, and it appears in consistent quantities that differ considerably from the intermittent nature of regional obsidian supplies in preceding periods. The increased circulation of obsidian is part of a spectrum of changes that began in the Terminal Archaic, but obsidian distribution patterns are particularly useful because they are quantifiable.

In some ways obsidian appears most closely linked to tasks associated with camelid pastoralism, such as shearing and butchering. However, in the central Andean littoral, Quispisisa obsidian is found in density in "cotton preceramic" and Initial Period (i.e., Terminal Archaic and Early Formative) coastal sites where presumably pastoralism, if present, was a very minor part of the economy. Furthermore, in the south-central Andean highlands obsidian is found in pastoralist rock shelters but also in regional centers, and the small discarded obsidian flakes and small projectile points do not appear to have served as adequate shearing implements due to their size.

Social complexity during first part of the "Early Agropastoralists" period is manifested most prominently along the Pacific littoral. In the coastal context of what is now the Department of Lima, in central Peru, monumental architecture dating back to 3000 BCE is well-established at the site of Aspero, and the transition to yet more monumental preceramic construction at sites slightly inland has been documented in recent research (Haas et al. 2005; Shady Solis et al. 2001). The shift inland is argued to be related, among other things, to the increased importance of harnessing labor surpluses through the production of cotton for anchovy nets and textiles, and to competitive monument building between elites. Evidence of exchange with highland and Amazonian groups is apparent in the form of tropical feathers and other non-local prestige goods. While these developments occurred over one thousand km to the north of the Chivay area along the Pacific coast, early complex organization is also reported in northern coastal Chile in the Chinchorro II and III traditions spanning the Late Archaic through the Middle Formative (M. Rivera 1991). A long history of cotton production for nets and textiles, imported wool textiles, elaborate burial traditions, and long distance exchange with the highlands and the Amazon characterize the later Chinchorro tradition. These regional patterns underscore the wide scope of the changes that occurred during the Early Agropastoralists time. It has been argued that the beginning of social inequality in the highland Andes may have been stimulated indirectly by demand for wool from aggrandizers in coastal societies (Aldenderfer 1999a).

Returning to evidence from highland obsidian distributions, the widespread circulation of obsidian during the Terminal Archaic and Formative is perhaps best discussed in the terminology used in the historical model of Nuñez and Dillehay (1995 [1979]; Dillehay and Nuñez 1988). While this adaptationalist model has theoretical limitations, it serves as a useful alternative to evolutionary chiefdom models that assign a paramount role to central-places in exchange, despite the decline of central-place models in geography (C. A. Smith 1976b: 24). Following the Nuñez and Dillehay model, it is possible that what is occurring in the Terminal Archaic and Early Formative is the emergence of regular exchange pattern between Qillqatani and Chivay that took the form of a caravan trade "axis" along the western Cordillera. This exchange pattern is among the earliest systematic and demonstrable cases of the circulation of diffusive items through largely homogenous altiplano terrain (Figure 3-4) in the pattern that has also been described as horizontal complementarity or the "Altiplano mode" (Browman 1981b). Subsequently, during the Middle and Late Formative in the Titicaca Basin, former "axis settlements" like Qillqatani, and the Western Cordillera axis more generally, became relatively less important in long distance exchange relationships. Regional centers in the Titicaca Basin like Taraco, Pukara, Chiripa, Khonkho Wankane, early Tiwanaku, and other centers, expanded in influence during this period of peer-polity competition. In these circumstances, the acquisition and ceremonial use of exotic goods appears to have been an important part of the competitive strategies of aggrandizers. Other evidence for Titicaca Basin-based exchange dynamics include the possible production of hoes of Incatunahuiri olivine basalt at Camata around 850-650 BCE that were then transported and used in southern Titicaca Basin sites (Bandy 2005: 96; Frye and Steadman 2001). While the nature of the relationship between emerging elites in Titicaca Basin polities and caravan drivers that provided links between settlements throughout the region is difficult to describe with precision, it appears that interregional articulation became considerably more elaborate by the end of the Early Agropastoralist period.

3.5.3. The Late Prehispanic

During the Late Prehispanic period the circulation of Chivay obsidian was subjected to pan-regional forces by expansive Tiwanaku and Wari and again during the Inka period. While obsidian appears to have had fairly consistent use in both the Tiwanaku and Wari domains, the use of obsidian relative to other goods appears to have declined.

Figure 3-13. Chivay type obsidian distributions during the "Late Prehispanic" time (AD 400 – 1532).

Tiwanaku and Wari (AD400 – 1100)

Following the Titicaca Basin chronology the Tiwanaku period begins with the emergence of the Tiwanaku state during the time that has been called "Tiwanaku IV" beginning around AD400 (Stanish 2003). This is centuries earlier than the start of the Middle Horizon, as defined by the presence of Wari in Ica. Wari in Ica spans the period from approximately AD 750 – 1000.

Obsidian consumption at Tiwanaku

Research by Martín Giesso (2000; 2003) on the Tiwanaku lithic industry has revealed patterns in the differential use of lithic material in the region. First, it should be noted that obsidian is not abundant in the Tiwanaku core area in terms of the capital of the expansive state. Giesso (2003: 365-366) notes that obsidian artifacts make up only 0.8% of the lithics by count (n=86), of the collections at Tiwanaku. Yet the Tiwanaku core lies 315 km from the Chivay source in Euclidean distance, or 70 hours by the hiking function and therefore while obsidian is relatively scarce, it has been conveyed a considerable distance. The spatial distribution and the artifact form of obsidian at Tiwanaku are more analytically relevant than the total count or weight of obsidian which was quite small. Intrasite data on the contrasts in temporal and spatial use of obsidian at Tiwanaku are critical because, among other things, these data would provide a gauge of the relative persistence of access to the Chivay source as Tiwanaku's regional influence expanded.

Giesso's comprehensive source sampling showed that ten different types of obsidian were in use in the Tiwanaku heartland, although of these ten samples only four samples derive from known source locations. He notes that of the ten obsidian types, only Chivay (Cotallaulli) type is transparent and rest are described as "opaque". Giesso's spatial assessment of the distribution of lithic production activities in the core region showed that obsidian microdebitage was concentrated at certain mounds and in residential sectors as compared with chert, quartzite, and other locally available products. Giesso also organized a sourcing study of basalt artifacts in the Tiwanaku area, and he examined the contexts of production at the Querimita quarry located on the southwestern shores of Lake Poopó in Bolivia (Giesso 2003: 369) just over 300 km south of Tiwanaku. The evidence from Querimita on the production and consumption of basalt provides an interesting regional contrast to the spatial patterning of Chivay obsidian. There are both Wankarani (Formative) and Tiwanaku sites in the vicinity of the Querimita basalt source in the direction of the shores of Lake Poopó, but diagnostic Tiwanaku materials at the quarry itself are not reported (M. Giesso 2006, pers. comm.).

At Tiwanaku, quantities of obsidian and quartz have been found in the construction fill at the ceremonial Mollo Kontu mound, a structure that has served as a local fertility shrine. Nicole Couture argues that "quartz and obsidian fragments also served as mountain icons, in the way that exotic crystals, minerals, and rock candies are used today by Aymara *yatiris*, or ritual specialists, to represent mountains and thunder in rites to promote agricultural and social fertility" (Couture 2003: 225). Obsidian from Mollo Kontu has been traced to six different sources: Quispisisa, Chivay, Sora Sora, Cerro Zapaleri, and two unlocated sources (Giesso 2000). "The high density of quartz and obsidian artifacts, often five to ten pieces per excavation level, indicates that they were not accidentally included as part of redeposited rubbish, but rather were deliberately added to the clay fill" (Couture 2003: 215). The diversity in the Tiwanaku urban core was such that Chivay material represented a relatively low percentage (76%) of the material, although the ratio of Chivay material in Giesso and Glascock's study on the whole was 90% Chivay, which is typical for the Titicaca Basin. Interestingly, Giesso found that the 19 obsidian samples from the Akapana and Putuni were all transparent samples from the Chivay source, a pattern supported by the ceramics assemblage from those sites that was entirely local. This pattern suggests to Giesso (2003: 368) that a cultural strategy of "ideological purity" was taking place at that location at Tiwanaku due to exclusive use of those particular materials that are perceived as "local" to the Titicaca Basin. Giesso notes that obsidian is found in the form of standardized projectile points, type 4E according to Klink and Aldenderfer (2005), and that evidence of production is found in commoner residential contexts, whereas finished points are often associated with elite ritual contexts. This suggests to Giesso that labor contributions for some segment of the Tiwanaku heartland commoner population may have taken the form of projectile point manufacture.

A comparison of the circulation and use of Chivay obsidian with Querimita basalt strongly suggests to Giesso that the source areas, production, and transport of both exotic materials were controlled by the Tiwanaku state. If so, research at the Chivay source should reveal some evidence of Tiwanaku materials as it did at Querimita, and perhaps research will reveal state mandated standardization of production activities. However, if no evidence of Tiwanaku presence is found at the Chivay source, then this suggests that the relationship between raw material procurement, long distance transport, and state sponsored activities involved a more nuanced relationship between the state and the peripheral economy.

Burger et al. (2000) also analyzed obsidian from Tiwanaku and in their study, from a collection of 18 samples, all from surface contexts, the results were all of the Chivay type. The original Burger and Asaro (1977) study of Bolivian obsidian revealed that three samples purportly from the site of "Sora Sora" were from the Titicaca Basin source, now known as the Chivay source. At 554 km from the Colca Valley this is the furthest reported transport of Chivay type obsidian to date. However, some doubts have arisen as to the spatial origin of these three samples supposedly from the site of Sora Sora (Burger, Dec 2006, pers. comm.), and given the anomalously high transport distance, these three samples are suspect unless additional supporting data become available. The second furthest reported conveyance of Chivay obsidian is 325 km to the Late Formative contexts of Kallamarka and to Khonkho Wankane in Bolivia, as mentioned above.

Obsidian consumption at Wari

At the imperial capital of Wari, obsidian flakes were likewise found in domestic contexts and have been interpreted as "kitchen waste" as no specialized obsidian production sites were found at the site of Wari (Isbell et al. 1991: 48; Stone 1983; *contra* F. Rivera 1978). In the funerary area of Wari known as the Cheqo Wasi sector the obsidian artifacts include a broken knife, 79 flakes (both utilized and unutilized), and two triangular fragments of obsidian with flat surfaces that may have been polished mirrors (Mario A. Benavides 1991: 64).

At the Wari site of Pikillacta, in the valley of Cusco, evidence from obsidian flakes found in household compounds suggests that obsidian production took place at the household level. In the Haycuchina and Waska Waskan residential clusters, evidence of craft production consists of "waste flakes" of turquoise-colored stone, obsidian, and broken marine shell all collected from the surface (McEwan 1991: 99). Obsidian flakes were found in middens at Pikillacta along with both utilitarian and elite ceramics.

Qillqatani

In Tiwanaku levels at Qillqatani there is a notable decline in the use of obsidian, and of the two specimens analyzed one was of the local low-quality Aconcahua type and the other was Chivay. Figure 3-7 reveals that there is a reduction in the percentage of obsidian in the assemblage from this level. In the "debris" category, obsidian falls below 10% for the first time since the Middle Archaic Period. Ceramics were clearly Tiwanaku influenced, but they were relatively poorly made (Aldenderfer, in press). One may speculate that with the establishment of Tiwanaku colonies in Moquegua, the dominant caravan traffic patterns shifted to an east-west pattern in the Qillqatani area. It is also possible that if the Tiwanaku economic sphere was dominating the circulation of Chivay obsidian, then the material would probably have been conveyed more directly into the Basin and the western cordillera exchange would have been relatively diminished.

The Colca area during the Tiwanaku Period

Relatively little is known about the Colca valley in time periods prior to the Late Intermediate period. The political context of the Colca during this time is intriguing and somewhat ambiguous because the Colca valley lay on the frontier between Wari and Tiwanaku. External cultural influences in the Colca valley proper during the Tiwanaku times appear to have been entirely from Wari, yet Chivay obsidian is not found in Wari sites except in sites with a Tiwanaku component in Moquegua. Given the predominance of Chivay obsidian at Tiwanaku one might expect to encounter diagnostic Tiwanaku material somewhere close to the Chivay source. A number of scholars have commented on the surprising lack of Tiwanaku material in the Colca area given the obsidian distributions in the Tiwanaku heartland (Brooks et al. 1997; Brooks 1998: 311-313, 454-459; Burger et al. 1998a: 211-212; Burger et al. 2000: 340-342; Wernke 2003: 69-75, 127, 438).

The geographically closest Tiwanaku sites to the Colca in the department of Arequipa are found on the south-west edge of the city of Arequipa (85 km due south), with the best evidence coming from the site of Sonqonata (Cardona Rosas 2002: 78-87). The Arequipa highlands are largely unstudied, and the closest known Tiwanaku site to the Chivay source on the altiplano appears to be 147 km to the east in the department of Puno at the site of Maravillas just north of Juliaca (Stanish 2003: 189). Tiwanaku sites in this region are generally associated with lakeside agriculture or are found at cross-roads along major travel corridors (C. Stanish March 2006, pers. comm.), and to date no Tiwanaku sites are known in the largely pastoral periphery of the northwestern Lake Titicaca Basin in the direction of the Chivay source. Tiwanaku pottery has been found in Cuzco at Batan ‘Urqo (Glowacki 1996: 245) and a Tiwanaku snuff tablet was found at La Real in the lower Majes valley of coastal Arequipa (García Márquez and Bustamante Montoro 1990: 28), but these appear to have been examples of trade goods along the Tiwanaku-Wari frontier.

In the main Colca valley close to the Chivay source, Wari-related ceramics have been excavated from a site just 4 km downstream from the town of Chivay and approximately 10 km from the Chivay obsidian source. A trench excavation exposed red-slipped wares from a domestic context with Tiwanaku Horizon dates in archaeological work associated with the William Denevan’s Río Colca Abandoned Terrace Project at the site of Chijra (Malpass 1987: 61; Malpass and De la Vera Cruz 1986: 209, 216; 1990: 44-46, 57). Radiocarbon dates associated with these red-slipped wares came from a hearth in a house terrace and produced dates of 1140 ±80 (WIS-1713; AD680–1030) and 1290±90 (QL-4015; AD600–900) (Malpass 1987: 61). This ceramic style has recently been investigated in detail by Wernke as part of his elaboration of the Colca valley ceramic sequence (Wernke 2003: 466-477). Other Wari-influenced sites in the Colca Valley include a large, recently located site in on the north side of the Colca river named Charasuta close to the town of Lari (Doutriaux 2004: 212-223) and the site of Achachiwa near Cabanaconde (de la Vera Cruz 1987, 1988; Doutriaux 2004: 202-207). Curiously, Chivay obsidian is not known to have circulated in the Wari sphere at all despite the proximity of these sites to the Chivay source.

In the main Colca Valley, indications of Wari ideological and stylistic influence are the strongest evidence for external links during the Tiwanaku Horizon. In addition to Wari influences at Chijra and Charasuta, the site of Achachiwa provides intriguing evidence of exotic obsidian intruding into the Colca valley. Achachiwa is a large site adjacent to the modern town of Cabanaconde that has a large Middle Horizon component that appears to be Wari influenced, as well as components belonging to a the local LIP occupation and an Inka occupation (Doutriaux 2004: 202-207; de la Vera Cruz 1987, 1988). Brooks reports that she collected seven obsidian flakes for analysis from Achachiwa that were visually distinct from obsidian she had encountered elsewhere in the Colca (Brooks 1998: 447). Of these seven flakes, none were of Chivay type obsidian although the site is only 46 km downstream of the source. Her analysis showed that six of the flakes were from the Alca source (96 linear km away) and one was from the Quispisisa source (300 km away), a strongly asymmetrical pattern that is non-the-less consistent with Middle Horizon obsidian distributions in southern Peru.

Discussion

Chivay obsidian distributions during the Tiwanaku period are somewhat of an enigma. As Tiwanaku persisted for longer than Wari one might expect Tiwanaku evidence at the Chivay source either preceding or simultaneous with Wari presence in the Colca valley. However, the nature of procurement and distribution of Chivay obsidian during the Tiwanaku period was such that diagnostic materials from the consumption zone do not appear at the Chivay source. There appears to have been considerable nuance in the relationships between state leaders, corporate integration, and ethnic local kin-based groups during the period of Tiwanaku hegemony. Groups living in the Tiwanaku peripheral areas were perhaps consistent with Dillehay's characterization as "…a patchwork of overlapping, geographically disparate, and apparently politically semi-autonomous core valleys, oases, and plateaus or foci of cultural development, each of which primarily exploited its own immediate peer area" (Dillehay 1993: 247). Along these lines, Stanish (2002: 188) notes that early states appear to have "selectively incorporated certain areas around the basin" rather than attempt comprehensive control. John Janusek summarizes a variety of evidence demonstrating that "Tiwanaku was an *incorporative* more than it was a *transformative* state, simultaneously employing multiple strategies of regional control and influence" (Janusek 2004b: 162), along the lines of corporate political strategies described by Blanton *et al.* (1996). Accordingly, a direct correlation between the predominance of Chivay obsidian in the Tiwanaku economy and clear, material evidence of incorporation in the archaeological remains of communities in the Chivay source area should not be expected. The political affiliation of Colca valley communities was probably made more complex due to the presence of the Wari frontier during the Middle Horizon.

The asymmetrical, export-only exploitation is consistent with a pattern that has been observed at a number of prehispanic obsidian sources in the Andes. Obsidian sources generally have few diagnostic artifacts or architecture in association with quarrying. It was mentioned earlier that Formative distributions of Alca obsidian were strikingly asymmetric with export to long distance consumption sites but no corresponding diagnostics from those consumers back at the Alca source (Burger et al. 2000: 314, 323). Similarly, the Quispisisa source has little diagnostic evidence the immediate vicinity linking the source to Wari or any other known group, despite the long history of use of that obsidian type in Wari sites (Burger and Glascock 2000, 2002). The asymmetrical nature of Chivay obsidian use during the time of Tiwanaku and Wari is, therefore, consistent with a pattern apparent at raw material sources elsewhere in the Andes where obsidian procurement does not involve reciprocation or discard of diagnostic artifacts from the consumption zone.

Late Intermediate Period (AD1100 – 1476)

Current evidence suggests that following the collapse of the Tiwanaku state, a prolonged drought occurred until AD1200 after which time Aymara chiefdoms emerged in the region referred to as Collasuyu by the Inka. A central question of this time period concerns the extent to which obsidian distributions can reveal whether Tiwanaku period interaction patterns persisted into the LIP in the forms assumed by economic organization and long distance exchange. While the LIP is known as the *auca runa* or the "time of strife" when fortified hilltop refuges "*pukaras*" were constructed in abundance in the Titicaca Basin and adjacent territories, the weapons used in these conflicts appear to have primarily been percussion weapons like slings and clubs, and not obsidian tipped-projectiles.

Chivay obsidian during the LIP

In a review that considers the LIP and Late Horizon together in one discussion, Burger et al. (2000) note the declining presence of obsidian in most LIP and LH contexts in the region. Many of the chemically provenienced obsidian samples from the Titicaca Basin come from surface contexts with either LH or LIP associations, and the pattern revealed in the Titicaca Basin from these samples is one of almost exclusive use of Chivay type material. One of the reasons for the strong presence of Chivay obsidian over Alca obsidian may have resulted from cultural affinities between Aymara groups (Browman 1994). The Colla in the North Titicaca Basin and the Collagua in the upper Colca area share many traits including the construction of *pukaras* (Wernke 2003: 262-263), mortuary features including *chulpa* burial structures and fiber-wrapped mummy encasings (de la Vega et al. 2005; Wernke 2003: 225-234), and other commonalities.

In the northern Lake Titicaca Basin, Arkush (2005: 247) notes that two-thirds of the occupied pukaras throughout her survey area contained obsidian on the surface, and that chert flakes and blades are common. In one instance, at Calvario de Asillo (AS1) prepared obsidian cores and a concentration of flakes was encountered. Obsidian projectile points were small, triangular base-notched points (series 5), consistent with the Klink and Aldenderfer point typology for the Terminal Archaic and onwards (Arkush 2005: 709-711). Metal objects are common as well, with copper and copper-alloy pendants and *tupus* (long pins) frequently found at *pukaras*.

Six obsidian samples from the mesa-top *pukara* and *chulpa* burial tower complex of Cutimbo were analyzed by Frye et al. (1998) and the samples were 100% from the Chivay source. Burger et al. (2000: 343-344) indicate that one obsidian sample from the renowned *chulpa* complex of Sillustani was also from the Chivay source. Burger et al. observe that while a single Alca flake was excavated at Taraco from an LIP context, and another was found on the surface at the LIP or LH site of Kolkeparke near Ayaviri (Burger et al. 2000: 343), the Titicaca Basin is otherwise entirely supplied from the Chivay source during the LIP.

At the rock shelter of Qillqatani (Section 3.4.2) a large percentage (15.4%) of the tools from LIP levels were made from obsidian, although the count is very low (n = 2) and the tools were extremely small. The single obsidian sample that was analyzed proved to be from the Chivay source.

In the south-western Lake Titicaca area, Hyslop (1976: 118-119) found that the Lupaqa sites he encountered in the course of his road system survey contained primarily basalt and quartzite flaked stone. More recent survey work in the Ilave and Huenque drainages (Klink and Aldenderfer 1996) found that high-quality cherts are abundant in the region, which suggests that the prominent use of basalt at the sites Hyslop encountered was by choice, not by necessity, and was perhaps a reflection of lakeshore agricultural activities.

Late Horizon (AD1476-1532)

The expansion of the Inka Empire during the Late Horizon resulted in a restructuring of the long distance movement of goods. The ability of the Inka state to transport stone is vividly demonstrated by the transport of hundreds of andesite ashlars weighing up to 700 kg apiece the 1600 km distance from Cusco to Saraguro, Ecuador (Ogburn 2004b, a). The ability to move people and goods over long distances was an integral part of state apparatus; however, it is evident from obsidian distributions that not all goods were more widely distributed during the Late Horizon.

It appears that if the Inka had a particular demand for a substance it could be acquired from over great distances. The Late Horizon was referred to as the “tin horizon” by Lechtman (1976) due to the lengths that the Inka would go to procure tin for copper production. In the Mantaro Valley, tin was not present in Late Intermediate Period coppers but it was found in all seven copper implements from Late Horizon levels where it made up, on average, 5% of the metal composition (Earle 2001: 311; B. Owen 2001: Tables 11.1-11.3). This tin is thought to have come from mines in Bolivia or southern Peru, and this exchange was facilitated by the Inka state (Lechtman 1976). Thus tin was transported from southern Peru, perhaps from the vicinity of obsidian rich lands of Arequipa, but apparently little obsidian was transported along those same Inka transportation routes.

Ethnohistoric accounts indicate that during the Late Horizon the control of natural resources sometimes occurred through restricted access to raw material sources in the Andes. Access to tunnels leading to particularly rich gold deposits at Inka gold mining operations were restricted at the tunnel mouths (Burger and Glascock 2002: 364; Sancho de La Hoz 1968 [1534]: ch. XVIII: 332). The deposits of other natural resources, such as obsidian, are distributed across the geological landscape such that directly controlling access would have been difficult or impossible.

Burger et al. (2000: 343-347) report very little Chivay obsidian circulating in contexts that are definitely Late Horizon in date. Small quantities of obsidian were found in Cusco, and these turned out to be entirely of the Alca type except for one notable case of Chivay material at Machu Picchu. In one of the only cases of Chivay obsidian use in the department of Cusco since the Late Formative, several unmodified nodules of Chivay obsidian were identified from a collection of small obsidian pebbles excavated by Hiram Bingham in 1912 at the gateway to Machu Picchu. Burger et al. (2000) note the significance of the unmodified state of these small obsidian pebbles, as the small size of these nodules suggest that it was not the tool-making potential, but rather the natural glass itself that was "suitable in its apparently natural state as an offering or sacred object comparable to quartz crystals" (Burger et al. 2000: 347; Rowe 1946: 297). This view is consistent with observations about the possible significance of the 'essence' of obsidian as natural glass in Andean cosmology that will be explored in more detailed below.

Discussion and review of "Late Prehispanic" obsidian

Obsidian distributions during the Late Prehispanic period reflect the dramatic changes in economy and ideology imposed by powerful states in the region. In the Tiwanaku and Wari spheres of influence obsidian circulation achieved its largest known extent. Particularly intriguing are the examples of non-local obsidian consumption in close proximity to rival obsidian sources, a phenomenon that occurs twice during the Middle Horizon. Three samples of Chivay obsidian were found close to the Sora Sora obsidian source in western Bolivia in a possibly Tiwanaku context (Burger et al. 2000: 340), and Quispisisa and Alca obsidian were found at the Wari-influenced site of Achachiwa, only 46 km downstream of the Chivay source, in the lower Colca valley (Brooks 1998: 447). During the LIP this pattern of high mobility and sprawling interregional contact is reversed as regional circulation of obsidian is curtailed and the Chivay regional pattern returns to a distribution confined to the Colca region and the North Titicaca Basin. Finally, during the Inka period, obsidian appears to have had a largely diminished significance, particularly in contrast to other materials that were circulated prodigious distances by the Inka. This discussion of the spatial distributions of prehispanic obsidian will be complemented by a review of the uses and forms that obsidian artifacts assume in the archaeological and ethnohistoric record.

3.6. Obsidian Use in the South-Central Andes

Obsidian was knapped into relatively few artifact forms in the south-central Andes. The most common formal stone implement was a bifacially flaked projectile point, but other bifacial tools such as knives and scrapers were also commonly produced throughout the consumption region. The other major technical class for obsidian artifacts were simple flakes. As a sharp, but fragile, cutting implement, a freshly struck obsidian flake was potentially useful for butchery and wool shearing purposes. Dransart (2002: 108-109) reports that in rural communities modern wool shearing is accomplished either with the lid of a tin can that has been folded over so as not to cut the user's hand, or with a broken piece of bottle glass. Contemporary herders in the Colca region report that obsidian flakes, and sometimes broken glass vessels, are used for castrating animals because it was explained that as non-metal tools do not oxidize, they are less likely to introduce infection into the animal (T. Valdevia 2003, pers. comm.).

A distinctive Andean method of camelid slaughter can be accomplished with a small, sharp flake is described by George Miller (1979: 27-36). The *ch'illa* method of slaughter consists of laying the animal down, cutting a small incision near the sternum with a small flake of stone, and reaching in and manually breaking the ascending aorta where it leaves the heart. Ethnoarchaeological studies have shown that simple flakes are often used in butchering and shearing, and therefore a prehistoric association between pastoral facilities and lithic flakes, both utilized and unutilized, seems probable.

3.6.1. Variability in Andean obsidian use

In many regions of the world prehistoric artifacts made from obsidian can be generally classified by whether the principal function is for display or for some utility more directly related to subsistence. In Mesoamerica and the ancient Near East, both areas with complex societies and elaborate stone tool production, obsidian was used to make bowls, vases, eccentrics, seal stamps, statuettes, and tables, as well as items of personal decoration such as labrets, ear spools, necklaces, and pendants (see references in Burger et al. 1994: 246). Craftspeople also developed efficient, high utility obsidian technologies as well, such as prismatic blades, a form that allows archaeologists to quantify cutting edge to edge-length, error rates, and other efficiency measures.

In the south-central Andes the diversity of artifact forms made from obsidian is relatively low, and it is difficult to differentiate display from utilitarian applications. For example, obsidian projectile points are both sharp and highly visible, suggesting that the points had a display function that underscored their utility as a weapon and as a cutting tool.

Hafting in the Andes

Archaeological evidence shows that bifacially flaked obsidian implements were hafted in a variety of ways. The majority of the hafting evidence from the Andes comes from coastal sites due to superior preservation. Projectile points were hafted to spears, spear thrower darts, and arrow shafts. Obsidian bifacial tools were also hafted to wood or bone handles for use as knives. Hafting materials varied regionally, but hafting was often accomplished using gum or resin, and hafts supported with cotton string have been found in some coastal sites (e.g., Carmichael et al. 1998: 79).

Evidence of use of obsidian

The artifact types predominantly manufactured from obsidian include projectile points and tools for cutting and shearing tasks. While simple flakes are wide-spread and were probably used abundantly for butchering, scraping, and shearing purposes, the utility of obsidian flakes is frequently discounted when flakes are relegated to the “debitage” or “debris” class. In Andean studies bifacially-flaked instruments are the most commonly analyzed obsidian artifact class in archaeological reports from sites in the Andes.

Obsidian artifacts are sometimes found in association with iconographic representations of dark colored artifacts that are similar in appearance to the very obsidian artifacts found in that context (L. Dawson cited in Burger and Asaro 1977: 15). Such is the case with black-tipped darts and knives depicted on Ocucaje 8 through Nasca 6 ceramics and textiles, and obsidian artifacts found in tombs from those contexts. Building on the discussion in Burger and Asaro (1977: 13-18), examples of obsidian artifacts from the south-central Andes follow.

Application	Form	Provenience	Description	Reference
Weapon (probable dart point), conflict	Point	Looted tomb at Hacienda Mosojcancha, Huancavelica.	A point made from obsidian was found embedded deeply in a human lumbar. (Figure C-10).	(Ravines 1967)
Weapon, with spear throwers	Point	Grave 16 at Asia, (central coast of Peru). Preceramic context.	Found in association with spear throwers	(Engel 1963: 56; Uhle 1909).
Weapon, hafted	Point	Tombs at Hacienda Ocucaje, Epoch 10. Early Horizon context.	Points hafted with gum and, in one case, cotton thread to wooden foreshafts.	(Burger and Asaro 1977: 14)
Weapon	Point	Carhua (south coast, Peru)	Point penetrating through arm muscle near humerus (Fig. C-11)	(Engel 1966: 212)
Weapon, dart	Point	Paracas Necropolis	Well-preserved harpoon (Figure C-9).	(Engel 1966: 180c)
Weapon, dart	Hafted projectile depiction	Nasca Phase B1 and B2 diagnostic attribute	Phase B has "Atlatl darts (arrows) in series as ornaments" (Figure C-6).	(Carmichael et al. 1998: 151)
Weapon, poison	Point	Eastern Lake Titicaca	Obsidian is among point types dipped in strong poison from herbs, perhaps curare.	(Cobo 1990 [1653]: 216-217)
Weapon, bow and arrow	Point depiction	Tiwanaku pottery	Archers with bow and black tipped arrows depicted on a Tiwanaku *q'ero* (Figure C-4).	(Bennett 1934: 426-459; Posnansky 1957: plate XXa)
Weapon, hunting	Point depiction	Nasca B vessel	Depiction of darts sailing towards a group of camelids .	(Burger and Asaro 1977: 16)
Tool, Ritual	Knife depiction	Nasca B pottery	Black knives associated with taking of trophy heads.	(Burger and Asaro 1977: 15)
Tool, Ritual	Knife depiction	Nasca textiles, Epoch 1 of EIP	Black knives associated with taking of trophy heads.	(D'Harcourt 1962: 110, 112)
Tool, Ritual	Knife, hafted	Early Nasca	Bifacial knife hafted to painted dolphin palate (Figure C-5).	(Disselhoff 1972: 277
Decorative, Ritual	Mirror fragment	Huancayo, Middle Horizon 2 context	Fragment of obsidian mirror ground and polished to .4 cm thickness.	(Browman 1970: 86)
Decorative, Ritual	Mirror	Huarmey, Wari	Mirror mounded in carved wooden hand (Figure C-8).	(Lavalle and Perú 1990: 185)
Medical	Obsidian knives with blood-stains.	Cerro Colorado, Paracas	Part of medical kit that also contained a chachalote (sperm whale) tooth knife, bandages, balls of cotton, and thread.	(Tello 1929: 55)
Medical	Chillisaa kala, Aymara for "black flint"	Titicaca Basin	Speculation about tools used for trephination.	(Bandelier 1904; Marino and Gonzales-Portillo 2000)

Table 3-10. Examples of obsidian use in the south-central Andes (part 1).

Application	Form	Provenience	Description	Reference
Medical, Ritual	Material used in folk cures	Canchis, Cuzco; and elsewhere	Modern use in folk cures, the stone was believed to have curative powers.	(P. Paz cited in Burge and Asaro 1977: 17; Cobo 1990 [1653])
Medical, Ritual	“knives of crystalline stone”	Titicaca Basin (?)	Abdominal surgery by “sorcerers”	(Cobo 1990 [1653])
Animal castration	Flakes, unmodified or retouched	Colca	“We use sharp pieces of obsidian or glass to castrate herd animals doesn’t cause infection like rusted metal knives.”	T. Valdevia 2003, Pers. Comm. (my translation).
Shearing	Flakes, unmodified or retouched	Andes	“Aboriginal shearing required special implements, perhaps obsidian knives.” Some modern pastoralists use broken glass and tin lids for shearing.	(Dransart 2002: 108-109; Gilmore 1950: 446)

Table 3-11. Examples of obsidian use in the south-central Andes (part 2).

Many of these examples are shown in Appendix C. of this volume. While the diversity of artifact forms was relatively low, it is evident that the visual and fracture properties of obsidian were relevant to the tools that were used from this material. Further north in the Andes, in Ecuador, a greater percentage of obsidian artifacts seems to have filled a primarily decorative role, including a bead, an ear spool, and three polished mirrors (see Burger et al. 1994: 246).

The evidence of use lithics may also take the form of cutting and scraping marks on faunal remains, but the lithic material type can rarely be established by these means. The continued use of glass and obsidian in modern contexts for shearing, butchery, and castration suggests that the prehispanic metals such as copper and bronze did not displace obsidian and other lithic materials for utilitarian tasks. Prehispanic metals were used largely for display, although metals were used in some weaponry, such as mace-heads (Lechtman 1984).

Obsidian in warfare

The evidence for obsidian use in conflict in the Andes comes from a variety of archaeological and ethnohistorical sources, but it is primarily in the form of indirect evidence. The data reveal a great expansion in the production of small obsidian projectile points after the onset of a food producing economy. The majority of Late Horizon weapons that the Spanish faced during their invasion appear to have been bola stones and percussion weapons like maces and slings (Cahlander et al. 1980; Korfmann 1973), as well as padded armor.

Archaeologists working in the south-central Andes vary historically in their assessment of the use of projectiles in the highland region (Giesso 2000: 43). Bennett (1946: 23) asserts that the use of bow and arrow were not important on the altiplano, Metraux (1946: 244-245) says that spear throwers were in use, while Kidder (1956: 138) indicates that evidence from projectiles show that arrows were widely used at Tiwanaku. Of the projectile points analyzed by Giesso from Tiwanaku, 19% were made from obsidian, with the highest concentration of points coming from excavations in the civic/ceremonial core at the Akapana East, K'karaña, and Mollo Kontu mounds (Giesso 2000: 228-238).

In a dramatic example of obsidian use as a weapon, one archaeological find (Figure C-10) shows a probable spear or dart point that penetrated the victim's abdomen from the left anterior abdomen and lodged on the anterior side of the lumbar vertebra.

Evidence of use of the bow and arrow in warfare

One of the strongest patterns in obsidian distributions in the south-central Andes is the sudden onset of obsidian use with series 5 projectile points in the Terminal

Archaic, after 3300 cal BCE In defining the small type 5D projectile points Klink and Aldenderfer (2005: 54) suggest that the widespread adoption of these point types may reflect the use of bow and arrow technology, as these points fall within the size range described by Shott (1997: Table 2) as associated with arrow points (although with substantial overlap with the size of the smaller dart points).

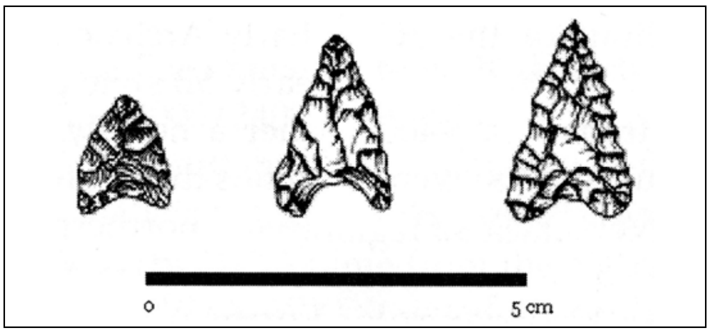


Figure 3-14. Type 5d projectile points from a Terminal Archaic level at Asana and Early Formative levels at Qillqatani, from illustration in Klink and Aldenderfer (2005: 49).

Additional metrics for differentiating arrowheads from dart and spear points have been suggested by Thomas (1978: 470) and Patterson (1985). With Mesoamerican projectile points, Aoyama (2005: 297) has found a very significant correlation between evidence from microwear analysis and projectile dimensions in his effort to differentiate arrowheads from dart and spear points. The relationship between the mass of the item and the velocity and distance of the projectile are discussed in detail by Hughes (1998). She notes that the innovation of fletching allowed for balanced projectiles that had smaller projectile tips and lighter shaft materials, which in turn permitted greater distance and velocity in weapons systems (S. S. Hughes 1998). On a related point, the notched base in all type 5 projectile styles reflects a change in hafting technology. Greater impact loads can be absorbed by mounting projectiles tips with notched bases into slotted hafts (S. S. Hughes 1998: 367; G. E. Van Buren 1974).

Obsidian has a number of attributes that make it a particularly effective material for projectile point tips, most notably are the predictable conchoidal fracture qualities of obsidian that allow it to be pressure flaked into very small projectile points. The sharpness of freshly knapped obsidian margins is unrivalled, and ethnographically obsidian is renowned as a brittle material that can fracture on impact, causing the fragments to produce greater bleeding in the victim of an obsidian projectile (Ellis 1997: 47-53). In materials science, obsidian has extremely low compression strength because it has no crystalline structure (S. S. Hughes 1998: 372). Due to the brittleness or lack of compression strength, missed shots can result in many broken obsidian projectile tips, and perhaps for this reason obsidian was not the predominant material for projectile point production until after the domestication of camelids when hunting was decreasingly the primary source of meat (as inferred from the ratio of camelid to deer bone in excavated assemblages).

Increased velocity and distance is possible with the use of bow and arrow, and obsidian has greater penetrating power, although lower durability, than other material types. Do these changes suggest a greater use of projectiles for warfare? Greater use of small, fletched projectiles might be expected in contexts where the individual needs (1) increased distance from the target (2) increased velocity, perhaps due to change in prey or to the use of padded armor. The use of obsidian may increase in contexts where one needs (1) a material that can be knapped into small, light projectiles as discussed above, (2) increased penetration with sharper material, (3) decreased concern for durability because in warfare the weapon will perhaps be retrieved by the opponent.

Although empirical evidence for warfare is scarce in the Terminal Archaic in the highlands, a study of 144 Chinchorro individuals from Terminal Archaic contexts in extreme northern Chile found that one third of the adults suffered from anterior cranial fractures that probably resulted from interpersonal violence, and men were three times more likely than women to have these wounds (Standen and Arriaza 2000). These wounds appear to have been caused by percussion weapons like slings, but the coastal evidence for interpersonal violence in this time period is strong. Additional support for the introduction of the bow and arrow in the Terminal Archaic come from the region among Chinchorro burials in coastal Northern Chile. Bows among the Chinchorro grave goods date to circa 3700 – 1100 cal. BCE, or the Terminal Archaic and Early Formative (Bittmann and Munizaga 1979; M. Rivera 1991; Standen 2003).

Possible use of poisons on projectile tips

A potential explanation of widespread adoption of the small type 5D projectile points is the greater availability of poisons that reduced the need for heavy, destructive projectiles. South American poison arrows are usually quite small and such arrows are frequently tipped only with a sharpened wooden point. According to Ellis (1997: 55), virtually all ethnographic examples of arrow use include some kind of poison applied to the arrow in order to have either a toxic or a septic effect on the victim. Ellis observes that due to the great variety of substances used to create such toxins, in many regions of study these substances would probably contaminate any chemical attempt to use residue analysis to differentiate the types of poisons used, or even the prey that was hunted, with a particular used projectile point.

A variety of highly effective poisons are applied to the tips of projectiles by hunters in the Amazon Basin today (Heath and Chiara 1977). In the prehispanic Andean highlands, trade contacts with the Amazonian lowlands to the east may have made available poison concoctions for application to projectiles, most notoriously the fast acting paralysis alkaloid *curare* prepared from the vine *Chondrodendron tomentosum* (Casarett et al. 1996).

Bernabé Cobo (1990 [1653]: 216-217) discusses the use of bow and arrow with poisons by “expert marksmen” in his chapter on warfare. He describes the widespread and expert use of the sling for warfare, which is consistent with reports elsewhere on the use of slings, but then he states that bow and arrow were more significant in warfare.

> The most widespread weapon of all the Indies, not only in war but also in the hunt, was the bow and arrow. Their bows were made as tall and even taller than a man, and some of them were eight or ten palms long, of a certain black palm called *chonta* whose wood is very heavy and tough; the cord was made of animal tendons, *cabuya*, or some other strong material; the arrows, of a light material such as rushes, reeds, or cane, or other sticks just as light, with the tip and point of *chonta* or some other tough, barbed wood, bone, or animal tooth, obsidian point, or fish spine.

> Many used poisoned arrows, their points anointed with a strong poison; but, among the nations of this realm, only the *Chunchos* used this poisonous herb on their arrows, and it was not a simple herb, but a mixture of various poisonous herbs and vermin; and it was so effective and deadly that anyone hit by one of those poisoned arrows who shed blood, even though it might be no more than the blood resulting from the prick of a needle, died raving and making frightful grimaces (Cobo 1990 [1653]: 216-217).

The Chunchos ethnic group is described as living in the "forests east of Lake Titicaca on the border of the Inca Empire". It is possible that Amazonian poisons became available in altiplano during the Terminal Archaic due to expanding exchange networks, together with Amazonian hallucinogenics and other lowland products, dramatically altering the efficacy of arrows. As a sharp but lightweight weapon, obsidian tipped arrows would have represented an effective poison delivery system to animal and human victims alike.

While there is no direct evidence for the use of Amazonian poisons on the altiplano, the dramatic change in projectile technology with the type 5D type, co-eval with expanding exchange networks in the region, suggest that a new technology for weapons systems, such as poisons and new shaft and fletching materials, may have influenced the design of projectiles in this time. The transitional economic context of the Terminal Archaic involved many changes, including shifts in both food production and interregional exchange, and the technology of lithic production show significant alterations that correspond to this period.

Multiethnic access to geological sources in the Andes

Salt procurement in the Amazon basin on the eastern flanks of the Andes provides an example of multiethnic access to a raw material source. During annual voyages to the Chanchamayo salt quarry ten days outside of their territory, the Asháninka of the Gran Pajonal (Ucayali, Peru) combine salt procurement with exchange with neighboring groups who share access to the source (Varese 2002: 33-35). Arturo Wertheman, a missionary who traveled through the region in 1876, explains

> Throughout the year small bands of Asháninka traders traveled [the Gran Pajonal] paths to obtain salt, carrying with them tunics or ceramics to exchange for other items and for hospitality. With them traveled their traditions, their hopes, and the information of interest to their society. The Pajonal, the vast center of Campa territory not yet invaded by whites, appears to have been the center of culture and tradition through which the Indians journeyed, like a constant flow of life through their very society (Varese 2002: 120).

Other ethnographic examples of multiethnic access to salt quarries are mentioned in the ethnographic literature. Oberem (1985 [1974]: 353-354) describes access by both the Quijo and the Canelo people to a large rock salt quarry located on the Huallaga River, a tributary to the Amazon lying further north on the border of Peru and Ecuador.

In the Cotahuasi valley of Arequipa, to the north of the Colca valley, the rock salt mine of Warwa [Huarhua] has been exploited since Archaic times (Jennings 2002: 217-218, 247-251, 564-566). Access to the Warwa quarry, which lies near the border of the departments of Arequipa, Ayacucho, and Apurímac, is described by Concha Contreras (1975: 74-76) as including caravan drivers from all three of those neighboring departments.

> El primer viaje lo hacen, mayormente, en el mes de abril. En esta época cientos de pastores se concentran en esta mina. El camino es estrecho y accidentado hasta llegar a la misma bocamina…Desde el fondo de la mina los pastores cargan a la espalda la cantidad de sal que necesitan llevar, de tal manera que hacen muchos viajes al socavón de la mina. En todo este tramo tardan 4 días, porque después de la mina, siguen cargando en la espalda hasta una distancia de aproximadamente cinco kilómetros, donde quedaron las llamas pastando, puesto que hasta la misma mina no pueden entrar juntamente con sus llamas (Concha Contreras 1975: 74).

There appear to be a number of protocols associated with salt acquisition at Warwa. Notably, the multiethnic visits by caravanners from various departments coincide in April despite the tight working quarters at the salt mine. Furthermore, there seems to be concern for impacts in the much-visited the mine area itself. The cargo animals are actually grazing a distance from the quarry and humans are obliged to carry the loads to these areas instead of attempting to load the animals close to the mine. These cases of multiethnic raw material access provide examples of the social and institutional nature of access to unique geological sources, and the focalized attention that these source receive from surrounding ethnic groups. The analogy with regional acquisition and diffusive transport of the raw material is perhaps the closest modern analogy to the nature of prehispanic obsidian quarrying that remains in the Andes.

3.6.2. Symbolic significance of obsidian

Inferring the symbolic significance of obsidian in the prehispanic Andes involves approaching the topic from a several lines of evidence because there are few direct indicators of valuation and symbolic meaning of obsidian in the Andes. Below, these issues are raised as a series of questions that may, or may not, be answered with archaeological evidence from the region:

(1) How did the symbolic importance of obsidian change through prehistory?

(2) Do changes in use of obsidian reflect local geographic availability?

(3) Did the visual properties of obsidian resonate with Andean aesthetic traditions?

(4) Was there social significance in the visible differences between major obsidian types?

Part of the difficulty in inferring the symbolic properties of obsidian is the result of a relative reduction in the importance of obsidian during the Late Horizon and Colonial period, to judge from ethnohistoric accounts. Ethnohistoric sources are a prime source of information, although through Spanish eyes, of cultural significance and symbolic value in the prehispanic Andean world. Despite the apparent decline of obsidian use in the late Prehispanic and Colonial periods, archaeological distributions suggest that obsidian had substantial cultural and ceremonial associations in particular contexts during in Prehispanic times.

How did the social and symbolic importance of obsidian change through time and space?

Obsidian flakes and bifacial tools were sometimes included as grave goods from the Terminal Archaic (3300 cal BCE) and onwards. Ethnohistoric accounts and archaeological evidence indicate that obsidian “knives” were employed in ritual practice as well as in medical procedures throughout the region, although it is not evident if these were bifacially-flaked tools or simply freshly struck flakes. In addition, concentrations of flakes of quartz as well as obsidian from a variety of non-local sources were found in the Tiwanaku ceremonial mound of Mollo Kontu in a regular pattern that was interpreted by Couture (2003) to indicate deliberate inclusion in clay fill rather than accidental redeposition.

Based on analogy from other goods, it is possible that in areas where obsidian is used in ceremonial contexts a finely-made obsidian implement may have been less likely to have been exchanged as an alienable product traded in barter. In some historical contexts, a ritual item may become a singular item and acquire a distinctive ‘genealogy’ related to its social history that precludes it from being bartered and circulated in equivalence for something ordinary such as a sack of potatoes (Hodder 1982; Kopytoff 1986).

However, on the whole, obsidian appears to be one of a number of products that escapes easy classification. On one hand, obsidian circulated in established networks controlled by llama caravan drivers who were responsible for the distribution of a variety of goods on the altiplano. These caravans appear to have been organized by households and derived communities of relatively humble means, to judge from other aspects of their material lives excavated at sites like Qillqatani. On the other hand, as a luminescent material with irregular spatial availability, obsidian had properties that qualify it as a "prestige good" in many contexts (Hayden 1998). In terms of rituals organized and performed on a local level, obsidian was probably one of a number of materials that were traditional but non-the-less slightly rare like ochre and shell. Craig (2005: 683-693) explores the evidence for the symbolic importance of discrete color groups in ritual items like ochre and obsidian in the Titicaca Basin Archaic and Formative site of Jiskairumoko by examining the patterning of obsidian and ochre in comparison to what were common-place, functional applications of these goods.

From the perspective of early aggrandizers in the Terminal Archaic and Formative Lake Titicaca Basin, obsidian probably represented a somewhat elusive product for labor investment and therefore was not a principal substance used in elite strategies by the time of the Middle and Late Formative. From the perspective of prestige technologies serving the agenda of aggrandizers by locking up surplus labor (Hayden 1998), the issue might be considered in terms of the following factors:

(1) Obsidian was relatively easy to acquire, perhaps too easily acquired, for the people living in the highlands of Arequipa; and it was not concentrated in specific, controllable points accessed only through mine shafts.

(2) Obsidian has functional properties that assured its continued circulation for the production of cutting and piercing implements, making it insufficiently rare to have served as a "preciosity" (Clark and Blake 1994; P. S. Goldstein 2000).

(3) While craft specialization was fostered in more closely-controllable contexts in regional centers during the Formative, obsidian sources were perhaps sufficiently distant to have escaped this kind of specialized craft production. In contrast, consider the various non-utilitarian obsidian products made by craftspeople in Mesoamerica, discussed above.

(4) As obsidian was primarily made into projectile point tips, it was perhaps associated with hunting, or the threat of violence. In some regional traditions, such as in Nasca iconography, obsidian appears to have been associated with trophy head taking. However, in the south-central Andean highlands there is no evidence of a direct association between violence, emerging leadership, and control of surpluses along the lines of Hayden's (1995) despotic leader model.

Obsidian products, particularly finely-made bifacial tools, were perhaps one of a series of items that served to differentiate status-seeking individuals in early transegalitarian contexts, but with later crafts investment obsidian appears to have been assigned a relatively specific role for projectile point production and for cutting implements.

Do changes in use of obsidian reflect local geographic availability?

One way to examine the social and symbolic significance of obsidian is to examine the changing use of the material as availability declines with distance from the geological source. To judge from the distant consumption zone, obsidian was used in both mundane contexts and also in ritual or ceremonial contexts. At Tiwanaku, obsidian was found dispersed into the fill of ceremonial mounds (Couture 2003). It is also sometimes found in Titicaca Basin burials as of the Terminal Archaic. As reported by Craig (2005: 570-574, 679-682), at Jiskairumoko and at other sites in the Ilave valley, obsidian has been found in burials dating to 3300 cal BCE and later along with other non-local goods including lapis lazuli (sodalite) beads, gold discs, and gold beads, as well as ritual items like a camelid effigy made from bone. If the associations of obsidian with ritual power were related to its non-local origins, one might expect this pattern to have been weaker in closer proximity to the Chivay source. Items from ritual contexts, such as grave goods from the Colca Valley, and in close proximity to the Chivay obsidian source, may provide data to test this hypothesis.

Do the unusual visual qualities of obsidian resonate with Andean traditions?

Andean traditions place a priority on visual attributes, and links between the visual purity of a material and its essence have been widely noted in some segments of the Andean literature. As a natural glass, the aqueous properties of obsidian cause the material to reflect light which may display the workmanship of obsidian artifacts, as well as the potential sharpness of obsidian tools. Obsidian used for prehistoric tool production was often a homogeneous glass that was visibly consistent, pure in color, and sometimes transparent or banded. The importance of visual qualities of metals in the Andes has received greater attention:

> The social arena in which metallurgy received its greatest stimulus in the Andes was the arena dominated by status and political display. An underlying cultural value system that appears to have strongly influenced the visual manifestation of status and power was a color symbolism oriented around the colors of silver and of gold. The most innovative and interesting aspects of Andean metallurgy arose from attempts by Andean metalsmiths to produce metallic gold and metallic silver surfaces on metal objects that were made of neither metal (Lechtman 1984: 15).

In Andean metallurgy, the appearance of consistency in color, reflectivity and material was prioritized because visual characteristics conveyed information about the inherent essence and animation of the object (Lechtman 1984: 33-36).

There is little direct support in Andean archaeological or ethnohistorical sources for inference regarding how obsidian was perceived, but it would be consistent for obsidian, a stone with the appearance of watery luster, to be associated with ceremonial power and ritual sacrifice given the well-demonstrated importance of stone and water in Andean cosmology.

Were the visual differences between obsidian types in the Andes important?

Visible differences between obsidian chemical types in the region are principally in terms of nodule size, fracture characteristics, glass color, and cortex. While nodule size and fracture characteristics are believed to have been important determining factors in explaining which obsidian types were circulated widely in prehistory

(Burger et al. 2000: 348), glass color is more of visual aesthetic issue. The obsidian sources in the south-central Andes are predominantly black or grey. Obsidian from the Chivay source is often a transparent grey and banded, and Quispisisa obsidian sometimes has a red coloration, although Burger et al. (2000: 314) state that the Quispisisa type is visually indistinguishable from Alca obsidian. As with many goods with discrete places of origin, these visual differences communicate information about the spatial origin of the stone that would have visually linked the material with regions and socio-political groups to knowledgeable viewers. To Brooks (1997; 1998: 452) the transparency of Chivay obsidian was a reason for its wide circulation in prehistory. Others have commented on the transparency of the material including Giesso (2003; 2000), and Burger et al (2000: 296). Giesso (2003: 368) observes that archaeological and ethnographic evidence from the Andes indicate that "transparent elements were viewed as mediators between different cosmological worlds". Further study may permit evaluation of observed patterns in the contexts of obsidian use that are linked to color.

Discussion

The social and ritual significance of obsidian in particular prehispanic Andean contexts appears to have varied across time and space, and with further research in the region into evidence of production and consumption these differences will be better understood. Archaeologists have established that the visual attributes of particular materials like metal were important in the late Prehispanic Andes. If this mode of interpretation may be extended, high quality obsidian shares some visual characteristics with metal such as shininess and an appearance of material purity.

Furthermore, obsidian from particular areas was often visually distinct and this may have conveyed information in regions such as Moquegua where a variety of obsidian types have been encountered. Obsidian was irregularly available across the landscape, and the mere possession of this highly visible material in obsidian-poor regions had possible social significance because it suggested that the holder participated in long distance exchange networks or had alliances with groups in obsidian-rich areas.

3.7. Models for the Procurement and Circulation of Chivay Obsidian in Prehistory

A number of models have been presented for regional interaction and exchange in the south-central Andes (Bandy 2005; Browman 1974, 1980, 1981a; Burger and Asaro 1978: 68-70; Dillehay and Nuñez 1988; Nuñez and Dillehay 1995 [1979]; Stanish 2003). This study evaluates a selection of these models at the Chivay obsidian source in the highlands of Arequipa. Renfrew explored various configurations for interaction and his "exchange modes" are reviewed above in Chapter 2 (Figure 2-2). These models will be discussed with respect to activity at the Chivay source area and material expectations for what may result from each model in the vicinity of the obsidian source. It should be noted that due to the extremely thin cortex on many Chivay obsidian nodules, decortication is not a consistently useful measure of reduction level or labor investment, but none-the-less the Upper Colca lab analysis sought to measure percentage of remaining cortex on flaked stone artifacts. When the geological cortex is of the extremely thin variety, it is sometimes left on the face of tools and it does not pose an obstacle to knapping. As cortical flakes from obsidian with a thin cortex are often smooth, and can be equally sharp, one should therefore not assume that nodules will be decorticated in the quarry area.

A number of modes of procurement are explored here, but these acquisition and exchange modes are not mutually exclusive either in time or space. That is, a variety of processes were likely to have been occurring simultaneously. For example, a independent caravan have transported an obsidian nodule to a site in the Ilave river valley, and then obsidian nodule may have been transmitted through down-the-line trade from the Ilave area to the Tiwanaku area. These models, therefore, will focus specifically on procurement and initial transport from the Chivay source because that is where more direct material correlates for these different models can be expected.

3.7.1. Direct acquisition Model

Description

Direct acquisition by the end user entails high mobility and multiethnic access to the Chivay source. In this model, those traveling to the source would procure only sufficient obsidian for their household or community needs and no more. The evidence of procurement at the source would be the direct impacts of communities of consumers where obsidian was perhaps circulated in a context of generalized reciprocity but specifically not exchanged against goods in *trueque* barter, as that is a different type of procurement. Thus, this category consists of direct, personal visits by the immediate consuming household throughout prehistory.

Model	Exchange Mode	Description	Material Correlates
Direct Access	None	Personal (household) procurement through visits to the source. No exchange.	High variability in procurement, advanced reduction, low density production. Possible presence of discarded non-local low-value materials, and non-local temporary architecture.
Down-the-line	Reciprocity, including barter	Local procurement supplying regional demand through exchange. Barter relationships, delayed reciprocity, and other arrangements between neighbors may have been reciprocated with obsidian.	Low variability in procurement, medium reduction, low to medium density of procurement and reduction. Local debris and architecture at procurement area. Non local portable objects brought into region possible from reciprocation.
Caravans, Independent	Freelance or non-market central places, reciprocity and barter.	Household organized caravans transporting a variety of goods near the Colca. Procurement and transport of obsidian as one of these goods.	Production associated with pastoral facilities, dense processing activity that is moderately systematic. Small triangular proj. point production, possible evidence from variety of non-local goods and architecture.
Caravans, Administered	Emissary, colonial enclave, entrepôt. Redistribution, barter.	Elite commissioned and delegated caravans transporting goods near the Colca. Obsidian procurement for elite use at regional center.	Production with pastoral facilities. Systematic reduction by part time specialists. Possibly non-local elite-related material. Possible evidence of control of source.

Table 3-12. Models of procurement and exchange for Chivay obsidian. Compare terms with those used in Figure 2-2 and Figure 3-3.

Based on low population densities during the Early Holocene it is assumed that the earliest regional consumers of Chivay obsidian in the south-central Andes, the residents of Asana circa 9400 BP, acquired obsidian directly. Direct household acquisition of resources, such as salt procurement, persists to this day in a few places in the Andean highlands. It is possible that the multi-ethnic nature of access to Andean salt mines may serve as a model for procurement that occurred at Chivay during much of prehistory.

As it is generally the altiplano pastoralists that possess the major means of transport, llama pack animals, and direct household procurement by such groups was perhaps common for many types of goods. For example, herders from the community of Paratía (Flores Ochoa 1968: 87-109), to the north-west of Juliaca in the department of Puno, made regular trips to the Colca valley to acquire agricultural goods. If Paratíans traveled directly, it is likely that they used the Quebrada Escalera route passing to the north of Nevado Huarancante which would pass only a few kilometers from the Maymeja area of the Chivay source. On the return voyage from the Colca, if llamas were not overly burdened, a special stop could have been made to acquire a few nodules of obsidian. Similarly, the household-organized llama caravans described by Nielsen (2001) could well have obtained lithic raw material for household consumption if their travel route passed adjacent to a scarce raw material source on a return journey.

This mode of transport requires that consuming households had the social and physical means to travel to the obsidian source. The ability to partake in regional transport, even in a logistical fashion described by Flores Ochoa and by Nielsen, required strong animals, the food security to undergo a risky journey, peaceful conditions and personal security on the isolated travel routes, probable social relationships or contracts with communities encountered along the way, and knowledge of the extraction source area. Conditions of multiethnic access were likely variable in prehistory and knowledge of travel routes and sources of raw material were best obtained through cordial relations with local groups. In short, this means of obsidian distribution requires relatively cosmopolitan travelers with the resources to personally visit the sources of goods needed by the household. This mode of transport is relatively inefficient because individual households or communities sharing resources, by definition, have to personally acquire and produce obsidian in this model of obsidian procurement.

Material Expectations

In the immediate vicinity of the obsidian source archaeological evidence of the direct acquisition mode would produce high variability in procurement, but relatively small quantities in production because consumption would be limited to the households of those visiting the source. Greater amounts of advanced reduction evidence, including bifacial thinning flakes and tools, broken and discarded during manufacture, will be in evidence at the source area. This type of procurement would have the greatest chance of resulting in diagnostic projectile points in the area as advanced reduction and potential discard in the area of the source is expected. When temporal control is available, primarily from datable organic material in excavated contexts, direct acquisition should result in irregular visits to the source area based on household need. In excavation units cultural material will likely be low-density, as soil and perhaps ash from adjacent active volcanoes will have time to accumulate as visitation rates are low.

There is some chance that undecorated, non-local pottery might be found in association with quarrying or with adjacent rest area bofedal zones. For example, Formative Period ceramics from the southern Lake Titicaca are typically fiber tempered, but in the north basin and in the Colca they are grit tempered. Evidence of fiber tempered plainware may have resulted from discard during direct access procurement by southern Titicaca Basin visitors. Other temper and paste characteristics may serve to identify non-local pottery. Alternately, non-local pottery may result from reciprocation activities (i.e., the Down-the-line model), but the notion here is that non-decorated, utilitarian pottery may have been too crude to have served as barter goods.

3.7.2. Multiple Reciprocal Exchanges (Down the line) Model

Description

The multiple reciprocal exchanges model involves the direct acquisition of obsidian by local people for the express purpose of transferring the obsidian to neighboring communities in exchange for other items. In this model, people residing in Chivay area, perhaps no more than one day's travel from the source, procure material and transport it to a location where the obsidian is then exchanged with neighbors.

This kind of procurement resembles Renfrew's (1975: 520) "Reciprocity" and the "Down-the-line" modes (see Figure 2-2), where goods are exchanged with neighboring groups of roughly equal status through a variety of configurations that are essentially reciprocal in some form. While a synchronic barter of obsidian for, say, a chunk of ochre from the neighboring region is easiest to describe conceptually, reciprocity relationships are a manifestation of a wide range of social mechanisms (Section 2.2.2). In the context of the Chivay area, reciprocal exchange arrangements such as barter for other products, or for grazing rights, for labor, or for social functions such as bridewealth, may be evident. Furthermore, delayed reciprocal arrangements between neighbors are extremely common. Evidence of Down-the-line exchange may be encountered in a wide variety of socio-political contexts from

Archaic Foragers to agro-pastoralists living on the periphery of states during the Late Prehispanic. If demand for a product is sufficiently high, archaeological evidence may be encountered of individuals devoting themselves to procurement in order to satisfy regional demand, but substantial quantities of goods would have to be reciprocated because the households that are sponsoring this increased procurement would have fewer provisioners working to bring subsistence to the household. Thus, if down-the-line demand is sufficiently great then the households devoting themselves to elevated rates of procurement would need to barter products for subsistence goods. In the Andes, the pattern observed from items like salt (Concha Contreras 1975: 74-76; Nielsen 2000) suggests that in modern circumstances when demand, and barter values, are sufficiently high, then the down-the-line network may be simply by-passed in favor of procurement through personal or caravan acquisition. Caravans from the consuming zone or adjacent highland areas will make the journey to procure the material and transport it for household use and for barter (a combination of the Direct Access model and the Independent Caravans model).

In a functioning Down-the-line system the flow of information is also important. The changes in the regional demand for a product like obsidian can return to the source area procurers through direct requests, or it might be reflected in increased barter value in a market context. Information exchange may also return specific demands from consumers as to the size, form, or quality of the source material. The temporal regularity of down-the-line reciprocal trade may also be quite variable, as down-the-line networks may dwindle and then be revived during a seasonal gathering or ceremonial occasion. Reciprocal relationships can take the form of mutualism and buffering, they may result from a need to complement the resources on a neighbor's territory, and they often present opportunities for ambitious individuals to advance their interests through differential access to non-local goods.

Material Expectations

Down-the-line procurement involves local people visiting the Chivay source and acquiring goods to supply the reciprocal exchange network, however large that it may be. In the quarry area one should expect local visitors, and therefore local styles in both discarded materials and local architecture. Procurement may take place in the context of embedded economic activities, such as hunting forays into the high country or pasturing of camelids in the rich bofedal adjacent to the source.

If reciprocation for obsidian takes the form of portable objects, such as non-local ceramics, one may encounter diagnostic, non-local goods in the communities adjacent to the obsidian source. These may be in the form of styles belonging to neighboring communities, or more exotic styles may be found on non-local goods that could have arrived through the exchange network from even more distant areas. There is a high likelihood that reciprocation for obsidian would have taken place in other forms as well: goods that are perishable, labor, or other assets that are otherwise less easy to detect.

If locals are involved obsidian procurement at the Chivay source one may also find that the large nodules available at the Chivay source are used in the local economy as well. That is, if nodules in the Chivay source are up to 30cm in length then large flakes, either cortical or non-cortical, may be expected to have been discarded in residential contexts in local communities. If large nodules are available then those that are not exchanged with reciprocal partners are put to use for local needs. Thus when large cores and flakes are procured in the Chivay source area, then appropriately large flakes should be discarded in the middens of communities in the adjacent consumption zone in the upper Colca.

Procurement and initial reduction at the source will have relatively low variability because it is conducted by the same local methods. Local people will have better knowledge of high quality extraction loci and perhaps there is lower variability in procurement locations as a result. As reciprocity networks, and particularly barter arrangements, are contingent on visual attributes of bartered items one should expect medium reduction of material at the source or in the adjacent communities. At the very least, nodules will be partially decorticated and an initial strike that provides entry into the core should be expected, as this serves to expose the quality of material on the interior to barter partners. Furthermore, if transport does not involve camelid cargo animals (because reciprocity is either taking place pre-domestication during the Archaic Forager period, or otherwise does not involve camelids) one might expect a greater concern for the weight of the nodules and therefore further reduction in the vicinity of the obsidian source.

More advanced reduction may also be expected as it minimizes risk and waste by producing blanks, preforms, and prepared cores in the vicinity of the source where obsidian is abundant. However, according to the Down-the-line model producers have the greatest social distance, and therefore the least information, about their consumers. Advanced reduction limits the possible forms that artifacts may take, and therefore producers would need to know what kinds of tools consumers were planning to produce in order to move beyond initial stages of reduction. Thus medium level reduction might be expected, but not an abundance of advanced reduction at the Chivay obsidian source.

3.7.3. Independent Caravans Model

Description

Long distance transport of goods by way of camelid caravans was well established in the prehispanic Andes. The strongest evidence for the importance of caravan transport comes in the form of ethnohistoric and ethnoarchaeological studies described earlier in this chapter, however archaeological evidence of caravan traffic is usually very light and it often requires inference from indirect evidence. The "Independent Caravans Model" described here consists of caravans organized on the household level, although ethnographic studies show that, in practice, the members of several households will often band together for company and for safety while participating in long distance caravans. It is worth pointing out that independent long distance transport does not necessarily involve cargo animals. It is possible that small quantities of obsidian were carried by traveling peddlers. As a variant to this model, one should consider that peddlers carrying small portable items, mostly cultural goods like herbs, shell, feathers, but potentially small obsidian tools or cores, could have circulated objects widely without the assistance of llamas.

According to this model, a household with a sufficient number of cargo animals, usually castrated male llamas, will initiate a trade caravan by transporting goods that they expect will be in demand, to regions that they anticipate will have complementary goods to offer them. According to some descriptions, caravans are pursuing a directed acquisition of specific goods and then they return directly home, while other models describe entire circuits where herders acquire goods, travel, barter for other goods, travel some more, perhaps re-trade their new goods and so on; finally returning to their place of origin several months later.

The mere presence of products distributed over larger distances is not proof of caravan transport, either household organized or administered, because other modes such as direct acquisition and down-the-line models actually result in widely dispersed goods as well. Furthermore, many of the distinctive objects that archaeologists recognize as non-local are often small enough to have been transported without cargo animals. Establishing the beginnings of caravan transport is not a simple task because there is no one signature for long distance caravan organization that is distinctive from other modes of transport. Furthermore, many of the goods are believed to have been perishable, complicating efforts to interpret prehispanic trade caravan patterns. Finally, studies of contemporary caravans emphasize that diversified strategies characterize caravan driving, whether in making daily decisions while on the trail, or in the larger context of economy and exchange. It is thus difficult to define a consistent indicator for caravan activity.

Portable diagnostic artifacts, whether decorated ceramics or other exotic goods, are often relatively small and therefore the artifact weight and total quantity frequently cannot be used to differentiate between caravan transport, traveling peddlers, and down-the-line exchange. The temporal regularity of exchange, however, is a consistent measure that archaeologists can recover from stratified deposits. When regular caravan transport routes developed then the scheduling of such transport may have been linked to the timing of annual events such as harvests and annual ceremonies, and if so these cyclical patterns would result a steady accumulation of non-local goods through time. In contrast, down-the-line exchange depends upon the articulation of many individual exchanges and it is not linked to the acquisition of scheduled harvest products in the same manner as caravan transport and therefore the presence non-local goods would have been irregular.

In terms of the network configurations discussed earlier (Figure 2-3), the configuration that describes the diffusion of obsidian in the region is distinct from the configuration of the regular articulation between herders and farmers that involved the barter of pastoral products for agricultural products. However the regular conveyance of some agricultural goods adjacent to a raw material source creates a context for conveying larger quantities of obsidian regionally. Ethnographic studies indicate that caravans will opportunistically embed exchange into other activities. For example, Nielsen (2000: 488) explains that caravans primarily organized around salt transport would carry a variety of other trade items, and they would occasionally stop to procure raw materials, such as lithics, when the caravan route travels past a known source. Similarly, there is caravans that visited the Colca valley in prehistory from the Titicaca Basin were passing with 3 km of the Chivay source if they used one of the popular routes into the Colca from the south-east direction. Thus, procurement of obsidian was likely to have been associated with long distance exchange opportunities.

Material Expectations

Caravan procurement would have consisted of pastoralists traveling to the Chivay source, acquiring obsidian that they believed to have exchange value, perhaps processing the nodules to some extent, and then transporting the material to consumers or to other traders in areas far from Colca. As temporality is a significant part of caravan organization, regular and dense procurement activities are expected when a caravan undertakes a detour from the principal travel route. Some preparation or maintenance of the trail from the principal travel route to the obsidian source is expected if the animals are heavily laden. The amount of processing and initial reduction in the source area probably reflected the number of days that a caravan would have been willing stop, and conversely the transport of whole nodules is conceivable with the assistance of cargo animals such that some extra grams of weight were less of a limiting factor. As mentioned, cortex is often very thin on Chivay obsidian, therefore it would not be surprising if some percentage of the material transported away from the source area included unreduced, whole nodules.

Ethnoarchaeological studies report that caravan drivers look for camps that include high quality pasture, water, and corrals if possible. When these features occur close to an extraction site, a relatively dense obsidian processing area may be found nearby because herders can nourish their livestock while simultaneously working stone. Because of the temporality of caravan activity, procurement was probably intensive, though episodic, through time. When caravans or animals were present, processing would occur and then the material would be conveyed away and the quarry area would see little use until the next episode of intense production. Evidence of production may be variable, however, because caravans could also transport whole nodules without very much difficulty.

Many of the artifact types that were produced from obsidian transported by caravans can deduced based on archaeological evidence acquired from consumption contexts dating to the Terminal Archaic and later. The principal artifact form made from obsidian during the time that camelid caravans conceivably operated (subsequent to the Late Archaic), is the small triangular projectile point diagnostic to the Terminal Archaic and later. This is not to say that other tool forms were not being made, as other non-diagnostic biface forms could also date to the Terminal Archaic or later, however the vast majority of bifacially-flaked obsidian artifacts are projectile points. Furthermore, cores were likely transported away from the obsidian source because simple flakes serve as valuable cutting tools. Therefore, the majority of obsidian production would have prioritized the production of cores and flakes that serve as blanks for triangular point production. If advanced reduction occurred in the quarry area it is likely that small, triangular point forms were the objective.

Reduction strategies that target the production of small triangular points were probably relatively flexible because these point forms are not especially long or delicate, and therefore it would have been possible to produce the appropriate blanks from a variety of core forms. None-the-less, the overall variability in formal tools forms produced from obsidian is exceptionally low because series 5 points look quite similar. Therefore in terms of intensified production from the Terminal Archaic and onward, relatively consistent reduction strategies in the procurement workshop zone may be encountered.

Because these caravans were independent, one might expect slightly greater variability than in the other models of obsidian distribution because various individual households were participating in this procurement, and methodological variation by region might be reflected in the reduction methods. Finally, independent caravans may behave in other, relatively variable ways such as in architecture, in divergent ceramic styles, and in the types of obsidian pieces that were being exported.

3.7.4. Elite-Sponsored Caravans Model

Description

Ethnohistoric evidence suggests that elites commissioned long distance trade caravans to procure materials that were used in a variety of elite strategies at the regional center. As discussed above, Stanish argues that Titicaca Basin elite-administered long distance trade involved acquiring goods for favorable barter rates in distant valleys and then acquiring prestige from the redistribution of these goods. Late Prehispanic elites were probably in a good position to initiate large caravans: they had immense camelid herds and their followers owned them tax payments in the form of labor. In addition, elites would have had the surpluses necessary to initiate a large scale trading venture.

Would such caravans have visited the Chivay source and extracted obsidian for elite consumption or redistribution? Stanish (2003: 69) argues that all Prehispanic trade was administered trade, as opposed to market-driven trade, but he specifically excludes trade in obsidian as “small and light” and capable of being transported through down-the-line exchange. Obsidian does not appear to have been a high prestige item along the lines of precious metals in the prehispanic Andes. Under the Inka there is evidence of control of access to tunnels leading to rich gold mines in the Andes (Burger and Glascock 2002: 364). With obsidian, however, there is no evidence of elite control either in obsidian consumption patterns in regional centers, or in the Arequipa obsidian quarry areas that are generally dispersed and it would have proved difficult to limit access to them (Jennings and Glascock 2002: 115-116). Thus extensive elite-administered acquisition or redistribution of obsidian should not be expected. Nevertheless, given the importance of exchange and non-local goods in issues relating to the origins of social complexity, any evidence of elite-organized raw material procurement should be studied closely.

Material Expectations

Elite-administered caravans would be relatively difficult to differentiate from independent caravans in their source activities. Elite related diagnostic pottery may be encountered in the vicinity of the source area. There may have been some degree of greater standardization if these were part time or full-time specialists working for the elites. Elite-sponsored procurement may involve greater intensification than would be expected from independent caravan procurement because these task groups likely have been organized and dedicated to the procurement objective. Finally, the export of large nodules may have increased as elite-sponsored caravan trains were reportedly large and capable, and the weight of nodules would not have overly interfered with the progress of the caravan following this model. In addition, if the object of elites was prestige building, larger nodules would probably have been more impressive in the distant consumption zone. In short, differentiating elite sponsored caravans at the source may be relatively difficult unless pottery or some other diagnostic material is found to have been associated with procurement.

3.8. Summary

This chapter establishes the background for further research into the production and circulation of Chivay obsidian in the prehispanic Andes. The chapter began with a review of different forms of exchange based on Polanyi's framework but discussed in light of Andean prehistory. The specific geographical and cultural conditions that distinguish ancient Andean economies were placed in a context that is comparable with other mountain culture regions.

Theories of culture change might suggest that regional exchange requires the managerial or coercive power of elites to organize caravans and benefit differentially from the trade goods. However, archaeological evidence shows that the persistent obsidian exchange that moved small quantities of obsidian since the Early Archaic saw a significant increase during the Terminal Archaic. This increased circulation of obsidian is an early symptom of the dramatic economic and social changes that would occur in the south-central Andean highlands in Formative times.

The evidence of this circulation was perhaps not apparent at early centers because these centers were not yet dominating regional exchange patterns through the control of labor and large herds of camelids that are believed to have been a feature of Late Formative primate centers. The mechanism responsible for disseminating obsidian to the region beginning in the Terminal Archaic is perhaps related to a number of interrelated phenomena. The principal factors governing this change may include: the lowered cost of interaction and transport of weight facilitated by caravan animals, the expansion of regional-scale social networks, and the impetus provided by the needs of some to differentiate themselves in this time of emergent social ranking through the ownership of non-local goods such as obsidian.

– Chapter 4 –

Regional Geography and Geology

of the Upper Colca Project Area

The Chivay obsidian source is located on the margins of the Peruvian altiplano above the Colca Valley in southern Peru. The geographical position of the obsidian source area (71.5° S, 15.6° W) at on the western edge of the altiplano above the richly productive Colca valley had bearing on the circulation of Chivay obsidian in regional prehistory. This chapter begins with an overview of the geographical relationships in the Upper Colca study area including climate, biotic zones, and resource availability. The chapter will then describe the ecological and geological context in the Colca Valley, and the influences that spatial relationships may have had in prehistory.

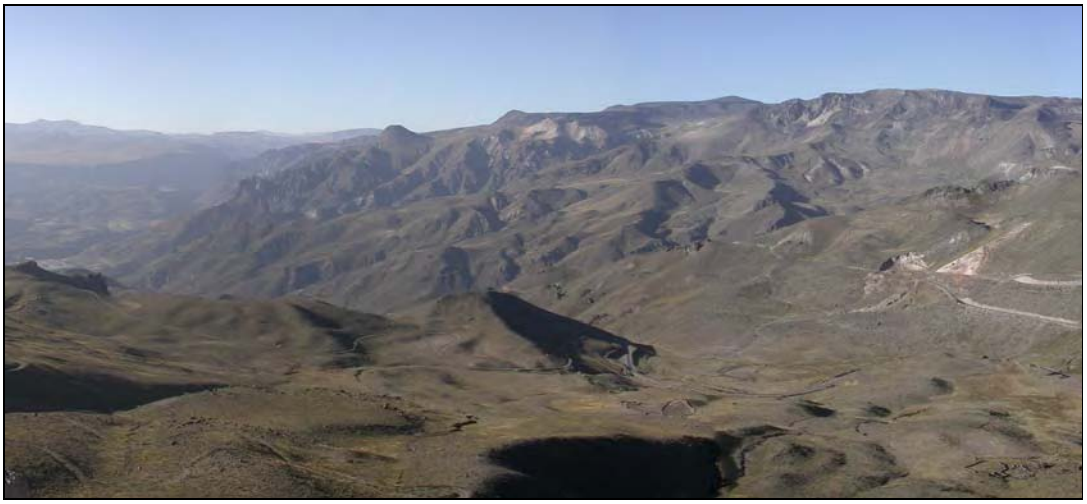


Figure 4-1. View of the volcanic Chivay source area above the town of Chivay in the Colca valley. The high point in the center-right of the frame, Cerro Ancachita, is above the Maymeja area. This view is from the Arequipa highway to the south-west of the Chivay source at 4720 masl.

Subsequently, further details on the geological structures in the area of the Chivay obsidian source will be presented, together with the geomorphological process that have influenced obsidian procurement in the area. Finally, this chapter concludes with a discussion the formation of silicic lavas and tool-quality obsidian, and the research that has been conducted to date documenting Tertiary obsidian flows in the Colca Valley.

4.1. The geography of the Colca Valley study area

A brief review the geography of Upper Colca study area better contextualizes the ancient lifeways and relationships that are the subject of this dissertation. The 2003 research project was organized into three distinct blocks of contiguous survey (1, 2, 3) with other adjacent areas numbered 4, 5, and 6. The three major survey blocks correspond with ecological zones in the Upper Colca area and the overall ecological variability in the project area will be reviewed here by a discussion of each block.

Ecological complementarity between highland herders and valley agriculturalists is a widespread feature of Andean economy. Research into the productive potential of “pure” pastoralism in the Andes has shown that the caloric return and efficiency is insufficient to sustain communities without inputs from non-pastoral communities (R. B. Thomas 1973; Webster 1973). The Upper Colca study area lies immediately above the altitude of intensive valley agriculture that begins at the village of Tuti (3840 masl), corresponding with the upper portion of the *suni* and with the *puna* ecological zones, and reflecting the local precipitation and temperature gradient (ONERN 1973: 39; Pulgar Vidal 1946). The town of Tuti is at approximately the altitude of Lake Titicaca, and in some ways the land use practices observable upstream of Tuti in the Callalli area are comparable to those in the Lake Titicaca Basin, although this western slope location does not have the moderating effect of the large lake body itself.

Local elevation	Zone	Description	Upper Colca Survey Blocks
4000 – 5000	*Puna*	Rich pasture lands and rugged volcanic terrain in the Chivay obsidian source area, the San Bartolomé puna near Chalhuanca, and below to the town of Pulpera.	1, 2, 4, 5
3600 – 4000	*Suni*	High elevation agricultural lands, lower quality pasture, upper river valley from Chivay to Sibayo / Callalli.	3, 6
3300 – 3600	*Kichwa*	Lower portion of the main Colca valley.	None

Table 4-1. Andean ecological zones with approximate local elevation values for each zone.

Annual rainfall ranges from 550 and 750 mm, depending on elevation, and the average annual temperature is 1° C in the puna (ONERN 1973). In this area, precipitation is higher with altitude, but temperature, especially night time temperature, drops with altitude. The result is a balance between the potential for dryland agriculture, altitude, and climate that has periodically allowed farming in the Upper Callalli area in prehispanic and Hispanic times.

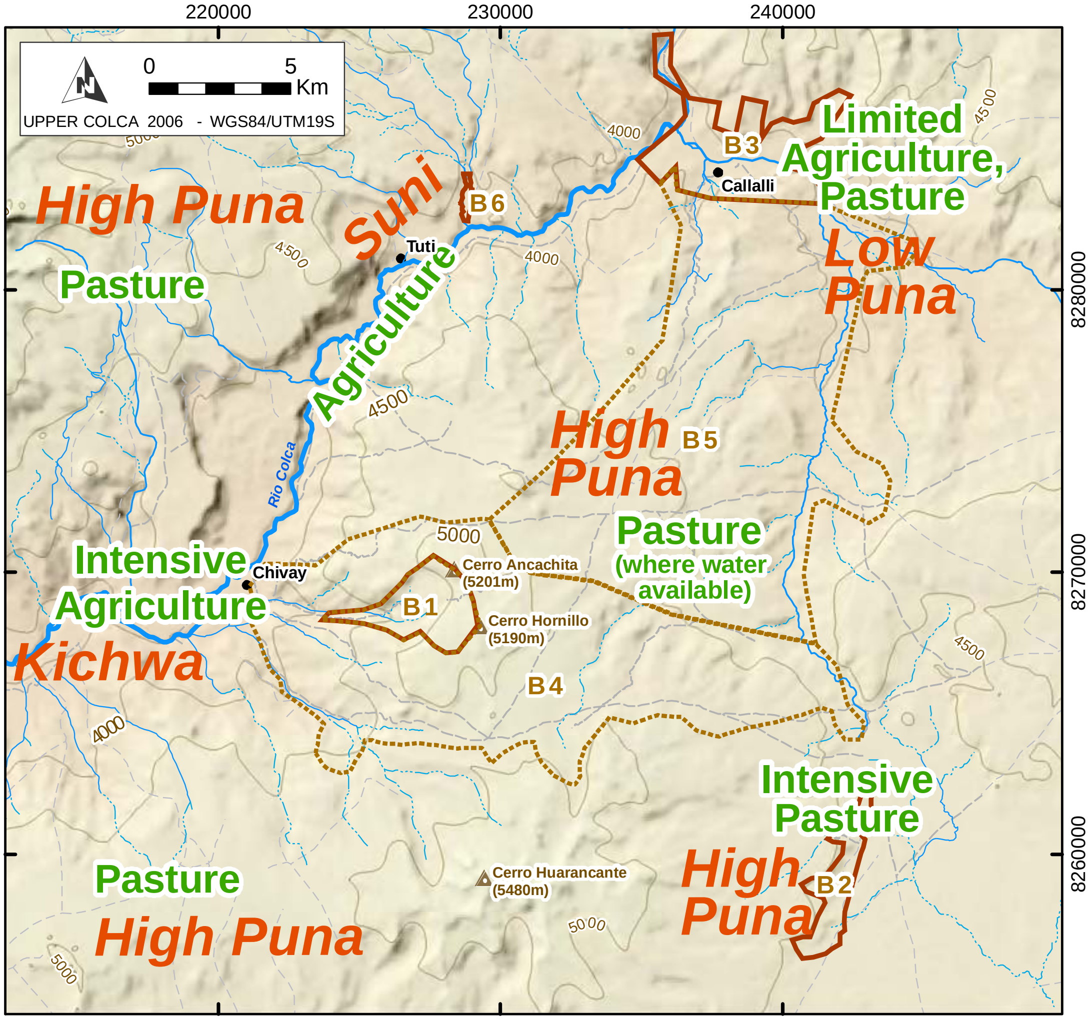


Figure 4-2. Survey blocks in the Upper Colca study area are shown with modern production zones described in Table 4-1. These zones reflect changes in altitude and rainfall as the Colca river, descending westward, is surrounded by puna pasture lands.

A relationship of mutual benefit exists between residents and resources of the higher altitude ecological zones and the vegetatively-productive main Colca valley. A principal assumption of this research is that the procurement of resources like obsidian have long been structured by the human use of complementary ecological zones. Some form of regular articulation between the highlands and the valley therefore probably existed through much of prehistory without special recourse for obsidian provisioning. This interaction may have taken the form of regular visits to the Chivay obsidian source area by valley agriculturalists, who may have been hunting or herding in the adjacent highlands, or by way of visits by highland pastoralists traveling from the puna regions in order to visit the Colca valley to barter for agricultural goods.

4.1.1. Climate across the study area

The Colca valley is located in the western cordillera of Andes in a semiarid climate that is cool and unpredictable. As a high altitude region of tropical latitude, diurnal temperature variation is more prominent than annual temperature variation (Denevan et al. 1987; Troll 1968). Precipitation is highly seasonal, however, and it is changes in rainfall and availability of pasture that strongly influence the scheduling and intensity of pastoralism and dry land agriculture throughout the study area. The south-central Andes is a region south of 15° S latitude, outside of the Intertropical Convergence Zone, and precipitation is relatively unpredictable with high interannual variability because it results largely from the convection of humid air from the Amazon Basin to the east (A. M. Johnson 1976). The western slope of the Andes thus lies in a rain-shadow, and warm, dry winds from the east result in low average annual precipitation as one descends the western flanks of the Andes. In the ecotone that is the Upper Colca study area the herding economy thrives, because these communities can seasonally exploit the rich pasture lands and greater rainfall of the high puna while simultaneously interacting with the communities and products of the main Colca valley, communities to which they may have family linkages.

Of the major obsidian sources in the Andes, the Chivay obsidian source is the highest elevation source and the environmental conditions in the area during prehispanic procurement visits to the source are the subject of some speculation. Annual climatic variability under modern conditions at the Chivay source can be inferred from the relationship between altitude and temperature, known as the lapse rate, and this rate may be calculated using records from nearby meteorological stations. A mass of rising air will cool at the dry adiabatic lapse rate that is often estimated as 0.98° C per 100m of ascent for dry conditions, while the saturated adiabatic lapse rate is typically 0.5° – 0.6° C per 100m at dew point when temperatures are around 10°C (Adiabatic lapse rate 1999). This theoretical lapse rate may be compared with empirical temperature data reported by the ONERN environmental investigation, a regional study of the entire Majes-Colca drainage that preceding the construction of the Majes hydroelectric project. These data include mean monthly temperature records from meteorological stations at Pañe near the Colca headwaters, Sibayo on the northern edge of our Upper Colca study area, and the mid-altitude stations of Arequipa and Pampacolca (ONERN 1973; WMO 2006).

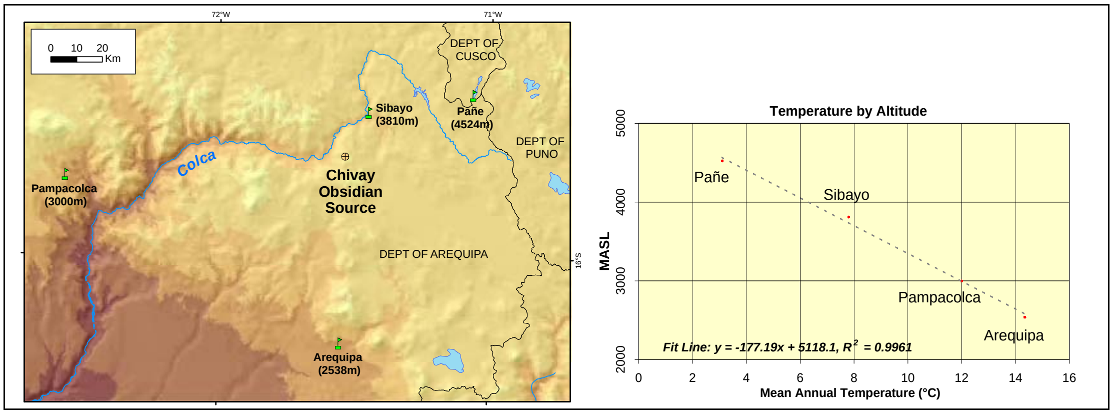


Figure 4-3. Temperature by Altitude at mid- and high-altitude Arequipa meteorological stations. All data from ONERN (1973) except Arequipa values from W.M.O. (2006). These data represent a lapse rate of -0.56°C per 100m of ascent.

These empirically-derived mean annual temperature values from the Arequipa sierra show a lapse rate of -0.56°C per 100m, which is in the range of the standard saturated adiabatic lapse rate of -0.5 to -0.6 per 100m, discussed above, from which can be inferred a mean annual temperature of 0.8°C at the Chivay obsidian source. Given the aridity of this region much of the year, the relatively low-slope (saturated) lapse rate is unexpected and the raw tabular data in the ONERN report suggests that a more detailed examination of the data will better allow the temperature variation at the Chivay obsidian source to be inferred.

Models based on local meterological data

Monthly mean temperature data collected from 1952 – 1970 at local meteorological stations show highs, daily means, and lows, and the considerable differences from the lapse rate function that probably result from the dramatic diurnal temperature variations and the relatively thin atmosphere in this region. The seasonal effects on lapse rate can be considered by looking more closely at data from the nearest reliable weather stations, at Sibayo and Pañe.

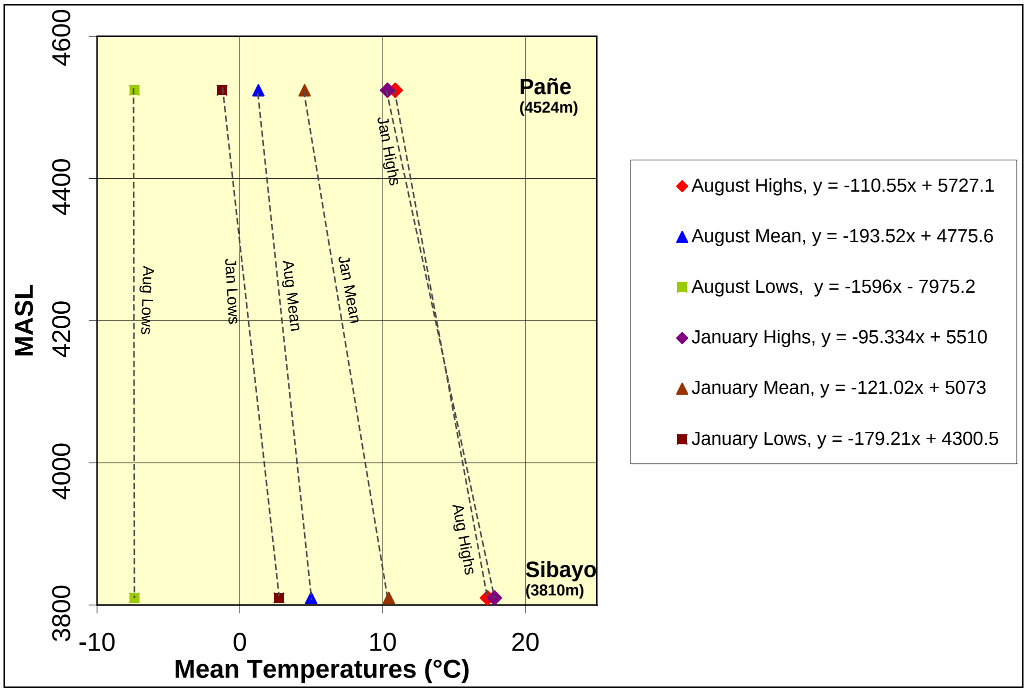


Figure 4-4. Comparison of Temperature highs, means, and lows for August and January from two meteorological stations with records kept between 1952-1970 (ONERN 1973).

		August (winter, dry)			January (summer, rainy)		
	Altitude	Lows	Mean	Highs	Lows	Mean	Highs
Sibayo	3810	-7.4	5.0	17.3	2.7	10.4	17.8
Pane	4524	-7.8	1.3	10.9	-1.2	4.5	10.3
Maymeja	*5000*	*-10.2*	*1.0*	*6.6*	*-3.6*	*0.6*	*5.6*
Temp. Change / 100m		-0.5	-0.1	-0.9	-0.5	-0.8	-1.0

Figure 4-5. Mean monthly temperatures (°C) from data in ONERN (1973). Inferred temperatures at the Maymeja area of the Chivay obsidian source shown in italics.

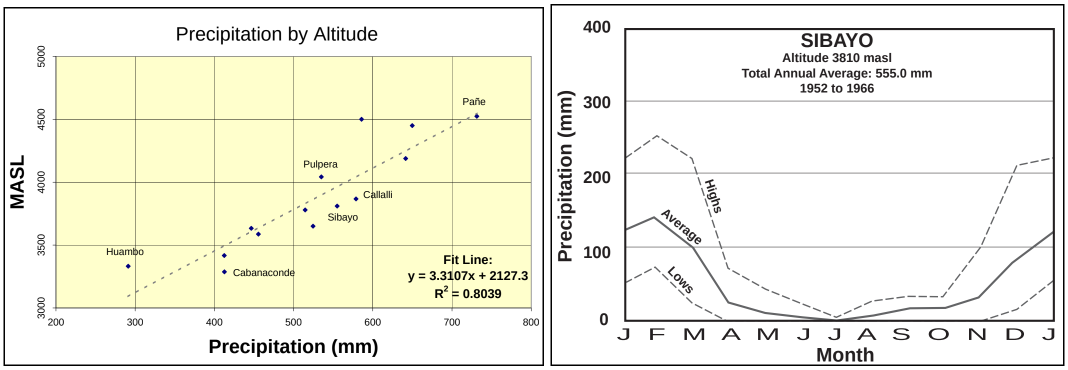


Figure 4-6. Precipitation by Altitude (left), precipitation in the study area (lines represent highs, averages, and lows) is highly seasonal as shown in 14 yr precipitation record from Sibayo on right. Data from ONERN (1973).

The local relationship between altitude, temperature, and precipitation on the dry western slopes of Arequipa are evident in these data derived from tables provided by ONERN (1973, Appendix II). Diurnal temperature variation, highest during the dry winter months of July, August, and September results in a steep lapse rate such that low temperatures in Sibayo, near the lowest part of the study area, are only 3° C warmer than those mean winter lows at the Chivay source. Curiously, the high temperature values cross over between summer and winter months (Figure 4-4)

resulting in somewhat more of a temperature difference between Sibayo and Pañe during the rainy summer months than the winter months, probably reflecting the higher precipitation at altitude. As most precipitation, including snowfall, comes during the summer months of January and February, greater cloud cover and reduced solar insolation at altitude are expected during the summer months.

At the Chivay obsidian source the inferred temperature values are in keeping with observations made during the course of research at the source in August and

September 2003, as will be discussed below. This is not to suggest that the modern climate regime existed during prehispanic times, but these relative contrasts in temperature and precipitation values throughout the Upper Colca study area probably have existed throughout the Holocene although actual precipitation and temperatures varied from those of the modern conditions. Paleoclimatic reconstructions from the Terminal Pleistocene and through the Holocene using data from cores collected in large lakes and glaciers were discussed in Chapter 3.

It is important to stress that adiabatic lapse rate temperature estimates do not account for other important factors affecting local climate such as local insolation, vegetative cover, and wind, as well as temperature contrasts due to solar heating where the atmosphere is thin, and temperature inversions in mountain valleys (uncommon at tropical latitudes). Further, orographic effects such as mountain and valley winds have specific and localized effects in the Upper Colca survey blocks. Seasonality in the upper Colca region includes rain and snowfall in the highest reaches during the wet summer months as well as a high incidence of lightning strikes (a major cause of death in the Peruvian highlands today). Modern herders in the Colca area adapt to these conditions by distributing their impacts and exploiting the high altitude resources primarily during the dry season.

The equatorial bulge in barometric pressure

An issue related to temperature variation is the presence of an equatorial bulge in atmospheric pressure as one ascends to high altitude (Ward et al. 2000: 26-28; J. B. West 1996). In low latitude areas, barometric pressure at a given altitude is correspondingly higher than is pressure at that altitude in mid and high latitude areas of the world.

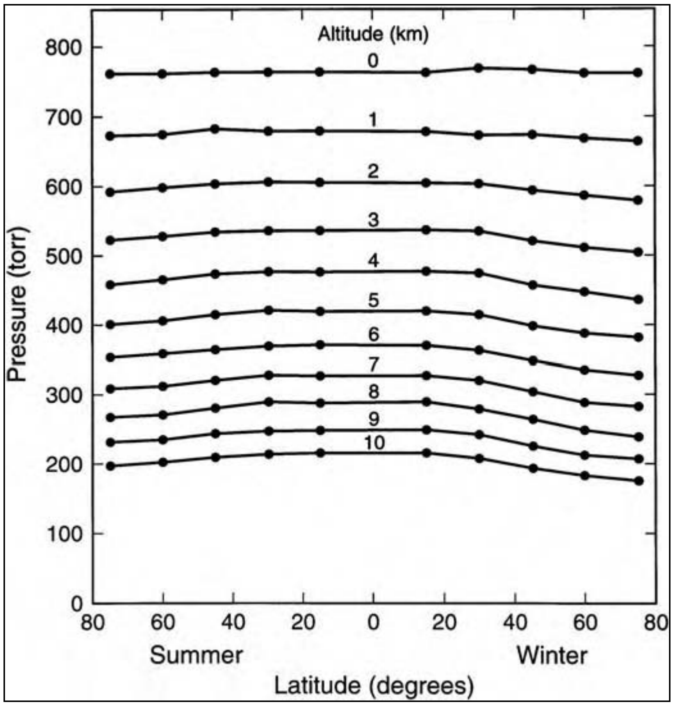


Figure 4-7. Latitude against barometric pressure (from J. B. West 1996). Lines show altitude in km. Annual temperature seasonality is minimal in the equatorial areas and thus seasonal effects at low latitudes are not shown in this graph.

Models of variance in barometric pressure with latitude at a given altitude based on data derived primarily from weather balloons explain why there is greater available oxygen at 5000m in low latitude areas than in high latitude areas. The differences in pressure are particularly notable during high latitude winters.

Altitude	15° latitude	60° latitude, summer	60° latitude, winter	*Equivalent Altitude*
4000	475	462	445	*3479*
5000	419	406	387	*4400*
6000	369	356	335	*5310*

Table 4-2. Equatorial bulge and effects on barometric pressure (in torr) at 15° and 60° latitude. From data in (J. B. West 1996: 1851). Equivalent altitude column shows altitude at 60° latitude with equivalent pressure to the value shown at 15° latitude.

As shown in Figure 4-7 and Table 4-2, the equatorial bulge in pressure means that the available oxygen at the Chivay source at 5000 masl is only close to the pressure that of a location nearly 1000m lower if the source were located at 60° latitude (in winter). In other words, during the winter at 60° latitude, at approximately the latitude of Anchorage Alaska, one would have to be at only 4400 masl altitude to find available oxygen at levels equivalent to that found at 5000 masl at the Chivay source. Barometric conditions similar to those found near the summit of Nevado Ampato at 6000 masl can be found in winter at 5310 masl near Anchorage, AK. The high altitude Chivay source is not as inhospitable as would be this zone at the equivalent altitude in higher latitude areas. Resource patches, such as rich bofedal grazing areas, are sufficient to draw seasonal or permanent residents to these altitude zones in the Andes. Raw material sources, particularly mining operations, are another significant draw to high altitude locations both in past and in modern times (Ward et al. 2000: 336-344).

4.1.2. Lower elevation biotic zones: Study Area Blocks 3 and 6

Beginning with the lower elevation part of the survey area and moving upstream, the vegetation of the Colca valley above Tuti consists of low grasses dominated by the *ichu* variety during the dry season. The Colca River is relatively low gradient in this area, and two or three levels of natural river terraces are evident along the valley margins. The geography of the zone is dominated by the fact that the confluence of two large river systems (Colca and Llapa) occurs here. This area holds the largest settlements in our study area, but both agriculture and pasture appear marginal in immediate area of these towns. Rather, the settlement of the upper river valley seems to reflect the importance of the articulation between the main Colca valley and the broad altiplano. The village of Sibayo rests precisely at the main confluence of the Colca River and the Llapa River, and as is evident in the Shippee-Johnson expedition, Sibayo has long served as a principal modern ingress to the Colca Valley until the Chivay-Arequipa highway was completed (Shippee 1932).

Settlements

The bulk of the contemporary populations in the study area reside in towns in block 3 established during the colonial period that are distributed along the Colca river. The largest settlement inside the study area is Callalli, a town with a 1993 population of 1295 persons, and across the Colca River the population of the town of Sibayo is 508, and upstream in Block 5 the cooperative of Pulpera numbers 85 residents (I.N.E.I. 1993). These towns are primarily service centers and district seats for widely distributed populations with an economy based largely on pastoral products, and on extensive interaction through trade with their wealth in camelid herds, and have long resided in rural hamlets and herding outposts. Callalli and Sibayo first formed as part of the sixteenth century reducción of the Yanque Collagua, and in the colonial period the province of Collaguas (Caylloma) held three-quarters of the livestock in all of Arequipa (Cook 1982; Manrique 1985: 95-96). The dominance of the herding economy in these upper valley towns is evident in the 1961 census where both Callalli and Sibayo populations are reported as 93% “rural”, while the average percentage for all nineteen towns in the Colca census, including large and dense agricultural communities downstream, was only 52% “rural” (tables in Cook 1982: 44).

These early villages also formed an important source of labor for colonial mining ventures in the Cailloma region (Guillet 1992: 25-27). Mercury and copper were mined between Callalli and Tisco (Echeverría 1952 [1804]) and Lechtman (1976) reports a structure in Callalli known as “*La Fundición*” that is described as “stone metal smelter, probably colonial, said to be for copper smelting: mineral, scoria on surface”. A location known as “Ccena” or “Qqena” is described as having “metal smelters near a pre-Spanish occupation site: mineral, scoria, surface sherds” (Lechtman 1976: 11). The toponym “Ccena” can be found close to the Llapa and Pulpera stream confluence upstream of Callalli. These historical smelters were not encountered during the course of our survey in this particular area.

Pyrotechnical installation

One structure ([A03-842], Figure 4-8) was identified in the course of the 2003 survey that appears to be of colonial period construction and it appears to have some kind of pyrotechnical function (B. Owen 2006, pers. comm.). The structure has two doors in the lower area, apparently providing access to the lower furnace. The internal lower construction is built of thermally altered stones and has a cracked lintel. A variety of pyrotechnical structures are known in the south-central Andes (M. Van Buren and Mills 2005) that were used to heat lead, silver, or copper, and other oven types (e.g., pottery, bread) are known in the region as well. Slag or other evidence of smelting was not encountered in the soils adjacent to the structure, however, although the building is immediately adjacent to a stream channel and such materials may be eroded or difficult to detect.

Figure 4-8. Exterior and interior of probable colonial pyrotechnical structure at Achacota near Pulpera, upstream and south of Callalli [A03-842]. One meter of exposed tape is visible in each image.

Vegetation and dryland agriculture in the study area

The Callalli area consists primarily of high elevation grassland *puna* ecology (1973). Dry bunch grasses are available much of the year in this area, but during the wet season (austral summer) a greater variety of grasses become available and herds are brought to the valley to exploit the pasture of *chilliwua* and *llapa* grasses.

Callalli and Sibayo lie in the upper reaches of agriculture at this latitude and evidence of abandoned fields are visible in the upper valleys. Plants like tubers, oca, and chenopodium were historically viable at this altitude (Echeverría 1952 [1804]), although microclimatic variability is influential in these conditions of marginal dryland agricultural production. Guillet (1992: 24) cites evidence for climate change from historical sources that describe the cultivation of maize above the current limits for this crop, and coca, membrillo, and peppers on terraces that lie at altitudes where these crops are not feasible today. Wernke (2003: 51-52) considers the significance of climate change evidence from ice cores in mountain ranges to the east for Colca valley culture history and agriculture.

In Markowitz's (1992) ethnographic study at Canaceta, a village at 4000 masl and approximately 12 km upstream of Callalli, villagers explained that they had formerly engaged in agriculture at this altitude, but that they had recently abandoned the practice due to lack of rainfall. She observes that practicing a mixed subsistence system of agriculture and pastoralism was an important cultural ideal in the Canaceta, but that in recent years due to changes in the climate and in economic circumstances they had increasingly become specialized on pastoral production complemented by exchange (Markowitz 1992: 48). Under modern circumstances there is probably not a very high return on labor invested in agriculture in this area as the increased economic integration, and an improved transportation infrastructure with intensive farming areas at lower elevations, has further induced residents towards specialized economic practices. The current distribution system emphasizes pastoral production in the highlands and higher yield agriculture on lands at lower elevations.

Figure 4-9. Tuber cultivation at 4200 masl surrounded by large tuff outcrops.

In the course of survey in 2003 cultivation was observed in a few high altitude locations, such as the upper reaches of Quebrada Taukamayo. The plots were at 4200 masl in a north-north-east facing (10°) aspect and a mild slope (8°). The area is relatively sheltered by the presence of lava tuff flows (see Figure 4-9) that may have had a temperature moderating effect acting like large terrace stones that are known to reduce diurnal variation by absorbing heat during the day and releasing heat at night in the immediate valley microclimate (Schreiber 1992: 131).

Flora and fauna

Important flora and fauna to residents of the Upper Colca region include the following (Gomez Rodríguez 1985; Guillet 1992: 130; Markowitz 1992: 42-44; Romaña 1987; Tapia Nuñez and Flores Ochoa 1984). Major flora comprise grasses such as *Chilliwa* (*Calamagrostis rigescens*), a frost-resistant perennial grass that thrives during the rainy season and in bofedales, grazed by a wide range of animals and also used for roof thatching. Other important puna pasture grasses include *llapa*, *malva, sillo,* and *paco,* though these are principally consumable by herbivores only during the rainy season. *Ichu* / *Paja* (*Stipa ichu*) is a common grass used for thatching. In the higher elevation bofedales one can encounter *parru,* a grass preferred by alpacas. Wild fruits are gathered seasonally by locals including *locoti* (cactus fruit), *q'ita uba* (wild grapes), and *sanquayo* (a plant related to chirimoya) (Markowitz 1992: 43). In the high elevation area of the obsidian source *yareta* (*Azorella compacta*), a green, flowering cushion plant is one of the few flora that grow in the unirrigated areas of this harsh volcanic terrain. In addition to animal dung, dried *yareta* is the only dense, combustible fuel widely available above 4500 masl. As a local herder, T. Valdevia demonstrated, the cushion plant will burn when it is kicked over and allowed to dry out for several weeks. Drought and cold-resistant shrubs, including *tola* and *cangi*, are valuable sources of firewood in the *puna* today, though the shrubs are over harvested in many areas.

Fauna species include a number of birds that are hunted for their meat including the Grey Breasted Seedsnipe known as *puko elquio* (*Thinocorus orbygnianus*), partridges (*pishaq*), and the *guallata*, the large white Andean Goose *(Chloëphaga melanoptera)* (Markowitz 1992: 43; R. R. Hughes 1987). Several Andean condors (*Vultur gryphus*), for which the Colca is renowned, flew repeatedly near our work at the Chivay obsidian source in 2003. Wild mammals observed in the study area include *viscacha* (*Lagidium peruana*), *taruca* deer (*Hipocamelus aticensis*), and the wild camelid *vicuña (Vicugna vicugna* or *Lama vicugna).* The trout found in the streams represent an important food source, but these fishes were introduced in the nineteenth century.

4.1.3. High Puna: Block 2 survey and adjacent Blocks 4 and 5

This high altitude zone of the study area is dominated by the Pliocene lavas and Quaternary moraines, as will be described in more detail below in the geology section. Much of these survey blocks consisted of porous lava rock and sandy soils covered by a mantle of ash, lapilli (rock fragments between 2 – 64 mm across) and the occasional volcanic bomb (molten rock between 64 – 1000 mm). During the dry season surface water was available only sporadically across the area and, unsurprisingly, reliable water sources frequently have archaeological sites nearby. The renowned “Ventanas del Colca” tuff formations occur on the edge of the San Bartolomé survey area (block 2) at the point where the highway connecting Callalli with Arequipa climbs out of the Pulpera drainage and straightens out for its run across the open puna grassland.

This area is also remarkably wet, the environment is productive, and faunal density is relatively high. Even during the dry season the Block 2 area has reliable water.

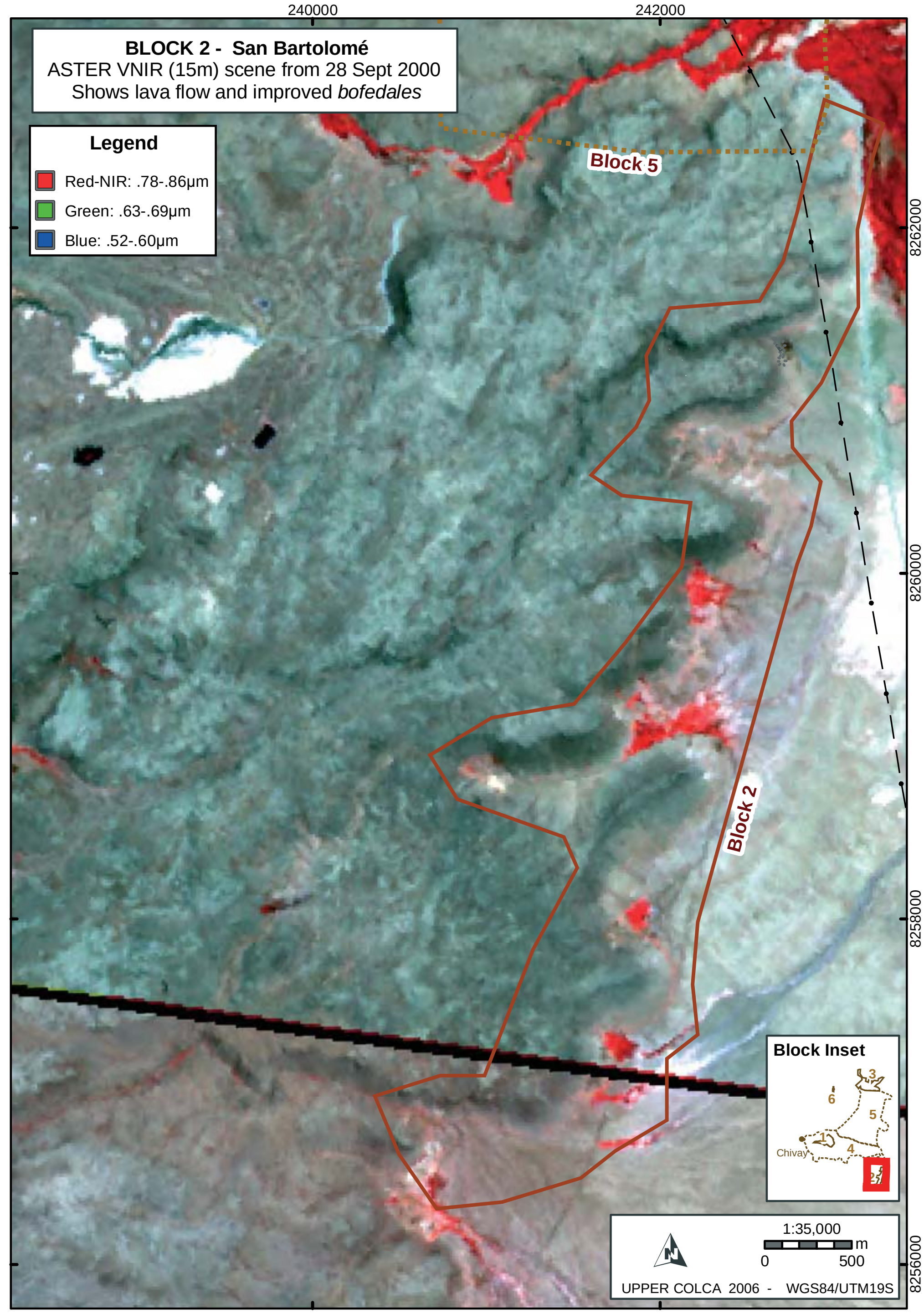


Figure 4-10. ASTER scenes with the terminus of volcanic breccia outcrop in green, photosynthesizing plant areas (bofedales) shown in red pixels, and ash in white. The black diagonal line is a seam between the two scenes.

Block 2 geography

Block 2 can be characterized as containing rich bofedales, reliable hunting opportunities, and access to lower Colca Valley resources only two-day's travel away. This area, known as San Bartolomé, can be considered a "puna rim" ecological area because animal and plant species are affected by the presence of lower elevation Colca Valley environments immediately downhill to the north and west, and warmer air rises from the lower valley affecting the local climate. The Pliocene eruption of the Barroso group vents of Huaracante, Hornillo, and Ancachita resulted in the predominantly silicic coulee flows of lava described as "Centro Huarancante" by the INGEMMET study (Palacios et al. 1993: 139). On the eastern edge of the Huarancante Group the viscous lava flows terminate in breccia outcrops where they overlie crystalline ignimbrites (TBa-c) of older Pliocene age, also belonging to the Barroso formation. Below the toe of the lava the crystalline ignimbrites rich in dacite appear as light colored, sandy soils, where perennial surface water has created good grazing opportunities in this flat expanse to the east of the lava flows. Bofedales are found below each quebrada descending from the lava formations, a pattern that is perhaps the result of subsurface water moving through the lava flows and emerging at the contact zone with the ignimbrite formation.

A number of small rock shelters occur along the base of the upper lava flow. The rock shelters are typically dry, but the floors are sloping out onto talus slope below and so they offer little in the form of shelter inside the drip line. There are some notable exceptions, as will be reported in Chapter 7, and relatively dense occupations were found at few of the best rock shelters. On the whole, Block 2 follows along the eastern periphery of a lava flow where there is a concentration of resources. Water emerges from the lava onto the open pampa, grazing opportunities for wild and domestic herbivores on the bofedales and adjacent grasslands are good, and Andean geese and other puna bird species are seen in the greatest numbers. The lava flow provides topographic variability on the perimeter of a wide and often windy plain, providing shelter and occasional, small rock shelters.

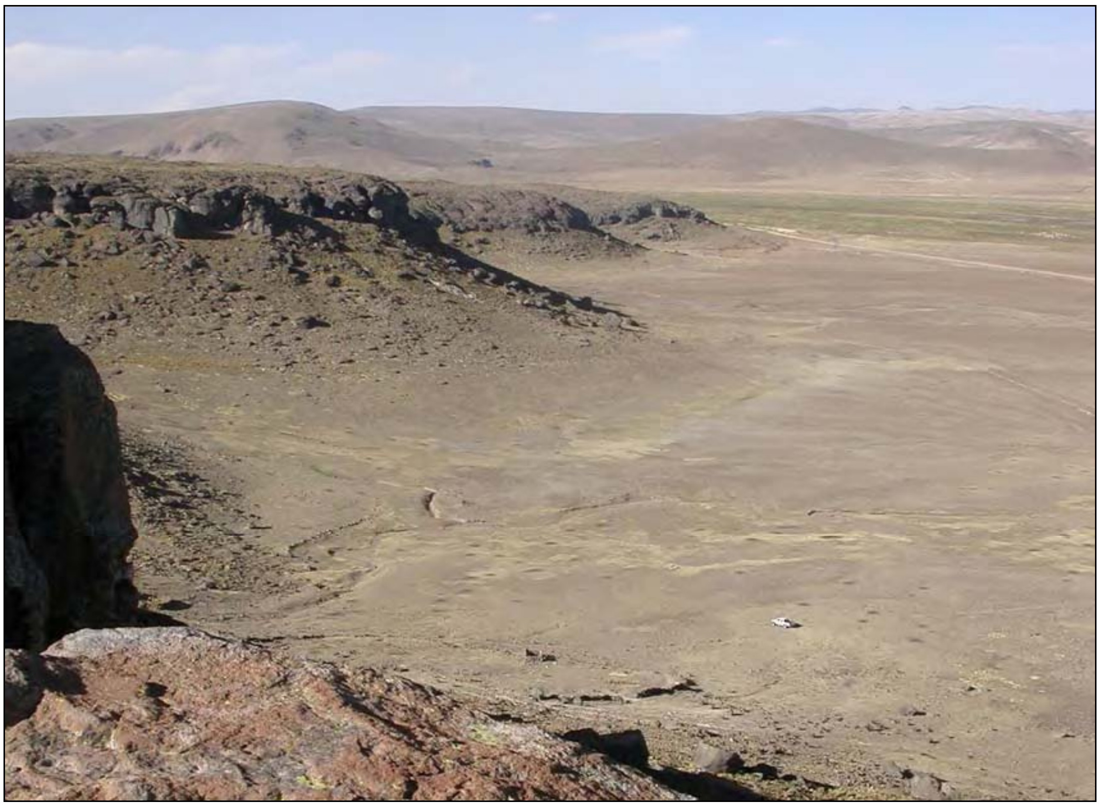


Figure 4-11. View of San Bartolomé (Block 2) area during the dry season from atop a toe of Barroso lava looking north-eastward. For scale, our white pickup truck is visible below. A rich bofedal is visible 3 km to the east-north-east.

Current environmental conditions suggest that the edge of the lava flow served as a rich ecotone with water, shelter, and numerous hunting opportunities for bird species, *vicacha, taruca* deer, mammals, and probably the wild camelids *guanaco* and *vicuña* at certain times in the past. We often observed a number of wildlife species in the course of research in this area including *viscacha* and geese, and perhaps the density of wildlife in this locale was due in part to lack of surface water elsewhere, on the adjacent lava beds and ashy soils. Even well into the dry season, parts of Block 2 area have reliable water and soft grasses.

Regional geography

Block 2 is a natural bottleneck for economic traffic moving between the Colca and the Titicaca Basin along what may be interpreted as the prehispanic trail system. Due to the steep descent to the Pulpera on the north side, and the glaciated volcano Nevado Huarancante on the south-west side, many travelers would probably have traveled through Block 2. The presence of a very large bofedal and rich hunting opportunities in the adjacent lava flows to the west probably made the Block 2 area an even greater attraction for travelers with caravan animals. This area lies on the periphery of the Colca valley and it is approximately one long day from the rich grazing areas of the Escalera access to the Colca valley, and about two days from the town of Yanque.

4.1.4. The Chivay Source: Block 1

The geological source of Chivay obsidian is above 4800 masl among the lava flows from two Barroso (Pliocene) volcanic vents named Cerro Ancachita and Cerro Hornillo. The discussion here focuses on the geographical context of Survey Block 1, and the geology of these volcanic features will be explored in more detail in Section 4.3.3, below.

In the high altitude portions of the Upper Colca survey, most notably in the Chivay obsidian source area above 4800 masl, the local temperature and climatic exposure is strongly affected by the lack of vegetative cover and the katabatic (mountain breeze) and anabatic (valley breeze) winds. The winds were a daily feature during the Block 1 fieldwork in the months of August and September 2003, and the winds are most notable in the mornings and evenings when the temperature differential between the high altitude areas and the warmer Colca Valley are greatest. Extrapolating the local lapse rate from Colca meteorological stations suggests that the obsidian source, at around 5000 masl, would have mean temperatures of 0.5 to 1.0° C year-round (Figure 4-4), not accounting for the effects of wind in this exposed area. In the course of fieldwork daytime high temperatures were approximately 5° C, and nighttime temperatures were commonly -9° C with the coldest night measured at -12° C. These data largely corroborate the estimates derived from the local adiabatic lapse rate discussed above.

4.2. Tectonic geology

The Colca Valley lies on the western margins of the broadest region of the Andean cordillera at 15° south. The Andes consist of several parallel mountain chains and in this region that includes areas of southern Peru, western Bolivia, and northern Chile the parallel chains separate and landforms between these mountain chains comprise the broad, high-altitude valleys and plateaus known collectively as the *altiplano*. The altiplano is a treeless region at an average altitude of 3700 masl extending from the Lake Titicaca Basin to Bolivia's Lake Poopó that is second only to the Tibetan

Plateau as the largest plateau in the world (Clapperton 1993: 45-47; Pearson 1951). The Quechua term *puna* for “elevated area” applies to the ecological band of the altiplano, but *puna* can also refer to a broader regions and life zones. The steep Andean cordillera includes volcanism over some of the thickest crusts in the world (Aramaki et al. 1984: 217), and has resulted in the steep mountains and compressed ecological zonation that strongly influences human organization and subsistence strategies in the region (Troll 1968; Winterhalder and Thomas 1978).

Figure 4-12. Select raw material sources in the central Andes (obsidian and basalt).

Name	Latitude	Longitude	Other names	Reference
Chivay	-15.6421	-71.5356	Titicaca Basin, Cotallalli	Burger, et al. 1998, Brooks, et al. 1997
Aconcagua	-16.8422	-69.8632	Aconcahua	Frye, Aldenderfer, Glascock 1998
Quispisisa	-14.0663	-74.3188		Burger et al., 2000, 2001, 2002.
Zapaleri	-22.6711	-67.2280		Yacobaccio et al, 2004
Sora Sora	-18.1661	-68.1831		Giesso, 2002, pers. comm.
Jampatilla	-14.2125	-73.9279	Pampas	Burger,et al. 1998.
Puzolana	-13.2090	-74.2225	Ayacucho	Burger, et al. 2005
Alca	-15.1202	-72.6928	Umasca, Cusco Source	Burger 1998, Jennings, et al. 2002
Querimita Basalt	-19.1079	-67.1553		Giesso 2000, 2003
Uyo Uyo	-15.6155	-71.6760		Brooks 1998, Wernke 2003
Yanarangra	-13.2432	-75.1721	Mistaken for Quispisisa	Glascock, et. al., in press.
Potreropampa	-14.3632	-73.3220	Andahuaylas A	Glascock, et. al., in press.
Lisahuacho	-14.3732	-73.3620	Andahuaylas B	Glascock, et. al., in press.

Table 4-3. Coordinates and names of select raw material sources in the central Andes. Coordinates in WGS1984 datum.

It is volcanic processes at a continental scale that have resulted in the discrete pattern of obsidian sources in the central Andes in an arching line between 3000 and 5000 meters above sea level. As discussed by Clapperton (1993) and Thorpe et al. (1981; 1982), the volcanic origins of these features involves a consideration of plate tectonics in western South America. Off of the coast of Peru the oceanic Nazca plate is subducting beneath the South American plate, resulting in the magmatism, seismicity, and tectonism characteristic of the central Andes. Geologists date the initial uplift and deformation of the Andean geosyncline to the Laramine Orogeny during the middle Cretaceous period, a period of worldwide mountain building. The Andean batholith, a massive igneous intrusion that underlies the western range of the central Andes (Cordillera Occidental), formed during this orogenic period. The eastern range of the central Andes (Cordillera Oriental) arose from laterally compressed geosynclinal rocks that emerged as folded stratigraphy. The trench between the western batholith and the folded eastern stratigraphy, known as the

Titicaca trough, continued to accumulate sediments through the Miocene. A quiescent period followed when the central Andean region matured through erosive processes into a relatively level surface of the altiplano, moderating the terrain that lay above the volcanic, sedimentary, and metamorphic layers that make up the structure of the Andes. This surface undergoing erosion could not properly be called the *altiplano* during the Late Miocene because, interestingly, the surface was still under 1800 masl by 10 Ma (Gregory-Wodzicki 2000). Estimates of uplift rates on the order of 0.2 – 0.3 mm/yr have created the raised plateau known as the Altiplano from the Miocene to the present. Recent estimates by Thouret et al. based on incision dates in major canyons of Ocona below the Cotahuasi valley suggest that “downcutting may have taken place before 9 Ma but most likely before 3.8 Ma and again before 2.7 Ma, based on dated valley infillings” (Thouret et al. 2005a). They suggest that accelerated valley incision was due to increased runoff that resulted from glaciation of the high Andean peaks, and by implication the Chivay obsidian source was at already at high altitude, probably covered by glaciers, by some time in the Late Miocene and Pliocene. Given the

4.3. Formations in the Upper Colca Valley

The volcanic terrain and the temperate lower valley in the Chivay area have largely conditioned human activity patterns in the region for the past 10,000 years. The local geological sequence will be summarized from text and maps from Palacios et al. (1993) the primary INGEMMET source for the region, as well as the ONERN (1973) geological study associated with the Majes Irrigation project, and the discussion will be supplemented with evidence from more recent specific studies in the region.

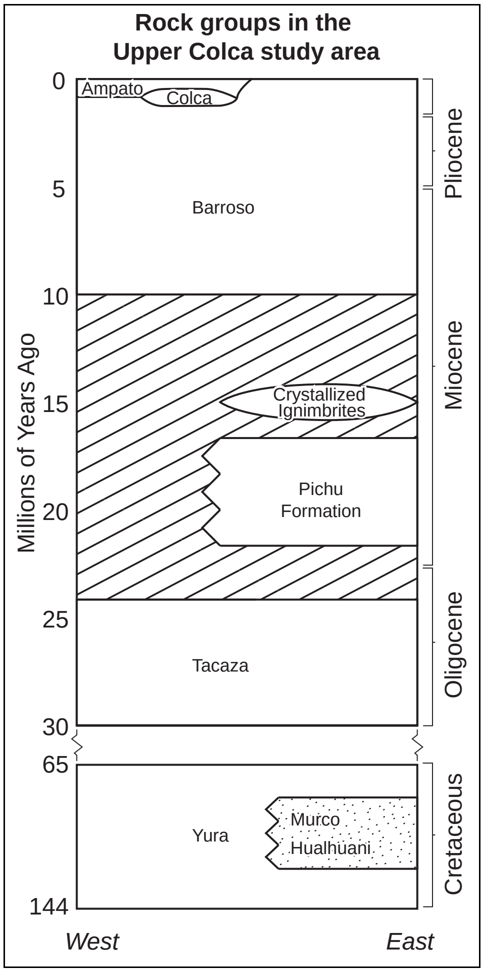


Figure 4-13. Rock groups in the Colca region (based on Palacios et al., 1993).

The Colca region is dominated by late Cretaceous sedimentary rocks overlain by Tertiary flows and tuffs of basaltic to rhyolitic composition. Some Jurassic sedimentary strata are exposed consisting of sedimentary and metasedimentary rocks. The region has continued to be volcanically active during the Pleistocene and

Holocene epochs in the form of stratovolcanoes that ring the Colca valley as well as exogeneous andesitic domes and flows occurring in the Colca River valley itself.

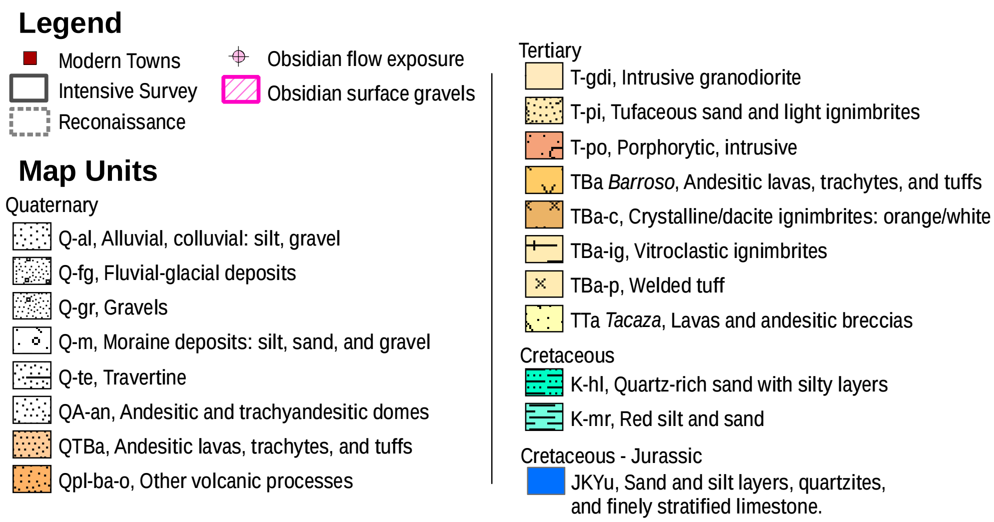
4.3.1. A geological descent of the upper Colca drainage

For the first 70 km from its origin the Colca River trends northwest at a low gradient, open channel descending towards the community of Huinco (3950 masl). This lower portion of this low gradient section of the Colca drainage is under the 250 million m^3 Condoroma reservoir, a product of the 1970s Majes Hydroengineering Project that, combined with water contributed by tunnel from the much larger Angostura reservoir in the Apurimac drainage, has resulted in a sustained year-around flow in the Colca between here and the Tuti diversion dam (Gelles 2000; Maos 1985). At Huinco, the river turns abruptly to the south-west where it continues to descend as a gentle channel, cutting through the Miocene lava formation known as Tacaza as well as wind-scoured river terraces. Immediately before entering the northern edge of Block 3 of our study area, the river cuts through strata of uplifted Cretaceous limestone striking west-north-west and forming outcrops and rock shelters on the edges of the upper river terraces (Figure 4-15). Downstream at the confluence with the Llapa River the Colca River returns again to the Tacaza formation for five more kilometers before entering the Inca formation, an andesitic exogenous dome dating to the Middle Pleistocene. This Quaternary formation fills the upper Colca valley from this point downstream to near the town of Coporaque and Yanque where fluvial conglomerates overlie it as a result of natural damming of the river by mudslides.

In its descent, 5 km below Sibayo, the incising of the Colca River begins immediately upon entering the recent exogenous dome of the Inca formation, an the river remains incised until it exits the Colca canyon approximately 100 km downstream. The Llapa River, which joins the Colca from river-left at Sibayo, emerges from the sandy tuff layers known as the *Castillo de Callalli* tuff formations (Noble et al. 2003) and the Chalhuanca rhyolite dome fields to the south-east of Callalli. The entrenched Colca River descends more rapidly upon entering the Inca formation approximately 10 km downstream with perennial tributary streams entering primarily from glacierized stratovolcanoes that ring the Colca Valley. The first of these tributary streams are the creeks entering from the north upstream of Tuti draining the southern and eastern flanks of the Nevado Mismi volcano, while streams that form just on the other side of Mismi have recently been confirmed by a National Geographic expedition in 2000 to be the source of the Amazon. Immediately upstream of the town of Tuti a diversion dam was constructed across the Colca where the river is entrenched in a ravine 50m deep. At this point water collected by the

Majes Project is diverted into a system of canals and tunnels along the south bank of the Colca that finally crosses into the fertile Pampa de Majes near the Pacific coast.

Below Tuti, the Colca river channel is deeply incised into Quaternary exogenous domes. Continuing downstream, the river turns west, again becomes entrenched, and begins dropping more steeply in the vicinity of Chivay. The geology, geomorphology and soils of the main Colca valley have been well-studied in the past several decades as a result of the "Colca Valley Terrace Project" organized by William Denevan (1986; 1988; Denevan et al. 1987) and more recent reviews of research in the main Colca valley can be found in dissertations by Wernke (2003: 34-66) and Brooks (1998: 57-84). In its steep westward drop to the Pacific littoral the river subsequently enters the 3,270m deep Colca canyon, the third deepest canyon in the world after the Yarlung Tsangpo (Tibet) and the Cotahuasi (Perú). Here the river cuts through folded sedimentary and metamorphosed layers predominantly belonging to the Yura group (Jurassic and Cretaceous) until it emerges as the Majes River on to the large alluvial plain that leads to the sea.



Cartographic sources: Palacios et al. 1993; Davila M. et al. 1988; Davila M. 1988; Ellison and Cruz 1985; Hawkins and Cruz 1985; Klinck and Palacios M. 1985, and 2003 field observations.

Figure 4-14. Legend showing geological map units in maps that follow.

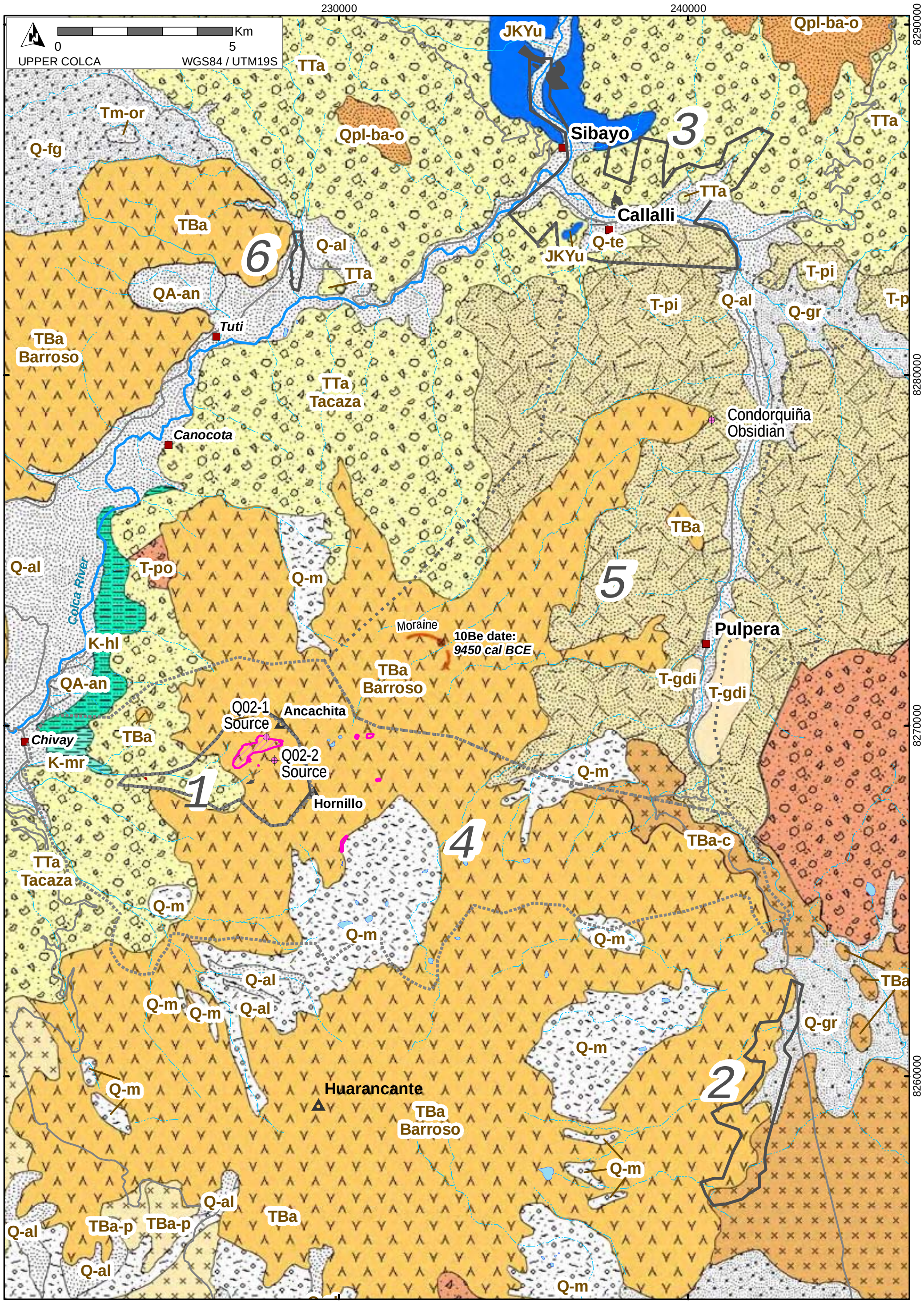


Figure 4-15. Geological map units and 2003 Survey Block boundaries (in gray) for the Upper Colca project study area. Legend shown in preceding figure.

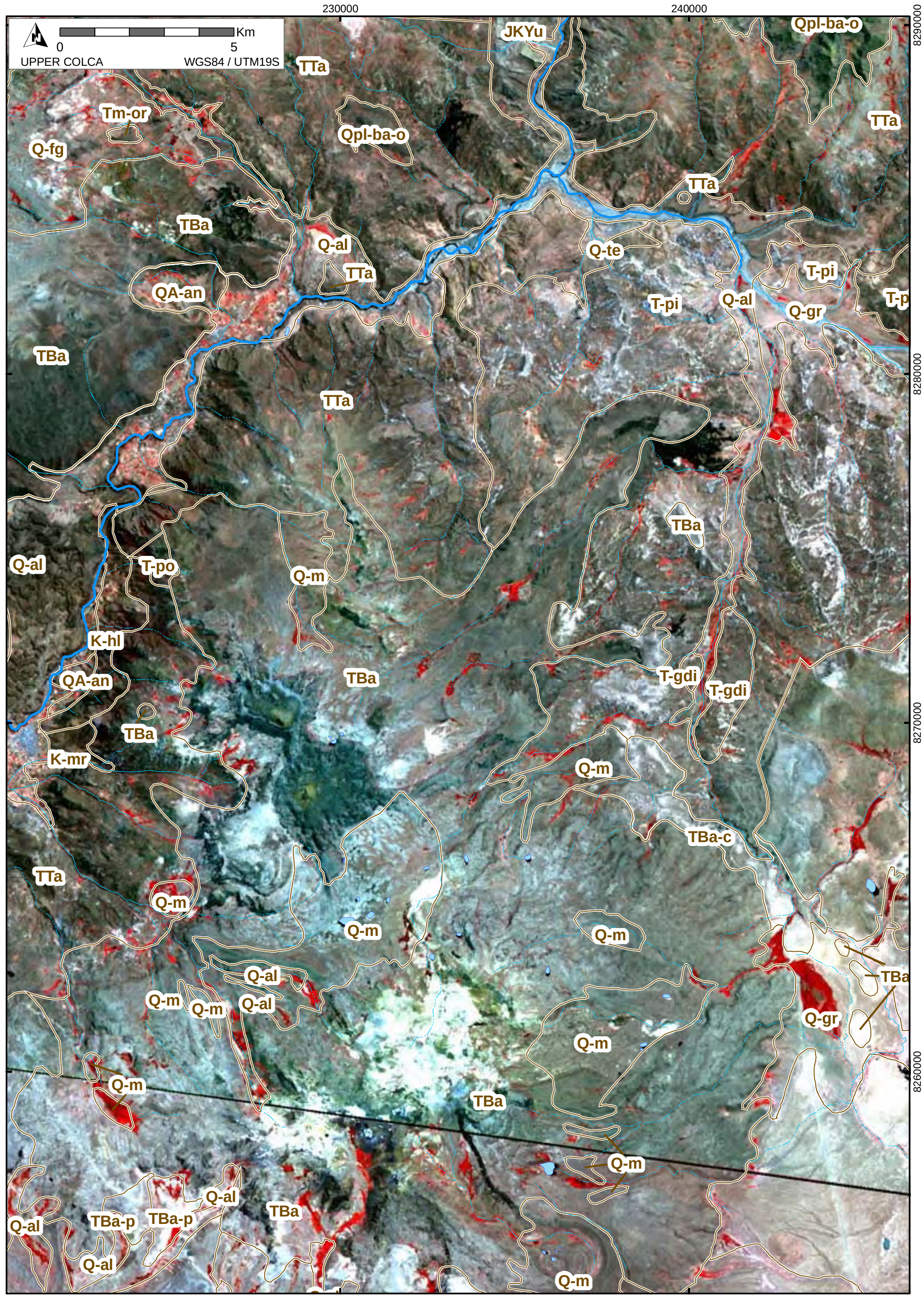


Figure 4-16. Geological map units shown on ASTER scene from 28 Sept 2000; legend is shown in Figure 4-14. In general, red pixels show areas of photosynthesizing vegetation (bofedales).

4.3.2. Yura and associated sedimentary strata

Starting with the oldest rock groups in the study region, the Yura group, the geological history of the Upper Colca region will be summarized through to the Holocene. The Jurassic and Cretaceous (> 66.4 Ma) sedimentary strata in the region include quartzite, shale to sandstone, dolomite, and limestone. The Yura sedimentary formation is exposed on both sides of the Chivay-Arequipa road around the Sumbay junction and to the 10 km to the east of the Llapa and Pulpera confluence. Quartzite outcroppings of the Yura formation appear to have provided material for the abundant artifacts made of quartzite observed in archaeological sites in the Callalli area. These quartzite Yura strata do not appear as cartographic units on the 1985 INGEMMET map (Ellison and Cruz 1985), but Parodi (1987: 47) notes that fine-grained quartzite outcrops occur west of Callalli and these features were encountered in recent fieldwork (JKYu west of Callalli on Figure 4-15). Quartzite outcrops form in metamorphic sandstone and occur in the oldest metamorphic strata in the Colca region. Similarly, chert, chalcedony, and quartz precipitate from diatoms in sedimentary contexts (Andrefsky 1998: 51-56; Luedtke 1994), and consequently exposures of these materials are found in the Mesozoic strata in the region and in cobbles form in many stream beds. Interestingly, cherts were noted in the Ichocollo creek in Block 6 of the survey, but an examination of the headwaters on the Cailloma (31-s) geology map (Davila M. 1988) reveals no layers older than the Tertiary in that watershed.

Steeply uplifted Cretaceous formations appear in two portions of the study area (Palacios et al. 1993: 28-30, 36) and these formations, in addition to nodules found in riverbeds, may have provided the local sources of non-obsidian toolstone in the area. The thick calcareous Yura sedimentary exposures north of Sibayo are dramatic examples of uplift of these Cretaceous strata. Additionally, the slopes just east of Chivay below 4000m between the town of Canocota, close to Calera hot springs, and as far south as the Quebrada de los Molinos consist of Murco and Hualhuani formation sedimentary rocks that include siltstone, quartz-rich sandstone, and limestone layers. These areas, in addition to cobbles encountered in riverbeds, may have represented the local non-igneous sources of material for stone tool production that include chert and chalcedony.

4.3.3. Oligocene and Miocene lavas

Tacaza Group

Flows belonging to the Tacaza group are found throughout the south-central Andes, however the only portion that appears in the Colca region belong to the older Tacaza with dates in the range of 30.21±0.73 Ma and 26.51±0.6 Ma. At 1900m thickness these Colca lava flows are the thickest Tacaza layers in the larger region (Palacios et al. 1993: 86).

Figure 4-17. Andesitic Tacaza deposits with breccias and tuff outcrops in the Quebrada de los Molinos drainage. The Chivay obsidian source in later Barroso deposits is found high above, on the right side of the photo.

In the Colca area, these deep deposits of lavas and breccias consist of andesites and trachybasalts (containing higher feldspar content) intercalated with tuff bands. The Tacaza layer appears predominantly on the western half of our survey zone.

Pichu Formation ash flows and the Castillo de Callalli

On the eastern side of the study area, the Tacaza formation is overlain with the Pichu formation consisting of sandy tuffs and white ignimbrites. Among these Miocene ignimbrites layers is the Castillo de Callalli formation, an ash-flow tuff that rises dramatically from Llapa river just upstream of Callalli and is a principal landmark in the Upper Colca region. In the INGEMMET study (Ellison and Cruz 1985) the Castillo de Callalli was assigned to the Pichu formation. This landmark is an approximately 400m hill of silicic ash-flow tuff ranging from densely welded to non-welded tuff. The layering in this formation has recently been subject to a more detailed study involving isotopic dating and phenocryst mineralogy (Noble et al. 2003). The recent work shows that this formation is not a single stratigraphic unit, as presented in the INGEMMET study, but rather it consists of two layers separated by 16 Ma.

Figure 4-18. The lower section of the Castillo de Callalli is known as "Cabeza de León". Evidence of an LIP pukara was encountered on the summit [A03-935].

The lower part of Castillo de Callalli is adjacent to the main road to Callalli and follows the Llapa River. The Cueva de Quelkata, a rockshelter with a predominantly Terminal Archaic component (J. A. Chávez 1978) that was dynamited by the Majes Project road construction, is at the base of this formation. This lower section has well developed columnar jointing and is a densely welded, devitrified ash-flow tuff, and K-Ar dating on phenocrystic hornblende indicates that this lower flow is 20.7±0.6 Ma (Noble et al. 2003: 33). The upper section is described as "partly welded vapor phase crystallized tuff with the physical characteristics of the distal part of an outflow sheet". Phenocrystic sanidine from this section yielded an ^{40}Ar-^{39}Ar age determination of 4.72±0.02 Ma (Noble et al. 2003: 35). The study suggests that the upper part of the Castillo de Callalli formation is associated with the Cailloma caldera to the north which erupted three times during the Pliocene. Further discussion of Miocene volcanism in the Orcopampa area of the Chila cordillera, between the

Chivay and Alca obsidian sources, can be found in Swanson's (1998) geology dissertation.

4.3.4. Pliocene lavas – Barroso group

Barroso lavas in the Colca area include predominantly andesitic and trachyandesitic flows covering an area of approximately 320 km^2. In the case of the Barroso group, the emplacements are contiguous lavas that occur as transversal flows, as andesitic domes, and occasionally as rhyolitic domes. At the Chivay source, two vents dating to the Barroso formation occur at Cerro Ancachita and Cerro Hornillo, and at the highest peak in the Centro Huarancante formation named Nevado Huarancante, to the south. Transversal flows and crests emanating from these flows created adjacent peaks such as Cerro Saylluta and Cerro Llallahue. Lavas, silicic coulee flows, and viscous volcanic breccias flowed from these vents and traveled up to 15km, into the Block 3 study area to the east. Curiously, in the Cailloma quadrangle study, immediately north of Chivay, Barroso group volcanism in the Cailloma caldera was dated to the Pleistocene rather than the Pliocene epoch (Davila M. 1988). The important distinction is that recent dating of Cailloma caldera deposits (Noble et al. 2003: 35) appear to pre-date the Barroso group flows that are responsible for tool-quality obsidian formation in the western Cordillera.

At the Chivay obsidian source, Barroso group flows are superimposed on Tacaza levels, and both groups have been eroded and incised by later fluvial and glacial erosion. It is proposed by Burger et al. (1998a: 205) that obsidian occurs at the Chivay obsidian source where silica rich magma from Barroso eruptions cooled rapidly when the flows contacted the older Tacaza group deposits. The emplacement of Barroso group obsidian flows will be discussed in more detail below.

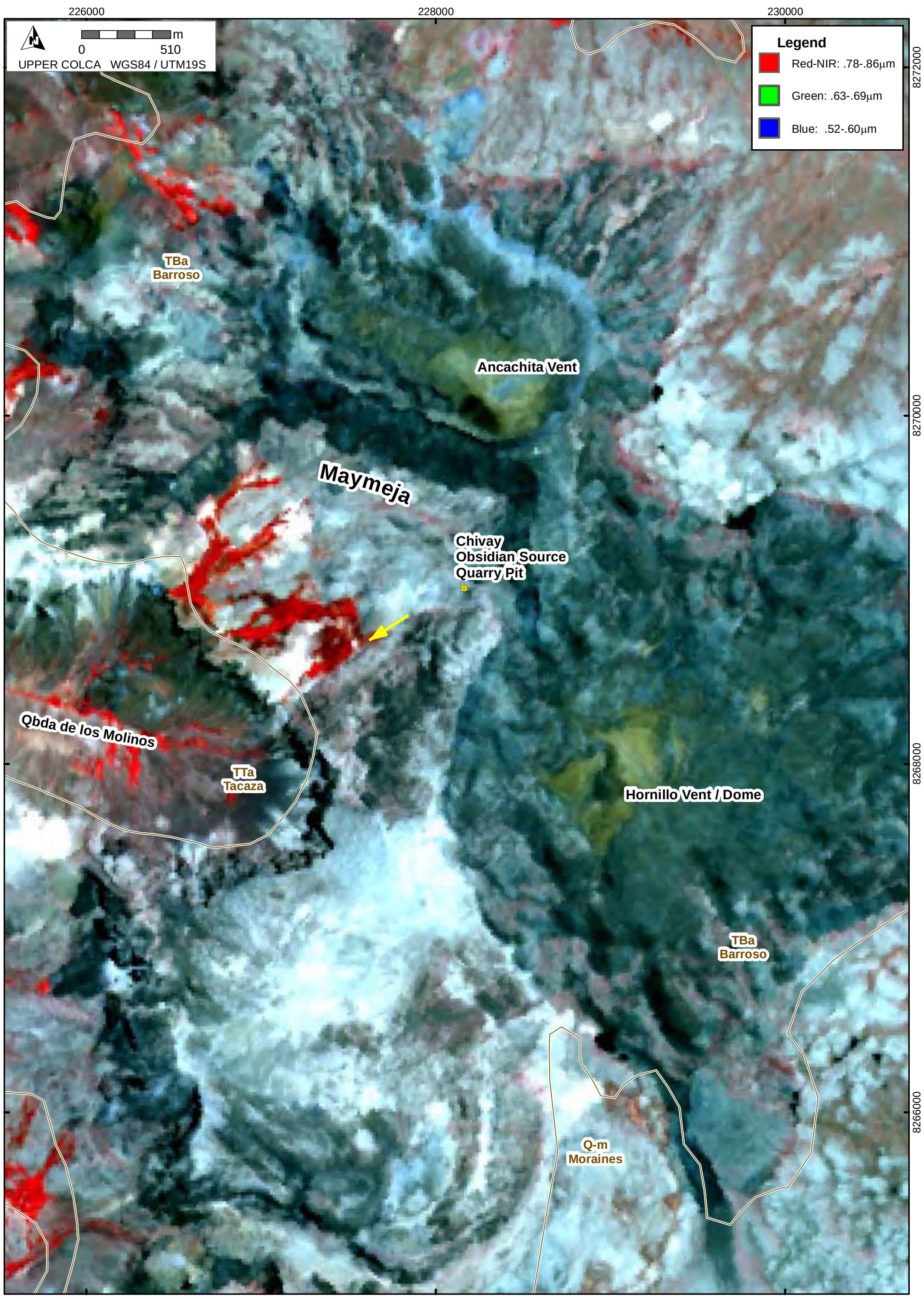


Figure 4-19. Detail of Chivay source, Maymeja area with INGEMMET geological map units shown on ASTER scene from Sept 2000. Contact between TTa and TBa on the west appears offset and likely conforms to the horseshoe shaped valley. Yellow arrow shows direction of glacial striations.

Origins of the Maymeja volcanic depression

The Maymeja area is a depression surrounded by transversal flows and domes that appear to have been heavily glaciated in the Pleistocene epoch. The Maymeja depression contains certain features that resemble those of a volcanic caldera resulting from eruption-induced subsidence and collapse. However, further consultation with volcanologists indicates that the Maymeja depression is likely *not* a caldera. The characteristics that do suggest that Maymeja is a caldera include: a circular, steep-walled perimeter, occasional ignimbritic deposits, the Anchachita and Hornillo vents located along the margins, and remnant vent-like features in the center of the Maymeja area (Szakács and Ort 2001; Karátson et al. 1999; Fisher and Schmincke 1984: 360). However, the small size (2 km diameter), an irregular southern and breached western margin, and overall paucity of ignimbritic materials in the region suggest, rather, that the margins of this area were defined by highly viscous rhyolitic lava flows from Ancachita and Hornillo that were subsequently eroded into the circular form of a cirque, particularly on the south-facing (heavily glaciated) slopes, as a result of abundant Pleistocene glaciation. An example of a large Pliocene caldera is the Cailloma caldera that dominates the Cailloma quadrangle immediately to the northwest of the Chivay area (Davila M. 1988). Rather, the Maymeja area can be more generally described as a volcanic depression that underwent significant glaciation during periods subsequent its Pliocene formation.

4.3.4. Pleistocene – Ampato group

Pleistocene Inca Formation

Named for the site of the Inka bridge over the Colca adjacent to Chivay, the Inca formation consists of Andesite and Trachyandesites that occur in exogenous domes and flows that appear to emanate from the north side of the Colca river, just north of the town of Chivay. These domes are composed of andesites and trachyandesites marked by a high percentages of alkali feldspars (Palacios et al. 1993). Two Potassium Argon dates from these flows by Sandor (1992: 232-235) indicate that they formed during the Middle to Late Pleistocene (64,000 ± 14,000 bp and 172,000 ± 14,000 bp).

4.3.6. Holocene stratovolcanoes

Arequipa is a volcanically active region with a number of stratovolcanoes that have erupted repeated over the past 10,000 years. These peaks include Huayna Putina, Misti, Sabancaya, and Ubinas (Gerbe and Thouret 2004; Thouret et al. 2002a; Thouret et al. 2002b; Thouret et al. 2001; Thouret et al. 2005b). The regular deposition of tephra from these peaks provides consistent strata that may aid in archaeological excavation work. Archaeologists working in the western cordillera will benefit from the tephrachronology sequences currently being developed by volcanologists in the region.

4.3.7. Glaciation

In modern times glaciers generally occur above 5,000 - 5,200 masl in Arequipa (Clapperton 1993; Dornbusch 1998; Fox and Bloom 1994), with differences in precipitation being the single largest contributor to variation in snowline altitude between the eastern and western cordillera. During the Last Local Glacial Maximum (LLGM) remote sensing studies of glaciated landforms suggest that there was a regional snowline depression of 600 - 800m in the western cordillera region of Arequipa during the Late Pleistocene (Clapperton 1993; Klein et al. 1999). However glaciological studies show that the response of snowline to aridity is not uniform across the region, and that “as snowline rises in response to increasing aridity, it becomes less sensitive to temperature perturbations” (Klein et al. 1999: 81). Recent evidence from ice and lake core studies in central and southern Peru (J. A. Smith et al. 2005) have shown that the LLGM occurred in the tropical Andes around 21,000 cal years ago or over 10,000 years before uncontested evidence of human presence in South America.

The extent of glaciation during the Terminal Pleistocene and Early Holocene in the Colca region is of direct interest to this study of the Chivay source because the Maymeja source area itself was potentially glaciated into the Holocene epoch, and glacial geomorphology appears to have eroded high altitude obsidian deposits like Chivay. Lake and glacial core studies, as well as radiocarbon dates on vegetative material in deglaciated areas, indicate that despite the evidence for glacial advance during the Late Glacial, aka the “Younger Dryas” (9550 – 10,850 cal BCE) in the northern hemisphere, the glaciers of the tropical Andes appear to have retreated during this period (Rodbell and Seltzer 2000: 335; Seltzer et al. 2002). The evidence suggests that the cooler temperatures were associated with a decline in precipitation, and that this precipitation decline resulted in glacial retreat.

Glaciation of the Chivay source area

These regional data on snowlines are corroborated by evidence of terminal glacial moraines in the Quebrada de los Molinos at 4400 masl and in the adjacent Quebrada Escalera at 4300 masl. On the east side of our study area glacial moraines were observed just west of the Ventanas del Colca feature on the south and east end of a dramatic U-shaped valley at 4350 masl on Quebrada Porhuayo Mayo. The INGEMMET map series (Palacios et al. 1993) indicates that morainal deposits of silt, sand, and gravel are evident elsewhere in the study area (Figure 4-15), typically at or above 4300 masl, corroborating the evidence from the regional model with a local snowline during the LLGM at 4300 – 4400 masl, or approximately 700 meters lower than conditions evident in 2003.

A team from the University of Maine including professors Daniel Sandweiss and Harold Borns explored the question of the Early Holocene deglaciation of the Chivay Source area in the late 1990s. As shown on Figure 4-15, a ^{10}Be date of circa 10,000 ^{14}C BP (9450 cal BCE) was acquired from a quartzite erratic on a moraine at 4650 masl to the east of the Chivay source area (data courtesy of Daniel Sandweiss, 2006). This sample suggests that the terrain surrounding the source was glaciated at this elevation and higher as late as the Early Holocene. Establishing the rate of deglaciation and the exposed areas at a given time period will require further glaciological study.

The evidence of glaciation in the Maymeja area of the Chivay source area is pronounced. Glacial erosion is evident on the south-facing slopes of the northern part of the Maymeja depression, as is expected in the southern hemisphere. The south and south-western slopes of Ancachita peak are steep and unstable, and at the base of this slope is a recessed glacial tarn that appears to retain water during the wet season. A moraine blocks the exit of this tarn feature, but on the slopes below lateral moraines parallel the path of the glacial tongue descending from below Ancachita. In the most deeply eroded part of this northern area contains the only continuous surface flow of obsidian encountered in the entire study area: the Q02-1 source which contained vertical, subparallel fractures and was unsuitable for tool production. Other effects of glaciation on obsidian distributions include the presence of transported obsidian nodules in parallel and terminal moraines in the Quebrada de los Molinos.

Figure 4-20. Glacial polish and striations (aligned towards camera) on lava flows adjacent to Maymeja workshop on the southern end of the Maymeja area.

In the southern portion of Maymeja a lateral moraine is similarly visible, and the striated and polished benches of lava dramatically attest to the extent of glaciation in the area (see yellow arrow on Figure 4-19). The direction of striation on the these lava flows is consistently south-west or dropping towards the Molinos drainage, and striations persist on high exposed benches suggesting that the glaciers were large as they were striating rocks over twenty meters above the base of the Maymeja area.

During the Middle and Late Holocene glaciers in the south-central Andes, on the whole, have retreated. Glaciological studies conducted in southern Peru and western Bolivia show that retreat is most notable during the time range from circa 10,000 to 3,000 BP (circa 9,000 – 1,000 cal BCE) (Clapperton 1993: 464-466), as well as in last decades of the twentieth century. There is evidence for small advances in glacial extent since 1000 cal BCE, most notably the Little Ice Age circa AD1500-1850. Currently Ancachita is slightly below an altitude permitting glaciation to flow downslope into the Maymeja area, though 5100 masl elevation is glaciated in drainages on peaks like Nevado Sara Sara with large glaciated expanses in the high altitude accumulation zone, and areas of peaks on the eastern side of the Andes like Carabaya (northern Puno) are currently glaciated as low as 4900 masl (Dornbusch 1998). The possible effects of this glaciation on obsidian exposure and weathering in the Chivay area will be discussed in greater detail below.

4.4. How obsidian is formed

Even in volcanically active regions of the world, the geological formation of high quality obsidian is a relatively rare event in nature because a number of features must co-occur for volcanic magma to become tool-quality natural glass. The following description was developed largely from Shackley (2005: 10-15, 189) and Fink and Manley (1987). Obsidian can form when rhyolitic magmas are extruded and quenched in the course of a volcanic eruption. Rhyolitic magmas are silica-rich, acidic melts that are capable of flowing as viscous lavas. As rhyolitic magmas approach the earth's surface, the high water content (up to 10% H_2O) begins to escape as vapor, changing the viscosity and the cooling rate of the flow, and resulting in a very low presence of water in obsidian. When water remains trapped in obsidian it sometimes forms bubbles of water vapor, reducing the homogeneity and fracture quality of obsidian for tool production. Fink (1983) found that obsidian emplacement tends to proceed along the following sequence associated with the eruption: (1) tephra fall-out from the initial explosive eruption, (2) basal lava breccia, (3) coarsely vesicular pumice, (4) the principal obsidian flow, (5) finely vesicular pumice, and (6) surface breccia. The best quality obsidian for tool-production often occurs not on the ground surface but slightly underground in subsurface emplacements around a volcanic vent where degassed magma squeezes into rock fractures free of dirt and ash particles. Obsidian over 20 million years old is rarely useable for tool production because, as a geologically unstable material, obsidian gradually devitrifies from a glass into a rock (Francis and Oppenheimer 2004: 163).

Characteristic	Value	Compare with
Composition	Rhyolite (Felsic)	As an intrusive rock it is granite
Silica content	Rhyolite is usually >70% wt SiO_2	Basalt: <52%, Andesite: 53-63% wt SiO_2
Water content	Obsidian: 0.1 - 0.5 H20	Perlite: 3-4%, Pitchstone: 4-10% H20
Age	Quality obsidian is usually <20 Ma	Obsidian >66.4 Ma (KT boundary) is devitrified.
Hardness	Obsidian: 5.0 – 5.5	Quartz: 7.0
Specific gravity	Obsidian: 2.6 (2600 kg/m3)	Pumice: 0.64, Water: 1.0, Basalt (solid): 3.0
Compressive strength	Obsidian: 0.15	Chert: 100 – 300

Table 4-4. Characteristics of Obsidian.

During the extrusion of rhyolitic lavas it is the supercooling (instantaneous quenching) of the lava that creates obsidian, an atomically disordered natural glass with the structural properties of non-flowing liquid. This lack of crystalline structure in aphyric obsidian results in an isotropic lithic material with excellent flaking properties and the potential for extremely sharp edges because it has no prevailing fracture direction and it fractures at the molecular level. Obsidian has a low specific gravity as it is acidic, it also lacks crystalline structure, and it has relatively low hardness. Obsidian has high tensile strength but it has extremely low compressive strength and, combined with the non-crystalline structure, the result is implements with relatively brittle characteristics and fragile working edges (S. S. Hughes 1998: 367; Luedtke 1994: 93; Obsidian 2006; Speth 1972: 52). The cortex of obsidian from primary deposits can visually vary widely depending on the context of emplacement and weathering processes. Obsidian flows that cool where tephra is present can melt a thin layer of the adjacent ash and the fused material appears as a thicker cortex (Figure 4-21).

4.4.1. Chemical differentiation

An important attribute of obsidian for archaeological investigation is that obsidian flows are chemically distinctive allowing artifacts to be chemically linked to their geological source areas. These chemical differences in obsidian are the result of certain elements crystallizing to solids and being removed from the magma as per the Bowen reaction series, resulting in a distinctive geochemistry for lava from most magma chambers and sometimes for each extruded lava flow. Prior to, and during, a volcanic eruption, magma evolves as changes in temperature and pressure causes chemical differentiation and leads certain minerals to crystallize and settle out of the melt.

> As magma evolves, further melting and crystallization change the nature of the solids, and crystals that accept the incompatible elements may form in the liquid. Some feldspars, for instance, are good hosts for strontium, as is mica for rubidium. "Evolved" obsidian magmas may contain these crystal "hosts," and the ratio of a given element between the liquid and solid phases will change dramatically. Changes of this kind issue a particular chemical character to a given obsidian…The result of these processes is that the incompatible-element mix of a given obsidian source varies from any other and becomes a sensitive indicator of origin (Shackley 2005: 10-11).

This process creates detectable chemical differences in obsidian that permits methods such as X-ray florescence (XRF), Instrumental Neutron Activation analysis (INAA), and various types of inductively coupled plasma mass spectrometry (ICP-MS), and Proton-induced X-ray emission—proton-induced gamma ray emission (PIXE-PIGME) to chemically characterize the material (Neff and Glascock 1995; Shackley 1998).

4.4.2. Obsidian color

The color of obsidian is most often black but it also occurs in red, brown, bronze, purple, blue, green, gray, silver, clear, as well as with banding that includes some of the colors listed above. Obsidian coloration results from the oxidation state of tiny crystals that occur in the melt (Volcano Hazards Program 2000). The black color that is common in obsidian is the result of tiny (< .005 mm) magnetite (iron oxide) crystals, red is usually from hematite present in highly oxidized obsidian, and green results from variations in iron oxidation. Microscopic crystals of various types of feldspars may yield the unique blue, purple, green or bronze colors associated with “rainbow obsidian”. Banding results from the folding-in of an oxidized flow surface as the lava continues to move, with each colored streak perhaps reflecting the individual pulses in the obsidian eruption. Gold and silver sheen obsidian is argued to be caused by bubbles of water vapor trapped in the glass that are stretched nearly flat along flow layers (Obsidian 2006). Given the unusual visual qualities of obsidian, the color and banding in a particular nodule are characteristics likely to have influenced human use of the material.

4.5. Pliocene (Barroso group) obsidian in the Colca valley

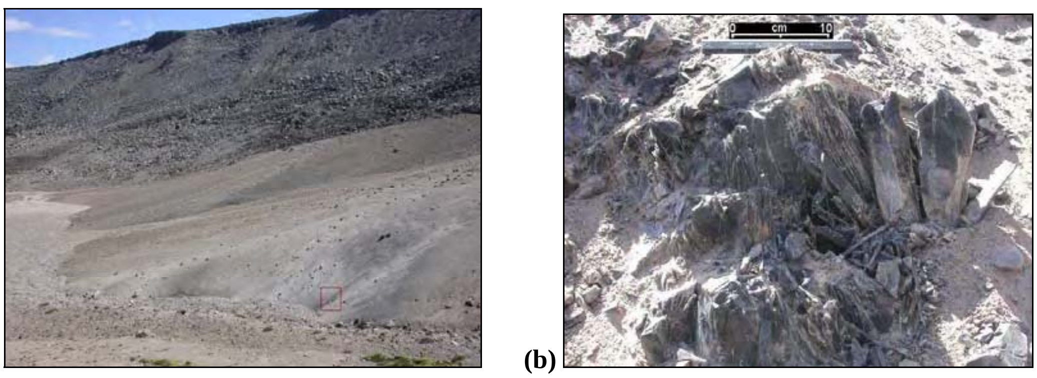
The obsidian that was widely used in the prehispanic central Andes occurs in Tertiary flows along the western cordillera. In the main part of the Colca valley, obsidian is found in the lower levels of Late Tertiary lava flows on both the north and south sides of the Colca river. East of the town of Chivay, the Chivay obsidian type has been observed to occur where Barroso flows contact the older Tacaza deposits

(Burger et al. 1998a: 205). Barroso flows (TBa), clearly evident in photos shown in Figure 4-11 and Figure 4-15, extend atop Tacaza flows to the east of Chivay, and obsidian has been observed where layers described as “Tertiary intrusive, porphorytic” (T-po) extend atop Tacaza flows to the northwest of Coporaque (Figure 4-23). A fission track date on an obsidian sample collected east of Chivay confirms the Pliocene origins of these flows with a result of 3.52 ± 0.15 Ma (Poupeau and Labrin, 10 Oct 2006, pers. comm.). To date, research has shown that high quality obsidian flows in the Colca valley that occurred during the late Tertiary fall into two chemical groups: (1) the Chivay type found to the east of the town of the Chivay, and (2) the “Uyo Uyo” type that lies across the Colca River, west of the town of Coporaque. In the course of fieldwork in 2003 the Upper Colca project sampled obsidian from both locations and had results analyzed by the Missouri University Research Reactor, as will be described below.

4.5.1. Chivay obsidian source observations

Obsidian at the Chivay source was observed obsidian in natural contexts eroding from the base of what is possibly a collapsed rhyolitic dome (Cerro Hornillo), and from the south-west flank of Cerro Ancachita between the elevations of 4900 and 5000 masl. In the majority of locales, obsidian appears as concentrations of cobbles in a pumaceous rhyolite soil matrix where unconsolidated outcrops seem to occur as jointed and weathered flow bands strike the surface. A similar context is described by Healan (1997: 84) at Ucareo, a central Mexican obsidian source, where he notes that unconsolidated outcrops are not in-situ, but such outcrops are best considered as "primary features" because they have not undergone lateral movement. Cobbles from these outcrops often have a very thin cortex at the Chivay source.

The only consolidated obsidian flow to strike the surface in the Maymeja area is finely jointed in the vertical direction, offering fragmented primary material that is poorly suited for obsidian tool making. It is notable that this flow is exposed in a gully in the northern portion of the Maymeja depression where glacial erosion is most pronounced and the bed of a small glacial tarn, forming only during the wet season, is located nearby.



(a) (b)

Figure 4-21 (a). Small box in lower-right gully shows Q02-1, an obsidian flow eroding out of ashy-pumaceous soils below western arm of Cerro Ancachita. (b). This obsidian is of limited use for tool making because it contains vertical, subparallel fractures.

On the southern half of Maymeja, a heavily exploited unconsolidated outcrop strikes the surface at the principal quarry pit (Q02-2), but only small nodules (5-10 cm long nodules, and a rare piece up to 15 cm long) remain. In these areas several quarry pit features, one large pit measuring 4 x 5m and 1.5 m in depth (Section 7.4.1), and two shallow pits measuring approximately 1-2 m in diameter that are possibly modern were observed further down the ridge. The larger quarry pit is located on a slope and on the downslope side lies a debris pile made up of primarily small, non-cultural (unmodified) nodules of obsidian, but with the occasional flake or retouched flake. Quarry pits surrounded by discard piles have been termed "doughnut quarries" by Healan (1997: 86-87) describing the Ucareo source in central Mexico where such pits have been found in great abundance. Variously sized quarry pits have also been described by researchers at other obsidian sources in central Mexico (Darras 1999: 80-84; Pastrana 1998).

Nodules at the Q02-2 quarry pit are found in two principal forms: a long, narrow form and a spherical nodule form. It is possible that the nodule forms reflects differences in emplacement, with the long, narrow nodules resulting from relatively thin flows while spherical nodules are unconsolidated outcrop forms. As will be discussed in Ch. 7 (Section 7.4.1), these nodule forms appear to have influenced knapping strategies as narrow nodules offer more angles and a different flaking geometry as compared with spherical nodules. Pastrana and Hirth (2003) describe reduction strategies for biface production that exploit long, narrow nodules at the Sierra de las Nevajas (Pachuca) source in central Mexico (Figure 7-2).

Chivay type obsidian outside of the Maymeja area

Elsewhere around the base of the dome Cerro Hornillo obsidian was encountered eroding from the ground in smaller nodules (2-5 cm long). These obsidian exposures are pronounced on the eastern and south-eastern slopes of Cerro Hornillo around 4900 masl where scatters of subangular pebbles and cobbles, or angular shattered felsenmeer carpets of these small obsidian pieces, were encountered. In glacially eroded areas and along wind-scoured ridges these obsidian surfaces occur as lag gravels where finer soil has been transported away by Aeolian processes, leaving only obsidian nodules. These nodules appear to be weathering from rhyolitic flows and the tool-making quality of the raw material seems to be compromised of three characteristics: (1) *Size* - remaining nodules were typically quite small; (2) fracture quality - heterogeneities in the material caused the material to fracture unpredictably; (3) visual quality - the nodules were often occluded with bubbles and ash particles.

Figure 4-22. Obsidian gravels exposure in tephra soils east of Cerro Hornillo.

In this study, obsidian containing heterogeneities due to the presence of bubbles or ash particles is termed “Ob2” obsidian, while homogeneous obsidian that was probably preferred for tool production in antiquity is referred to as “Ob1” obsidian.

Pulpera / Condorquiña flow

In the course of the Upper Colca Project research an obsidian source was encountered on the eastern toe of the Barroso lava flow where flows emanating from Cerro Ancachita and Cerro Hornillo terminate near the community of La Pulpera. According to the INGEMMET map (Ellison and Cruz 1985), this obsidian appears to have formed where silicic lava flows belonging to the Barroso group contacted Late Miocene ignimbrites from the Pichu formation and cooled rapidly leaving obsidian exposed by erosion in this area. This obsidian does not appear to be of tool-quality as the nodule size is small (<5cm) and it contains many heterogeneities that interfere with the fracture characteristics of the stone. Samples of this obsidian were sent to M. Glascock at the Missouri University Research Reactor in 2002 and the samples were determined to be of the same chemical group as Chivay (Glascock, pers. comm. 2002).

Obsidian Cortex

The cortex of nodules at the Chivay source is often remarkably thin. The spherical nodules, described above, seemed to be more closely affiliated with a very thin cortex that is under a millimeter in thickness where hydration appears only as a slight discoloration on an otherwise smooth external surface. In other cases, particularly on long and narrow nodules, a textured and raised, but sometimes rough and ropey, cortex is evident that was referred to as “tabular cortex”.

This geologically derived variation in cortex is meaningful to archaeologists because when the cortex was thin it appears that it was sometimes left undisturbed on the faces of many preforms, but when the cortex was the rough or tabular type, it seems to have been a central obstacle to knapping. Cores partially covered with rough cortex were discarded after flakes were removed from the non-cortical face. One possible explanation for the intensified quarrying observed at the Q02-2 quarry pit is that nodules recovered in this area contained a high frequency of the thin type of cortex, a cortex type which would have represented less of an obstacle to knapping.

The cortex form can influence reduction strategies in important ways. First, if cortex is extremely thin then it does not pose a structural obstacle to knapping and the priority on reducing an item's weight by decorticating it close to the raw material source may be lessened. Second, the thick tabular cortex on one side of long, narrow nodules greatly limits the potential of these nodules unless the cortex can be removed effectively. We speculate that the origin of the very thin cortex is related to the glacial history of the obsidian source. These unconsolidated outcrops were likely to have been compressed and eroded by the presence of glaciers and the effect of this glaciation on obsidian outcrops may have served to further fragment and introduce water into the obsidian flow, which appears in the oldest specimens as a layer of perlite. As a consequence, the extremely thin cortex may have resulted from glacial erosion and moisture introduced during the Pleistocene, rather than from characteristics of the original quenching environment of the obsidian flow. Obsidian hydration dating may allow direct dating of the fracturing of the obsidian, however the unreliability of hydration dating in contexts of high temperature variation and unknown moisture levels (Ridings 1996) suggests that results from hydration rinds alone are probably of limited value.

4.6. Other Tertiary obsidian in the Colca valley

Other Barroso group deposits in the region include Pampa Finaya on the north side of the Colca River. In the course of his archaeological survey Steven Wernke (2003: 36, 39) surveyed Pampa Finaya and, unlike in the Chivay source area, obsidian was not found on the perimeter of this Barroso flow where it contacts Tacaza layers. However, Wernke identified an obsidian source to the west on Cerro Caracachi, a distinctive knob-shaped peak at the head of Quebrada Huancallpucy that is at a contact zone between a layer described by INGEMMET as an porphyritic intrusive material (T-po). This source was exposed in a distinct stratigraphic context and that the obsidian appeared to be of low quality for knapping as compared with the Chivay type.

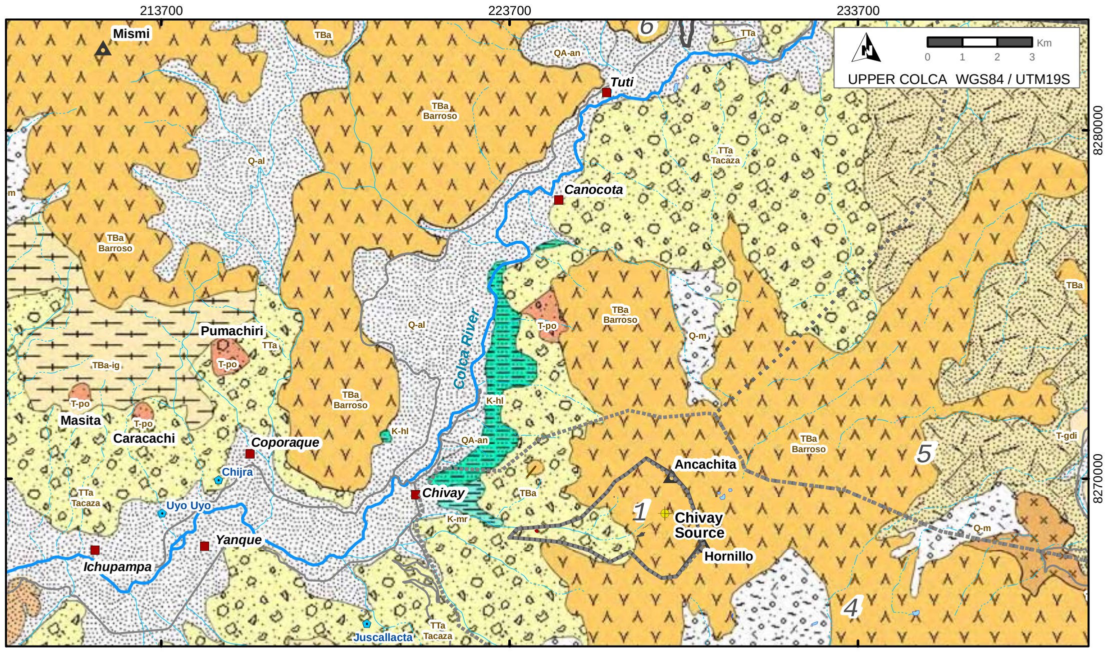


Figure 4-23. Geological map units with Uyo Uyo sampling locations. See Figure 4-14 for legend. Selected archaeological sites in the main Colca Valley shown in blue.

On 30 Nov. 2003, I visited the area of Cerro Masita and Cerro Caracachi on the suggestion by Wernke (2003, pers. comm.) in order to collect geological samples, to determine whether higher quality obsidian is encountered on this dome, and to compare the deposits with what had been observed at the Chivay source (see Appendix B4). I approached Cerro Masita was approached from the road in the drainage north-west of Ichupampa and only observed small pieces of low quality obsidian near the summit of Caracachi (documented by Wernke) and on the eastern flanks of Masita. Analysis by at Missouri University Research Reactor (Glascock, 2005 pers. comm.) established that this material belongs to the “Uyo Uyo” chemical group first recognized in samples provided by Sarah Brooks (1998: 443-445). In 1993 Brooks collected modified and unmodified nodules from the site of “Uyo Uyo” near Coporaque that were analyzed at MURR in 1995. Brooks (1998: 443-445) writes that the geological origin of these nodules was not determined, but the presumption was that the source lay uphill from the site of Uyo Uyo, as there were many unmodified nodules at the site, an observation that was confirmed by these hikes. No large nodules were encountered, however, and it appears that the Chivay source east of Chivay remains the sole source of high quality obsidian in large nodule form in the Colca valley.

Rare 6 Type distribution

In her dissertation, Brooks (1998: 443) notes that Glascock identified the Uyo Uyo samples as matching the "Rare 6 Type" obsidian that had been previously encountered in Burger's earlier work with Lawrence Berkeley Lab (Burger and Asaro 1977: 56). However, Glascock cautions that the calibrations are not perfect between the LBL and the MURR results, particularly with small sample sizes. In recent communications Glascock (2006, pers. comm.) is not confident that the Uyo Uyo and Rare 6 Type are the same type and he believes a re-analysis would be required to confirm it.

In Burger's earlier study he identified Rare 6 type from two projectile points in Cuzco and Puno (Burger et al. 2000: 312-313). One sample was from the surface of the site of Chinchirmoqo that lies 2 km from Pomacanchi in the department of Cuzco. The other Rare 6 Type sample was a projectile point found on the surface of the site of Taraco on the north side of Lake Titicaca. These surface samples are difficult to assign to a specific time, though Burger et al. placed both samples in the "latter part of the Early Horizon and Early Intermediate Period", a period that roughly corresponds to the Middle to Late Formative using the chronology of the present project. Excavation work currently underway by Charles Stanish and colleagues at the site of Taraco may reveal additional Rare 6 Type obsidian artifacts.

4.6.1. Tripcevich source sampling work

In the course of Upper Colca 2003 survey work geological samples of unmodified obsidian were collected from a variety of natural contexts throughout the Upper Colca study area as well as elsewhere in the Colca valley. In order to best characterize the elemental variability within a chemical type, Shackley (1998: 100-101) recommends collecting samples from throughout the primary and secondary deposition area in sufficiently high numbers to recognize sub-source variability and reduce the chances of mischaracterization.

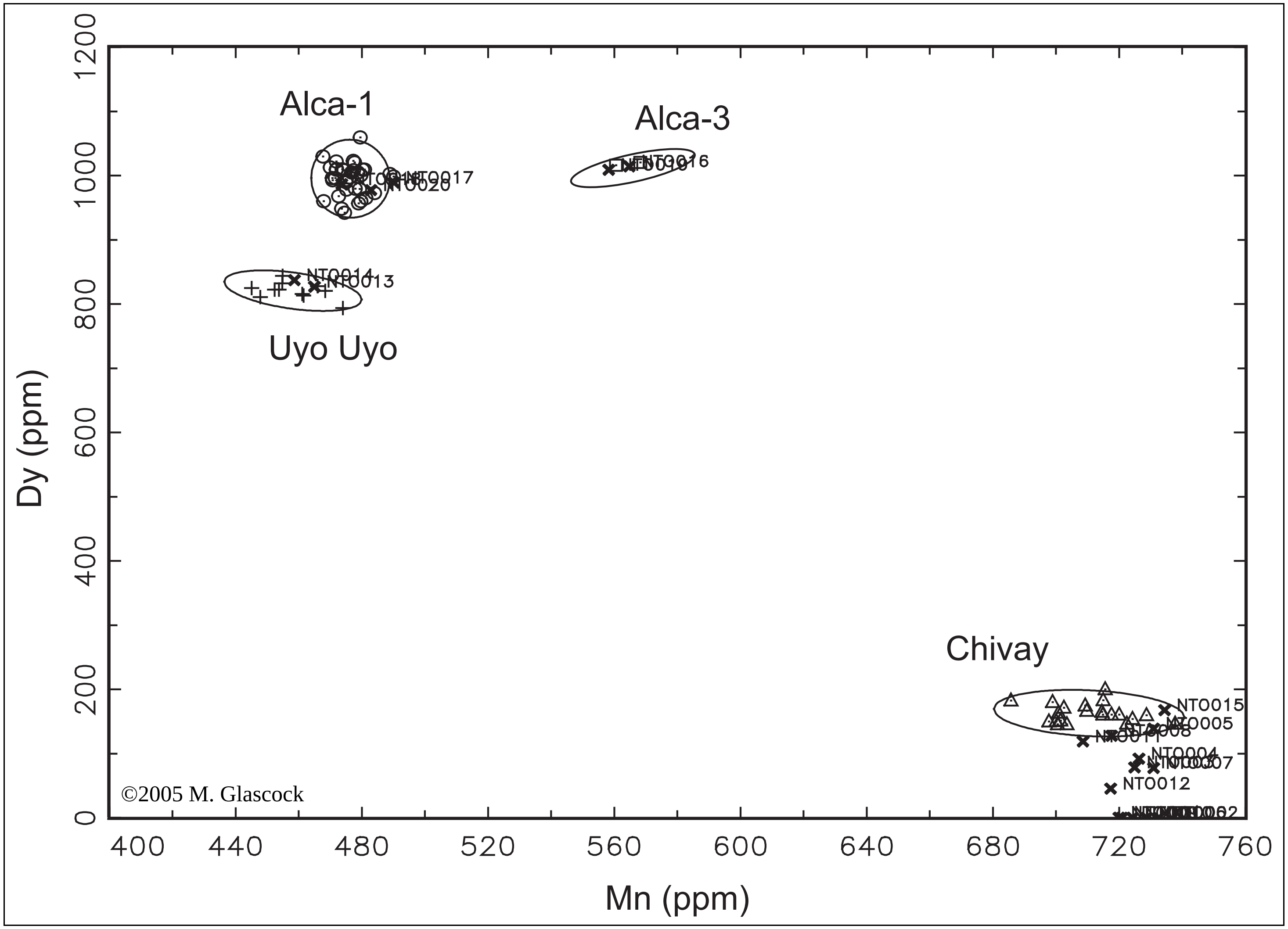


Figure 4-24. Bivariate plot showing Dysprosium against Manganese for Tripcevich 2005 samples.

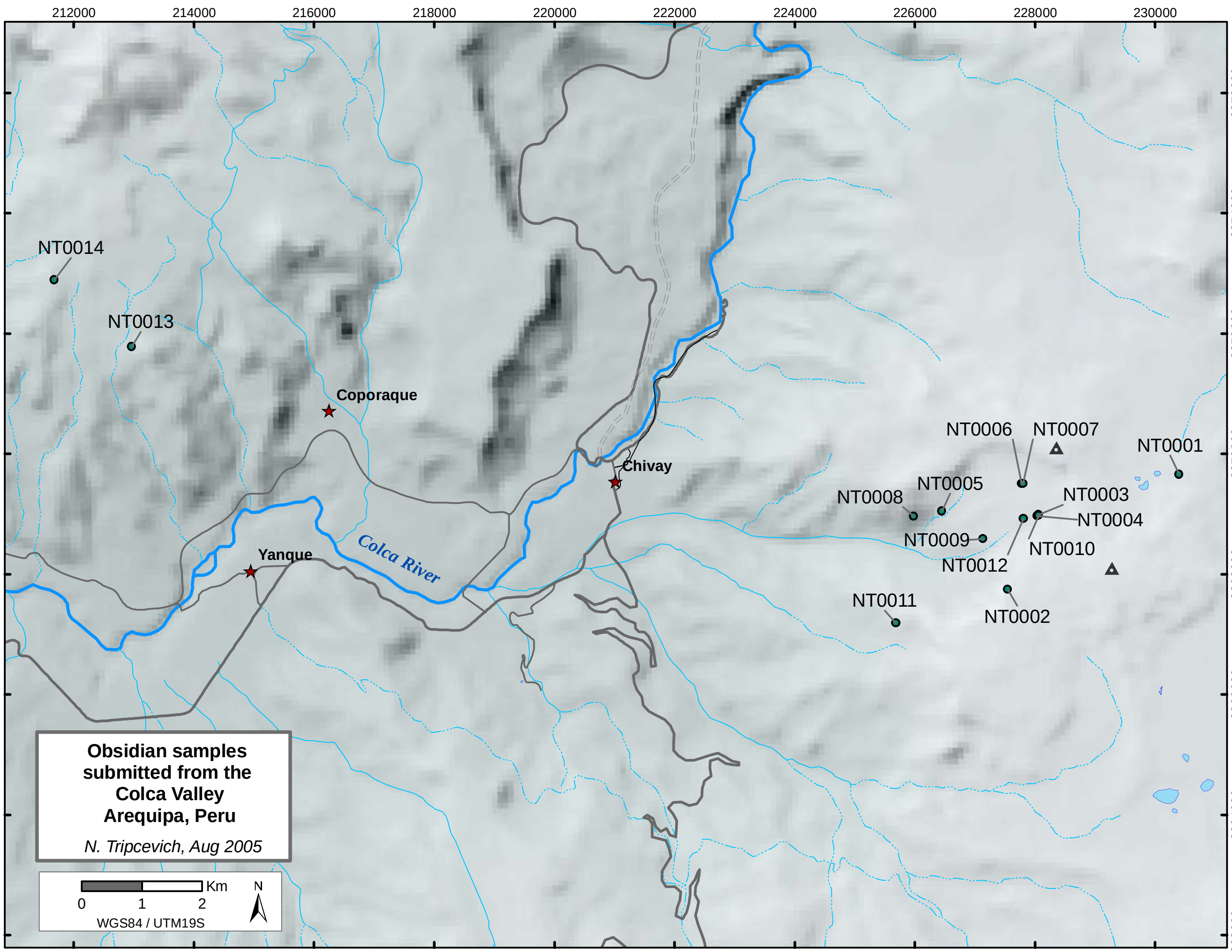


Figure 4-25. Map showing locations of Colca valley obsidian source samples analyzed by MURR in 2005.

On Figure 4-24 only samples NT0005, NT0008, and NT0015 fall within the Chivay ellipse giving the impression that there is chemical variability at the Chivay source. Bivariate plots across other elements, however, show that all of the samples fall squarely within the Chivay ellipse.

MURR ID	Result	Region	Description	Quality	Date	Elev	Longitude	Latitude
CQP001	Chivay	Colca	Condorquiña source near Pulpera	Poor	2002	4160	-71.41795	-15.55677
CQP002	Chivay	Colca	Condorquiña source near Pulpera	Poor	2002	4155	-71.41793	-15.55675
CQP003	Chivay	Colca	Condorquiña source near Pulpera	Poor	2002	4160	-71.41795	-15.55677
NT0001	Chivay	Colca	East of Cerro Hornillo	Med	2002	4972	-71.51366	-15.63657
NT0002	Chivay	Colca	Maymeja SE rim along trail departing area at 140°	Good	2003	5003	-71.54049	-15.65356
NT0003	Chivay	Colca	Quarry pit Q02-2, A03-219	Good	2003	4916	-71.53554	-15.64233
NT0004	Chivay	Colca	Chivay	Good	2003	4911	-71.53577	-15.64257
NT0005	Chivay	Colca	Chivay, A03-570. Cortex battered, poss. from glaciers.	Good	2003	4722	-71.55058	-15.64167
NT0006	Chivay	Colca	Chivay, northern Maymeja	Med	2003	4900	-71.53812	-15.63772
NT0007	Chivay	Colca	Chivay, northern Maymeja	Med	2003	4902	-71.53794	-15.63770
NT0008	Chivay	Colca	On western shoulder of Ancachita with ash sample	Med	2001	4622	-71.55493	-15.64239
NT0009	Chivay	Colca		Good	2002	4798	-71.54423	-15.64587
NT0010	Chivay	Colca	Quarry pit Q02-2, A03-219	Good	2003	4915	-71.53556	-15.64247
NT0011	Chivay	Colca		Good	2003	4685	-71.55794	-15.65837
NT0012	Chivay	Colca		Good	2003	4885	-71.53793	-15.64292
NT0013	Uyo Uyo	Colca	W. side of Cerro Caracachi	Poor	2003	4450	-71.67602	-15.61547
NT0014	Uyo Uyo	Colca	East slope of Cerro Masita	Poor	2003	4372	-71.68787	-15.60532
NT0015	Chivay	Ayaviri	Artifact from Yana Salla, Llalli	Good	2001	4200	-70.87933	-14.94699
NT0016	Alca-3	Cotahuasi	Near small rock shelter by top of landslide	Good	2001	4288	-72.73238	-15.11981
NT0017	Alca-1	Cotahuasi	From across valley near old canal	Med	2001	4203	-72.71776	-15.12254
NT0018	Alca-1	Cotahuasi	From across valley near old canal	Med	2001	4202	-72.71776	-15.12254
NT0019	Alca-3	Cotahuasi		Good	2001	4329	-72.73268	-15.11858
NT0020	Alca-1	Cotahuasi	Above Ayawasi	Med	2001	3760	-72.73644	-15.14140

Table 4-5. Peruvian obsidian source samples submitted to MURR by Tripcevich in 2002 and 2005. Coordinate datum is WGS84.

Three samples were provided from the low-quality Condorquiña source in the Pulpera area that were collected in 2002 in order to evaluate the chemical variability within the Chivay source. While the quality was poor, this characterization demonstrates further association between that the Chivay obsidian chemical type and the Pliocene Barroso lava flows evident in the Colca valley. One artifactual sample that turned out to be Chivay was from the town of Llalli close to Ayaviri, in Puno.

Additional samples were submitted from the Alca source collected during fieldwork in 2001 from an exposure described by Justin Jennings (Pers comm. 2001) to the west and south of Cerro Aycano. Kurt Rademaker and colleagues (2004) have since encountered much larger obsidian exposures to the east of this area, on moraines located on the northern slopes of Nevado Firura at approximately 4700 masl.

4.7. Conclusion

The geography and geology of Chivay obsidian deposits conditioned the human use of this source in prehistory. Spatial relationships around the source were reviewed here in terms of three primary contrasts. First, on a regional scale, the location of the Chivay source above the rich and productive Colca valley meant that the source was only a few hours from communities residing in the main valley, but that it was also accessible to puna residents, and herders and caravan drivers as the economy based on camelids expanded. Given the inefficiency of pure pastoralism, obsidian exchange was likely part of a larger pattern of sustained contact between herders and agriculturalists. Second, exploitation of particular sources of obsidian over others was probably limited by local conditions, as water is much more available in the Maymeja area than elsewhere around Cerro Hornillo. Finally, the quality of obsidian varies due to the formation and erosion contexts of Chivay obsidian in prehistory. The Q02-2 quarry pit appears to have been the source of obsidian that predominantly consisted of large nodules of homogeneous glass with a relatively thin and inobtrusive cortex, permitting efficient and predictable quarrying and production in prehistory. As will be discussed in the chapters that follow, these geographical factors were influential in the archaeological use of the Chivay obsidian source area as was documented in the course of the 2003 research project.

5. – Chapter 5 –

Research Methods and

Data Recording Strategies

5.1. Introduction

This chapter reviews methods and equipment used in the course of the Upper Colca Archaeological Research Project, and it describes the creation of indices and measures that are used in analyses in subsequent chapters. Research at the Chivay obsidian quarry presented two principal challenges. First, the obsidian source itself is situated in a rugged, high altitude landscape that required working out of backpacker campsites and involved careful decisions regarding time budgeting during survey and excavation at the source. Second, raw material source areas present a challenge in the sheer volume of archaeological materials that are typically found in these areas. Sources require a modification of the established "site-oriented" survey paradigm for mapping and sampling during fieldwork, and for analysis during lab work. An additional goal of this project was to implement mobile GIS to record archaeological distributions in a digital format that integrates easily with a GIS database, and at a finer scale of resolution than is possible using traditional archaeological survey methods.

This chapter will review the research methods used both in the field during survey and excavation work, and in the subsequent lab analysis. Research design required an explicit selection of survey methods and these will be discussed below. Laboratory analysis of artifact collections was broad such that, for example, simple flakes were analyzed with nearly the detail of projectile points. This expansive analysis strategy required explicit sampling methods so that detailed analysis took place on representative samples from across geographical space and across artifact types, as sampling reduced the total count of artifacts requiring detailed analysis. Collections from survey and excavation were analyzed in two stages, (1) basic sorting and weighing of all collections, and (2) detailed analysis of selected artifacts from the larger population. The integration of field and laboratory digital data permitted the production of detailed summaries promptly for a Peruvian government report, and it allowed for the integration of GIS spatial analysis tools with the detailed data of lab analyses.

5.1.1. Locus rather than Site-oriented survey methods

Raw material sources are archaeologically complex features because, as foci for ancient procurement, there are frequently a large number of overlapping palimpsest occupations. A siteless survey approach is theoretically compelling (Dunnell 1992; Dunnell and Dancey 1983; Ebert 1992; Foley 1981; D. H. Thomas 1975; but see Binford 1992), however in practice most projects must balance detailed mapping against expediency and recording speed, as will be described below. The theoretical aims of this research were to detect and record meaningful variability in prehispanic artifacts and features throughout the study area, but also to focus on concentrations of lithic reduction activity and the variable material types that were evident in lithic scatters. The Upper Colca survey was not a “siteless survey” if that technique is taken to mean that the position of every artifact is recorded individually. Rather, it involved recording concentrations of non-diagnostic artifacts as loci in a mobile GIS system using a GPS polygon to delimit the loci (Tripcevich 2004a, b). The result is a regional survey approach that is approximately as fast as traditional survey recording methods, but with much finer resolution and with greater detail on data that are more relevant to the theoretical goals of the research as determined by the field researchers.

5.1.2. Data recording in both categorical forms and field journals

The approach to data recording taken with this research project was essentially two-pronged where the mobile GIS archaeological recording system was complemented by more subjective notebook records written in a narrative form. These two complementary recording methods were employed, to some extent, in every data recording situation.

Method 1 - Digital forms with a spatial reference: The field crew aimed to record comparable and relatively objective data categories used digital forms linked to GPS-based spatial provenience in the mobile GIS data recording system. This system shares many of the advantages, and the limitations, of traditional, paper-based fieldwork forms.

Method 2 – Personal notebooks: Complementing Method 1, all team members had field notebooks where they were meant to record both data and more abstract observations on a daily basis at a variety of scales including the local, site-level scale, observations about regional patterns, and the relevance to larger goals of the project. Field notebooks may also take the form of digital audio recorded as one walks over a site.

While a two-pronged approach using both objective forms (traditionally, as paper forms on a clipboard) and field journals is not unusual, the distinction between the two systems is made more explicit by the use of mobile GIS. The digital recording system takes care of two aspects of archaeological feature and artifact recording: spatial positioning and data logging into comparable, form-based attributes. Conversely, the field notebooks fill the important role of capturing a range of other insights from fieldwork that are difficult and inefficient to capture in a digital form. In a notebook, observations and reflections on the contexts and patterns under study are more naturally recorded in narrative form, along with schematics, flow charts, or casual site sketches. The importance of reflection and observation has long been known to geographers and other field scientists.

> There is at present enthusiasm for field mapping and their techniques… But map what and to what purpose? Is not this possibly another horn of the dilemma? ...Routine may bring the euphoria of daily accomplishment as filling in blank areas; the more energy goes into recording, the less is left for the interplay of observation and reflection (Sauer 1956).

Field notebooks provide an important contrast to the regular, systematized data notation of the mobile GIS system. Furthermore, many of the fieldworkers did not have access to the mobile GIS system, and as there was only one system in the 2003

Upper Colca team then only one person could be logging data into that system at a given moment. Months after the fieldwork was over, in the course of the analysis process, the various field notebooks provided daily observations, detailed notes on sites, and an overview that corroborated the geographically detailed and categorical organization of the mobile GIS database. Another valuable form of complementarity between the two systems is that one is geographical while the other is temporal in structure. Mobile GIS is inherently spatially focused, as it is a cumulative process of recording and improving spatial features with attributes and mapping detail, and when the GPS is activated the user is automatically viewing data layers in close proximity to the current location. Field notebooks, however, are temporally organized as they are logged chronologically as the field research progresses. Field notebook pages are easily photocopied and scanned into a file such as PDF, allowing the written logs can join the digital database albeit in an unsearchable form. Ultimately these two forms of data acquisition complement one another, and as mobile GIS increases in capability and in popularity, the dirt-smudged field journal will most likely continue to serve an important, material function.

5.2. Geographical context

As this research involves GIS analysis at regional, local, and intrasite levels of analysis, methodological issues related to spatial data organization will be described below.

5.2.1. Geographical datum and regional data sets

At the regional scale, data on obsidian consumption patterns in the central and south-central Andes were gathered from the original sources cited in summaries principally by Burger, *et al.* (2000; 2002), as well as some more recent contributions from other sources. Regional studies of obsidian distributions require incorporating spatial data from a variety of maps and records. The bulk of these data consist of site locations and other archaeological phenomena, and these data derive from studies between 1960 and 2000 where spatial data in the Andean countries was referenced to an older coordinate system based on the Provisional South American Datum of 1956 – La Canoa, (PSAD56). Currently, the governments of these Andean countries are shifting their cartographic divisions to a modern datum based on World Geodetic System 1984 (WGS84) or the related *Sistema de Referencia Geocéntrico para las Américas 2000* (SIRGAS 2000) (Fortes et al. 2006), a new continental reference system for South America. The Upper Colca Project functioned entirely in WGS84 in order to be consistent with global data sets such as satellite imagery and other forms of spatial data that have recently become available. The datum change from PSAD56 to WGS84 results in an incompatibility between historic datasets and recent work, when obsidian artifacts from older collections are chemically provenienced and the precise spatial origin of these artifacts can be difficult to ascertain. Ultimately all of these sites should be revisited and mapped with GPS using a modern system such as WGS84, but in the meantime a relocation of these site positions and transformations of the historic geographical data are required.

Spatial data in Peru and Bolivia are almost universally rely on the 1956 La Canoa (Venezuela) datum based on the International 1924 ellipsoid known as Provisional South American Datum (PSAD56). If data from PSAD56 and WGS84 data are inadvertently combined, the resulting misalignment of map features in the Arequipa area is approximately 300 to 700 m.

Ellipse	Datum	Semi-Major Axis (meters)	1/Flattening
International 1924	Prov South American 1956	6378388	297
WGS 1984	WGS 1984	6378137.0	298.257223563

Table 5-1.The two reference ellipsoids used in Peruvian and Bolivian cartography (NIMA 1977).

Three parameter metric transformations that can be applied to UTM coordinates in the central Andes are shown in Table 5-2.

	NIMA/NGA 1991 TR8350.2 report			PERU IGN 2005
	PERU	BOLIVIA	MEAN FOR ANDEAN NATIONS	PERU (no error published)
Direction	PSAD56 → WGS84	PSAD56 → WGS84	PSAD56 → WGS84	PSAD56 → WGS84
ΔX (Eastings)	–279 m ± 6 m	–270 m ± 5 m	–288 m ± 17 m	-303.55m
ΔY (Northings)	+175 m ± 8 m	+188 m ± 11 m	+175 m ± 27 m	+265.41m
ΔZ (MASL)	–379 m ± 12 m	–388 m ± 14 m	–376 m ± 27 m	-358.42m
No. Satellites	6	5	63	
ArcGIS Transformation	1208: PSAD_1956_ To_WGS_1984_8	1202: PSAD_1956_ To_WGS_1984_2	1201: PSAD_1956_ To_WGS_1984_1	

Table 5-2. Three parameter cartographic transformations for UTM coordinates from PSAD 1956 (La Canoa) to WGS 1984 (Dana 1998; Mugnier 2001; 2006: 496; NIMA 1977).

By using the WGS 1984 datum, the geographical data collected in the course of the Upper Colca Project research registered properly with newer spatial data from a variety of institutions such as international, US government, and private remote sensing sources. These datasets include global topographic data like SRTM, satellite imagery and DEM sources like ASTER, and these data are also consistent with web products like Google Earth. Furthermore, WGS84 is the native coordinate system of the Global Positioning System and therefore the dGPS data acquired during fieldwork in the Upper Colca did not require an additional geographical transformation. The majority of maps in the region will be released in WGS84 or SIRGAS 2000 in the coming years.

5.2.2. Regional datasets

Sources of spatial data were used in the regional analysis component of this project consist of digital raster and vector sources, and scanned paper-based maps. The first group include topographic datasets acquired from ASTER (Abrams et al. 2002) and hole-filled SRTM (Jarvis et al. 2006), and the second group are vector datasets acquired from Vector Smartmap and derivative datasets (NIMA 1995). Peruvian and Bolivian government maps were scanned from paper, georeferenced, and transformed (IGM 1986; Klinck and Palacios M. 1985; Palacios et al. 1993) so that all now coincide with the WGS84 datum.

5.3. Data recording approach

5.3.1. Introduction

This research project encompassed three major zones: a river valley zone, a high *puna* zone, and the obsidian source itself. A principal challenge in the archaeological evaluation of contrasting survey regions is the construction of meaningful categories that allow for comparison between these varied zones. Consequently, this project sought to strike a balance between the in-field assessment of sites and features based on the experience of archaeologists, and the significance and categorization provided by ancillary lab results and spatial analysis.

The 2003 field recording approach resulted in the presentation of data in this chapter that is a combination of two major forms of information. (1) Data that were recorded during survey work that described features and artifacts assessed by fieldworkers and quantified both in the field and in the lab, in the course of subsequent lab analysis. These categories are scalable, but the larger structure of the database is rigid in order to allow for comparison between different contexts. (2) Data were derived through inference and subjective assessment in the course of fieldwork by the project director (Tripcevich) and by five other experienced archaeologists who participated in segments of the fieldwork. The insights and notes of other project participants were also included into this subjective data category.

The result is a project that is integrated by using comparable quantitative measures, but that is informed by the subjective experience and interpretation of the archaeologists that conducted the fieldwork. The following data presentation is therefore based on quantitative measures, but the comments and assessments are informed by the insights from daily observations and personal notebooks.

5.3.2. Organization, sampling, and inference

Regional archaeological surveys must devise classification schemes that allow for meaningful comparison between features mapped throughout the survey area. In the Upper Colca Project, some artifact classes had radiating distributions that created special problems when devising comparable categories. This situation is best explained through an example that illustrates the challenges of consistent data recording.

The radial attenuation problem in artifact densities can be observed most dramatically in obsidian concentrations throughout the survey region as one departs from the Chivay source. In such situations, the human eye is easily misled by large concentrations of artifacts because the eye is attuned to the presence of contrasting or unusual materials, an issue that makes consistent sampling methods all the more important. In this example, the field crew would readily observe single flakes of obsidian far from the obsidian source, while at the source area itself a given obsidian flake was common place and obsidian densities were relatively deprioritized. Yet in the obsidian source area a flake of *chert* was notable as it provided contrast. While these contrasts are meaningful: it is important that one might find a flake of chert at the obsidian quarry, far from the river where chert is usually found, such features should be mapped and observed separately with observations indicating that this is a-typical for the area. Ample effort should also be given to mapping features that *are* typical to the area for faithful representation of general distributions.

This example illustrates a major methodological challenge for archaeological survey that exists in both conventional and digital recording systems. A systematic sampling strategy is the most cost effective way to describe the common features found in a region, because random samples can be extrapolated to the larger population. These distinctions in artifact identification correspond to two types of survey differentiated by Banning (2002: 27-38) as “statistical survey” and “prospection survey”, as will be discussed in more detail below. Attributing the finds in the database based on the type of survey strategy that was employed permits a more consistent depiction of broader features of the landscape in later analysis.

5.3.3. Aggregating by Sites versus Loci

Spatially delimited “sites” were deprioritized in this project in an effort to capture changes in the continuous field of obsidian artifacts and related sites as one approaches the obsidian quarry workshop area. Rather than relying on the ill-defined concept of *site* as the basic unit of analysis (Dunnell 1992), the Upper Colca Project survey team focused on recording *loci* of different artifact classes. Site boundaries were in fact recorded, however, because it was impractical to record isolates in the same detail as one recorded spatial structure in the concentrations conventionally thought of as a *site*.

For example, it was difficult to reconcile the density of the category *High density lithic scatter* between a workshop at the obsidian quarry, on one hand, and a residential base in the valley bottom; a problem that was resolved with sampling. Furthermore, pottery was almost non-existent in the lithic quarry area, even though on a regional scale there is ample evidence of consumption of obsidian by groups that possessed ceramic technology. In order to examine data in an integrated framework, broad categories such as “Site Type” were given minimal priority in favor of explicit and comparable categories based on features and on artifact concentrations described as loci. Broad *site type* categories were assessed primarily for purposes of cartographic representation and to facilitate communication in the course of research, however analysis and interpretation focused on basic and comparable categories of data by artifact class.

5.3.4. Site and Loci recording structure

Archaeological sites and features were recorded primarily in terms of categories built around artifact classes while in the field. The site – isolate dichotomy is useful for expediency while doing fieldwork, but “Sites” and “Site Types” did not form the basic unit of analysis. Rather, in the course of survey, if a given group of artifacts was isolated or belonged to a “site”, and if it was sufficiently large to be considered a site, then the recording strategy shifted to a more detailed analysis method.

When it came time for a site to be documented, attributes were recorded on numerous levels: on the level of the site, on the level of loci of three feature classes (lithics, ceramics, and structures), and finally on individual artifacts found in spatial association with that site. With these categories, the data and the lab results could be used to categorize the sites after-the-fact based on actual data and not only based on in-field intuition. In this manner, in-field impressions of archaeological features contributed to, but did not structure, the framework in which data was recorded. The structure provided by digital forms and GPS based mapping technology was complemented by interpretive notes and impressions that were written on field journals in daily narratives during fieldwork. The details of our Arcpad mobile GIS recording system are provided later in this chapter.

5.3.5. The Primary Key: ArchID

A stable, primary key ID number was assigned to all phenomena that were individually mapped. Every feature or artifact, including sites, loci, and individual artifacts that were mapped separately, were assigned their own “ArchID” number in a single number series regardless of the archaeological feature type. The ArchID primary key is a unique identifier integer that was value-free, as no further feature information was embedded in the number. For example, some archaeologists may classify sites by number range. In that system, rock shelter sites might be numbered between 100 and 200, and administrative structures might fall between 400 and 500, for example. However, that type of encoding of meaning into ID numbers is problematic for database design. The primary key approach adopted here is consistent with database normalization methods and the First Normal Form (Codd 1970) where one ensures that each table has a primary key that serves as minimal set of attributes that can uniquely identify a record. The First Normal Form further specifies that repeated fields be eliminated, and that each attribute must contain a single value and not a set of values. This kind of tabular organization is intuitive for those who have worked with computer databases, but the database normalization literature makes these features explicit.

The ArchID approach to numbering sites, loci, and artifacts in a single series is consistent with the low-interpretation field documentation system. The approach to survey provenience used in the Upper Colca survey is low-interpretation because an interpreted hierarchy is not encoded in the proveniencing system. For example, in some systems the Site ID# is primary, and structures and artifacts encountered inside that site are numerically subsumed by the site numbering, unless they are isolates. In other words, sites receive the principal numbering system, and any artifacts and features found "inside" sites receive index numbers from a secondary range that force the site assignment into the proveniencing of every artifact in that area. The weakness and spatial dependence of this system become more evident when features from different temporal occupations are recorded in a single, multicomponent site. In contrast, the upper Colca survey used a single number series so that the "site" assignment number did not intrude into the proveniencing of every feature inside the site, as features were mapped individually and thus were independent spatial entities.

The advantage to this approach, and to categorizing sites in later analysis rather than in the field, is that documentation and interpretation are distinct steps and data can be reinterpreted and individual loci reassigned to other time periods independently of the site context and spatial provenience in which they originally belonged. In other words, the GIS does the work of spatial provenience, proximity, and overlay, while numbering systems are dedicated only to the task of serving as a key for referencing records and tables in the database. Categories and types were used in this document for analysis, data presentation and summary, however, in the course of original data acquisition during fieldwork there was an explicit effort to document features based on simple artifact and feature characteristics rather than by a generalized typology or classification. There is no single file with all ArchID numbers represented, as they are distributed across the nine file types shown above in Figure 5-7a. However, in a post-fieldwork GIS processing step an

“All_ArchID_Centroids” point file is created that serves as a single reference point for all ArchID numbers used throughout the season (see Section 5.10.1).

5.3.6. Site classification

Meaningful construction of site categories requires a combination of quantitative measures and qualitative assessment based taphonomy and other formation process issues. In the loose volcanic soils of the Upper Colca, relatively high erosion rates result from downslope movement and stream-channel migration, combined with wind deflation and seasonally-intense precipitation. For example, high density lithic loci are commonly found at the base of slopes due to the disturbance and erosion that are part of site formation processes (Rick 1976; Michael Brian Schiffer 1983). These artifact aggregations at the bottom of hill-slopes may appear to qualify as high-density loci when assessed quantitatively and through sampling, however a qualitative interpretation of the context reveals the formation processes at work.

In the Upper Colca project area anthropogenic effects, due to a high incidence of site reoccupation, include the direct and indirect effects of the later reuse of space. These include palimpsests, site maintenance and disturbance, interments, and reuse of construction materials for residential or mortuary structures. The indirect effects are primarily the result of intensive pastoral production that occurred in the Upper Colca in the last few millennia. These include erosion and trampling (although camelids have two digit pads instead of hoofs), and landscape modification for pastoral production such as corral construction and the modification of water distribution to enhance grazing opportunities at bofedales.

5.3.7. Linking Field and Lab data: an example

Every feature and artifact that was mapped individually received a unique identified key (ArchID number) that was used after the fieldwork was over to connect the GPS derived geographical location to associated attribute tables for recording numerical and text characteristics, and other field observations. The ArchID number links Arcpad GPS derived data to these other tabular data in a GIS through One-To-One or a One-To-Many relates. Collections were conducted during the course of fieldwork and in many of these spatial proveniences, a number of individual artifacts were collected and examined creating a One-To-Many relate situation.

An example would best illustrate this situation. In this example, a concentration of lithics is identified and it is mapped and described during fieldwork as lithic locus ArchID: 100. All field acquired data are linked through the number 100, including the polygon delimiting the concentration, environmental and cultural observations at the location, photograph numbers, the date and time of the mapping that is automatically logged. Bags of artifacts collected from that provenience, including ceramics, would receive the ArchID 100 spatial identifier. Furthermore the #100would be noted, or the range of numbers in that area, in the verbal field journal descriptions providing an explicit link between digital tables and interpretive description.

During a later phase of research, when bags of artifacts are opened and analyzed, an artifact-specific level of proveniencing occurs. A collection of artifacts that are spatially provenienced to a polygon: ArchID 100 results, however when it comes to time acquire detailed measurements on those artifacts, some of these artifacts should now be numbered individually. The solution in the Upper Colca Project was to create a catalog ID number, or "rotulo" in Spanish (RotID), such that each spatial provenience has lab numbers inside it numbered 1 to *n.* In practice, the bags would be tagged with a number and a decimal as in **ArchID.RotID** or **100.15** for the fifteenth artifact analyzed from spatial context 100, although digitally the two number series remain integers stored in separate fields. Lithics, ceramics, bone, and any other artifact class were stored together in a single second-level number series, yet in practice there was an attempt during lab work to keep all artifacts of a single class within a contiguous numbering range.

5.3.8. Theoretical relevance of the provenience system

These data recording issues are methodologically specific, but the issues have theoretical importance because later analyses are circumscribed by the units of analysis used in proveniencing. The above descriptions highlight an apparent contrast in the methodology:

Situation 1: Individually mapped and located artifacts and loci that are found at larger sites receive their own ArchID numbers. These are independent entities that may, or may not, belong to the larger site upon further interpretation. Importantly, the GPS derived coordinates store this spatial relationship and the numbering system is independent of spatial location.

Situation 2: As in the example described previously, lithic locus ArchID 100 contains fifteen artifacts *rotulo* numbered RotID 1 through 15 that are analyzed and retained as 100.1 through 100.15. In this case, the artifacts are locked into their spatial container that is the ArchID number. While it would be ideal to have geographical positions for every artifact analyzed, it is not practical to spend so much time in the field and therefore, by necessity, the RotID is inside the ArchID spatial provenience. In other words, spatial provenience is the first level, while artifact provenience is the second level.

In sum, the object here is to allow the GIS to manage spatial information and use the ArchID number system not as a geographical hierarchy, but rather as a linking system to other forms of data be they attribute tables, artifact collections, or digital photos. On a theoretical level, when particular loci are subsumed within particular sites by the numbering strategy (as per the hierarchical system where loci are inferred to "belong" to sites), it is impossible to later extract the loci from within the site in the database because their numberings are inextricably linked. If later analysis reveals that the locus is likely a later occupation and not related to the site itself, there is no easy way to reverse the hierarchy in proveniencing. In the non-hierarchical proveniencing system used by the Upper Colca project, the location of that locus inside the site boundary is already conveyed in the GIS and that liberates the ArchID numbering system to serve as an effective primary key for the database.

5.4. Survey Strategy

5.4.1. Goals of Survey and Testing

The goals of the Upper Colca Archaeological Survey were to document the prehispanic use of the Chivay obsidian source and to record changes in obsidian processing evident at the source. Quarry research presents special challenges to archaeologists because prehistoric patterns are obscured by the sheer quantity of non-diagnostic materials from early reduction stages, and the compounded reuse of space over time (Ericson 1984; Torrence 1986). Working at the Chivay obsidian source involved additional challenges in its remote location at high altitude where roads and electrical sources were unavailable. The research design therefore had to maximize the time spent camping at the high altitude source using field methods that could be used effectively to detect variability in obsidian production at the source.

Very few archaeologists had visited the source area prior to this work, and therefore the research team had to accomplish basic documentation of the source area. However, detecting change in obsidian production required a relatively in-depth investigation, such as analyzing lithic production loci and excavating test units to acquire temporal control. Preliminary visits in 2001 and 2002 indicated that the rugged, high altitude terrain around the Chivay source precluded a systematic and extensive survey of contiguous lands near the source. While total coverage surveys are preferable in theory, it simply was not worthwhile to survey many square kilometers of jumbled rhyolite boulders and skree fields, terrain that were barely passable on foot, when the vast majority of all the locations for sizable sites could be targeted by the general criteria evident on maps and imagery. Furthermore, a comprehensive study of activities related to the source area demanded that time was budgeted for an investigation of the highly productive lands approximately one day's travel away from the obsidian source, in order to place obsidian procurement in the context of the local economy. A research strategy that approached the entire region in terms of survey and testing in three major contiguous blocks was deemed the most effective approach to documenting the source region.

5.4.2. Surveys types: Prospection, Statistical, and Spatial Structure

The principal goal of the survey work was to document archaeological distributions in source area and adjacent terrain. Banning (2002) describes the goals of archaeological survey in terms of three principal types of survey that emphasize different research goals.

Type	Prospection / Purposive	Statistical	Spatial Structure
Application	For *finding* archaeological sites.	For estimating population parameters, evaluating probabilistic hypotheses and constructing locational models.	For detecting spatial patterns such as settlement lattices, travel routes. Also good for documenting continuous phenomena.
Implementation	Prioritize the locating of sites by incorporating background information, predictive models, and remote sensing.	Sampling strategies for documenting artifact density, diversity, and site types within stratified samples or numerical samples.	"Total coverage" or nonsite survey to identify spatial interrelationships that might be missed by sampling approaches.

Table 5-3. Types of archaeological survey described by Banning (2002: 27-38).

Banning makes the point that while sampling is a common approach to archaeological survey, sampling is actually a poor method for prospecting for sites or for characterizing settlement lattices because major clues can fall outside of the sampling window. Each method has specific strengths and weaknesses, and often archaeological surveys are a mixture of several types.

5.4.3. Surveyor interval and sampling

Following Banning's (2002) terms, the Upper Colca survey work was a combination of all three survey types. The survey was prospective because it attempted to document a little known region and find the majority of the large sites associated with the obsidian source, but it was also statistical because survey zones were deliberately stratified so as to permit predictive statements about the use of space throughout the study region. Finally, the Upper Colca research also involved survey for spatial structure because it consisted of three large blocks within which the land was thoroughly surveyed so as to document intersite relationships and travel routes.

Many contemporary archaeological surveys will claim to have conducted "100% survey" of large regions, but then they will have had a survey interval of 30m or more between surveyors. Surveys focused on documenting complex societies with standing architecture are particularly likely to refer to their widely-spaced surveys as "100% surveys". A wide surveyor interval is actually a non-explicit kind of sampling that de-prioritizes smaller sites and those lacking standing architecture, resulting in an often unstated bias in the results. Subsequently, the region is considered "surveyed" though many smaller sites falling between transects were surely missed. While smaller sites are found in these widely spaced surveys, it is only if the site happens to fall across one of the surveyor lines. More realistically, such a survey method is somewhat successful because the surveyors cover a lot of ground but then they will veer off their route to visit high likelihood locations for sites such as rock shelters and lake shores; a technique belonging to the realm of prospection survey.

5.4.4. Survey design

The Upper Colca Project survey goals emphasized investigating the Chivay source area, the geological contexts for obsidian formation, and the principal areas of human settlement within one day's walk from the source. In the implementation of the survey, high-likelihood areas in the obsidian source zone were evaluated using a prospection survey. This included a careful survey of the entire Maymeja area itself and large portions of the southern rim using a surveyor interval of 15m.

Source	Institution	Scale / Res.	Comments / Application
ASTER imagery	NASA, JPL (Abrams et al. 2002)	15m	Visual and NDVI analysis
ASTER DEM	NASA, JPL (Abrams et al. 2002)	30m	Representation, slope calculation
SRTM DEM	NASA, USGS, CGIAR (Jarvis et al. 2006)	90m	Regional relief mapping
Aerial photos	Servicio Aerofotográfica Nacional, Perú	1:60,000	Historic aerial photos.
Topographic maps	Instituto Geográfica Nacional, Perú	1:100,000	Features, toponyms (PSAD56), scanned
Geology maps	INGEMMET, Perú	1:100,000	Geology (PSAD56), scanned
VMAP1	NIMA (1995)	1:250,000	Regional map
VMAP0	NIMA (1995)	1:1 million	Continental map

Table 5-4. Digital data sources used in developing the survey strategy.

Selection of survey regions involved the use of a number of spatial data sources (Table 5-4), as well as interviews with local residents, personal visits, and consultation of previously published reports. Preliminary field visits with a Trimble Geoexplorer GPS in 2001 and 2002 involved collecting ground control points and GPS lines on major roads and other features. After post-processing using the AREQ base station (International GPS Service), these data permitted the georeferencing of aerial photos and scanned maps directly to the GPS acquired data.

Survey Area Criteria

Stage	Feature	Included	Excluded
I. SELECTIVE SURVEY Source Area	Bofedal marshlands	500m buffer around highest 33% of ASTER NDVI* values.	The top 1% of NDVI* values, corresponds to standing water.
		AND	
	Terrain	Land less than 7km from Maymeja Land over 4000m, to keep survey out of town of Chivay.	Terrain with slope over 15°.
		AND	
	Geology Map	Obsidian appears on interface between Barroso and Tacaza.**	
		AND	
	Judgmental	Grassland appearance in ASTER imagery and adjacent to 10+ Ha area of under 5° slope.	Boulder field appearance in ASTER imagery.
II. Test Excavations			
III. COMPLETE River Valley	Corridor	Land within 500m of high river terrace.	Terrain with slope over 15°.
	Total Coverage Transect	All land within a 500m by 4000m area, ridgetop to ridgetop across river valley.	None (no land is excluded).

* ASTER NDVI is 15m resolution ASTER satellite imagery Normalized Difference Vegetation Index, an index of vegetative photosynthesis activity (Jensen 1996).

** It has been noted that obsidian seems to occur where the Late Miocene Barroso group lavas cooled rapidly when in contact with the older Early/Middle Miocene Tacaza Group (Burger et al., 1998).

These criteria were established from field visits and the locational modeling literature. The source area is in remote and relatively rugged terrain, so a selective survey was designed in order to efficiently document the area.

Figure 5-1. Criteria in designing regional survey from three stage research proposal including obsidian source survey, testing program, and concluding with the river valley survey.

Survey in the area of the obsidian source, outside of the Maymeja depression itself, was selective as it focused on high likelihood areas. Survey coverage in the Blocks 2 and 3 zones was contiguous with a 15m surveyor interval although here the survey region was delimited by other criteria. First, in the Block 2 (San Bartolomé area) a particular strip of land was targeted that paralleled the terminus of a Barroso lava flow. The survey block was surveyed 100% at 15m intervals along this densely occupied region. In Block 3, a maximum steepness and distance to river criteria was used to concentrate survey efforts to the river corridor region. Thus, in Block 3, all lands were surveyed within 500m of the high river terrace above the principal drainage (Colca, Llapa, and Pulpera drainages), and terrain over 15° slope (33% slope) were not surveyed. This maximum steepness limitation excluded many eroded regions where preservation is poor, but it also excluded a number of areas that were perhaps occupied. In order to evaluate the survey criteria in Block 3, a swath of land 1 km wide by 3 km long was surveyed at truly 100% coverage at 15m interval, and these areas could then evaluated to gauge the effects of the survey criteria used elsewhere in Block 3 that excluded the high slope and non-riverside areas. This 100% survey test swath will be described in more detail below.

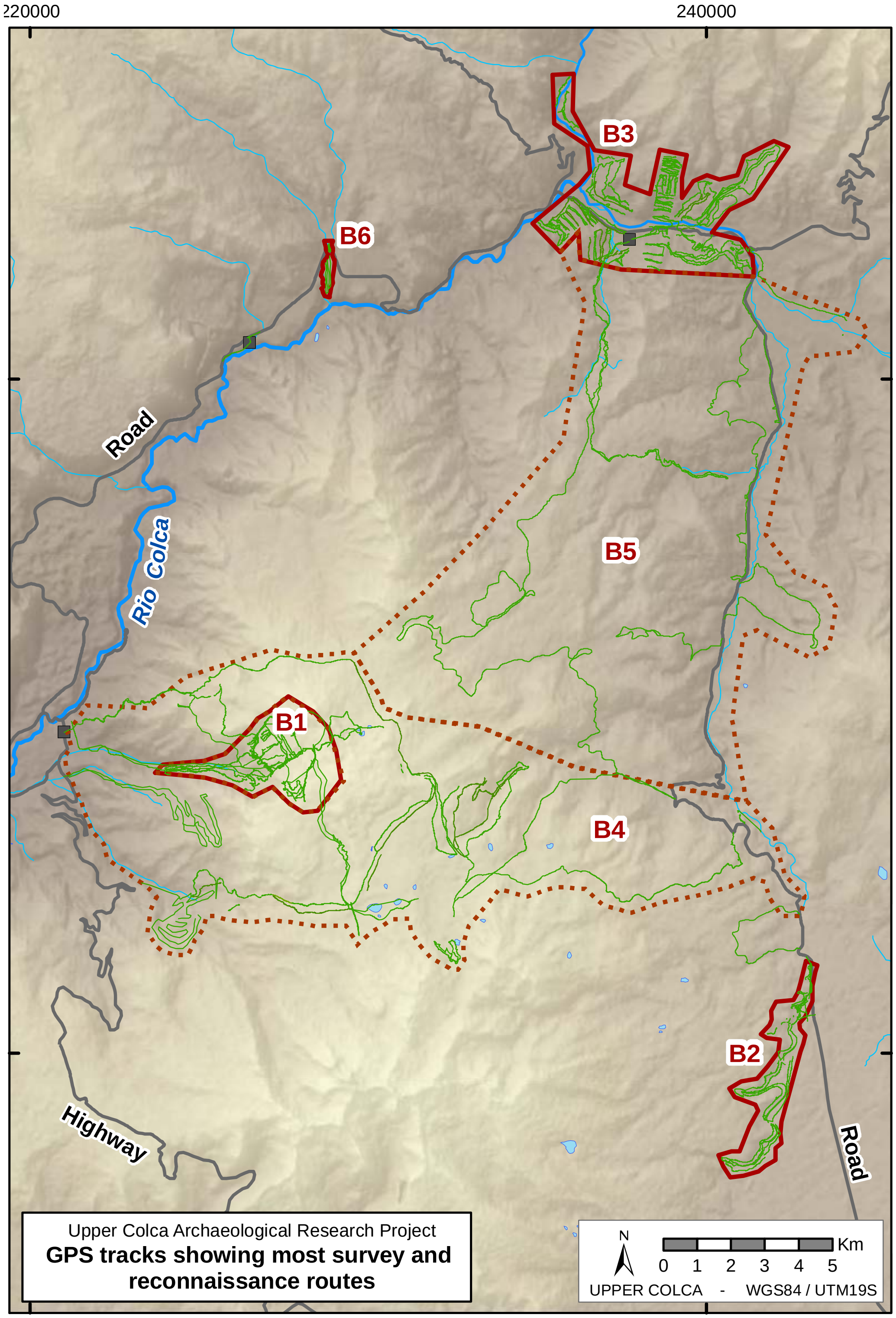


Figure 5-2. GPS tracks from edges of most survey routes showing emphasis on Blocks 1, 2, 3 and 6.

With GPS units the survey coverage and spatial sampling is made relatively explicit, permitting future researchers in the region to focus on areas that were under-investigated in the 2001, 2002 and 2003 survey efforts. With GPS track loggers becoming easily available, explicit coverage reporting will likely be more widely adopted in the future.

5.4.5. Testing the effectiveness of the B3 survey strategy

While survey criteria for coverage in Block 3 were relatively restrictive, a swath in the vicinity of Callalli with a diversity of topographic and ecological conditions was selected for conducting a "100% survey". The goal of covering ground at a 100% was to evaluate the effectiveness of the survey strategy that was being applied throughout the rest of Block 3. The survey coverage in Block 3 included only areas within 500m of the highest river terrace, and slopes under 15° (33.3%) incline.

The 100% survey revealed seven small sites, some lithic isolates, a lone broken vessel and a wall on a hilltop location that was undiagnostic but is probably a Late Intermediate Period pukara construction. The area of the 100% survey swath is 0.5 km wide by 3.5 km long (area = 1.7 km^2) and if *only* the area outside of the regular survey model is included, the area is 1.1 km^2. The sites located in the areas outside of the survey model fall into two major groups: pukaras on hilltops and small, eroding lithic scatters with no reliable temporal assignment found on steep open slopes. Other regional evidence points to a pattern of intensified pastoral production during the LIP and Late Horizon, and these dispersed sites may result from herders working while they monitor their flock during the wet season when the hillslopes of Callalli contain rich graze.

ArchID	Slope°	Altitude	Feature type	Notes
587	29.4	4185	lithic_p	
588	15.1	4128	site_a	
589	20.3	4156	site_a	Visib is +33
590	8.9	4100	site_a	
591	16.0	4073	site_a	
592	18.2	4077	site_a	
593	21.0	4020	lithic_p	
594	22.8	3967	site_a	
605	11.7	4087	ceram_p	
607	13	4164	site_a	Pukara. Visib is +3.12
608	15.3	4161	ceram_p	
609	19.6	4149	struct_l	Possible Pukara wall.

Table 5-5. Sites and isolates from 100% survey strip that would not have been encountered using the regular Block 3 survey strategy.

Given the high effort expended in completing the 100% survey, and the eroded condition of most sites on steep slopes, a slight modification of the survey strategy would have resulted in the group encountering virtually all the informative sites in the region. The improved survey model would be like the one that was employed (500m from the high terrace and < 15° slope), and furthermore it would include a visit to all the major hilltops in the region searching for pukaras. With prospection survey, it is often true that pukara walls can be identified with binoculars or on imagery (Arkush 2005), allowing for targeted climbs of only those hills with visible walls.

5.5. Mobile GIS for archeological survey

Mobile GIS can be incorporated into archaeological survey methods with varying degrees of change to the traditional survey techniques. This section describes the methods implemented in 2003 where a predominantly digital recording method was used.

5.5.1. Standard survey practice

The standard survey practice in the 2003 season consisted of a single team of four to six surveyors spaced 15m apart. The team swept across hillslopes following contours, and at the end of each survey transect the team would sweep around and return towards the opposite direction in the adjacent transect following a boustrophedon configuration. The survey team would assemble to investigate sites when they were encountered, although the team would not necessarily assemble for isolated finds.

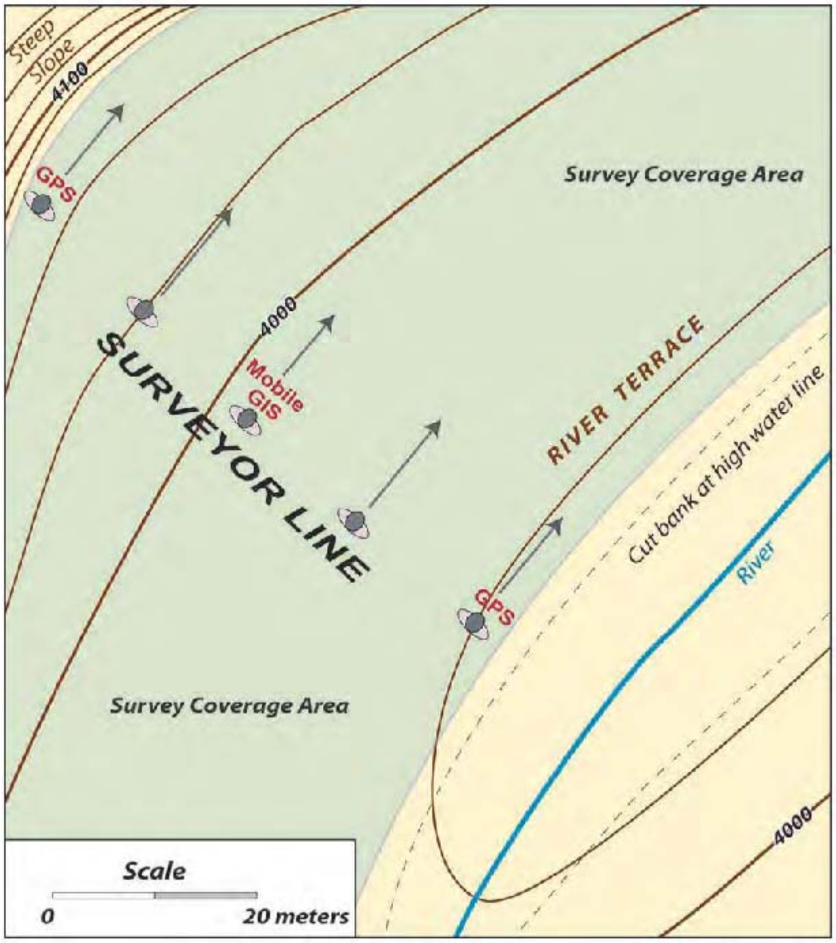


Figure 5-3. An example of a pedestrian survey line following a river terrace at a 15 meter interval. In this survey, only one mobile GIS unit is used. GPS units carried by the surveyors at either end of the survey line mapped the extent of all surveyed areas.

The portable equipment carried on the survey by each team member included basic day hiking equipment such as personal gear, lunch, copies of maps and a compass, and everyone had a small FM walkie-talkie. In order to map the extent of daily survey coverage, and to quantify the distances between surveyors, those hiking on either end of the survey line carried a Trimble GeoExplorer GPS logging a polyline attributed with the side of the survey that they were walking (right or left) as well as the number of surveyors hiking that day. GPS datalogger tracking devices are more widespread today (in 2006) and pair of small USB based dataloggers such as the

Sony GPS-CS1 for geotagging photos are also suitable for continuous data stream mapping on either end of a survey transect. A separate mobile GIS system consisting of Dell Axim PDA with a Trimble Pathfinder Pocket GPS receiver was carried for mapping archaeological sites into Arcpad as will be described in more detail below.

5.5.2. The contribution of mobile GIS

Current mobile GIS technology contributes to traditional archaeological survey methods in several ways. First, mobile GIS aids surveyors with navigation because the anticipated survey transects, and some other relevant guidance information, can be clearly indicated in conjunction with the current GPS location. Second, mobile GIS allows researchers to record new vector data along with attribute forms that are more flexible than those provided by GPS or by data dictionary approaches in the past. Finally, mobile GIS allows researchers to transport digital datasets into the field so that they can do error checking immediately, review the work of other research teams, and perform queries on large existing volumes of data in digital form.

When a surveyor encountered an archaeological feature the surveyor would first determine if the feature exceeded the specification for isolates and then, should the feature be a site, the surveyor would call a halt to the survey line. Site boundaries were established for two reasons in the 2003 fieldwork. First, in GIS it is generally required that a geographical feature be delimited and that a database record is created before it can be attributed. Thus, one cannot describe a site that has not yet mapped, unless some kind of more complicated work-around is employed such as the creation of a temporary attribute record. A second beneficial effect of delimiting sites as an initial step, however, is that the team is forced to travel over the site completely and assess the extent and variability before an attempt was made to describe it.

5.5.3. Hardware configuration

Mobile GIS systems permit surveyors to attribute spatial locations with a variety of data types. Currently the GPS unit is the primary digital input into the mobile GIS and this permits the mapping of point, lines, and polygons delimiting archaeological features. In the GIS the spatial data is attributed and once post-processing is complete the new data joins the larger GIS database.

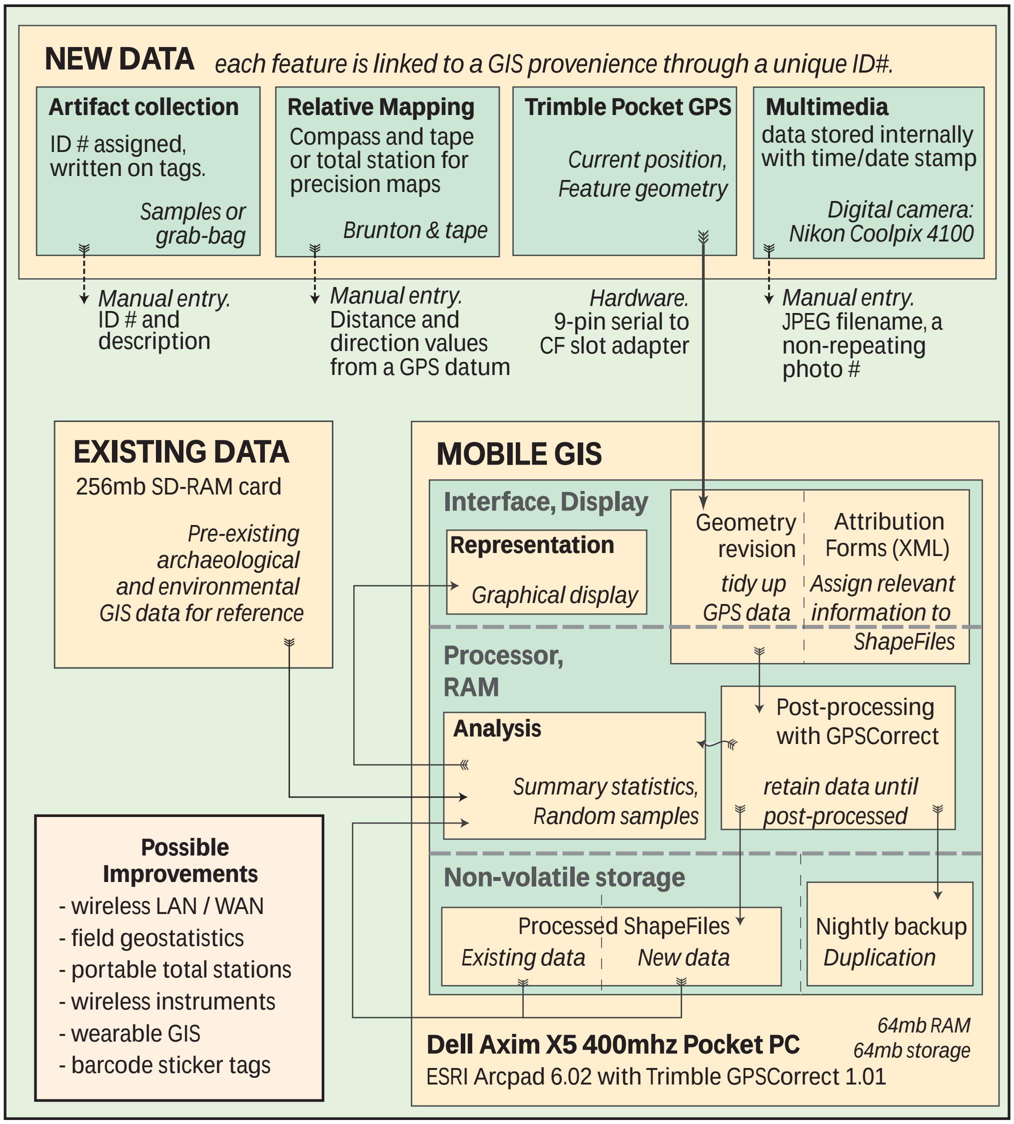


Figure 5-4. Mobile GIS implementation with ESRI Arcpad 6. New data sources from external instruments are shown in the top row. Where post-processing is needed new data is not integrated with other data until later. New and existing data can be summarized and displayed together.

Existing inputs to the mobile GIS system in 2003 are relatively limited. Important attributes that currently must be entered manually include the digital photo numbers associated with each archaeological feature, and relative measurements collected at the site. Additional instruments in the future might include wireless tapes that can transmit precise lengths back to the mobile GIS of features like the dimensions of a doorway. Alternately, for in-field lab analysis on non-collection survey, wireless calipers or scales could be used to transmit the size of an artifact to the mobile GIS linked to the spatial provenience.

5.5.4. Defining loci and sites

When an archaeological site is encountered during survey in this Arcpad system the site must be delimited first, using the Site-A polygon, and then loci located within the site are delimited and described as related in two accounts (Tripcevich 2004a, b). The locations of individual artifacts of interest are mapped and bagged separately using a Lithic_P or Ceramic_P geometry type. These include diagnostic artifacts or other materials of specific interest.

Locus / Site	Min. Density Artifacts
High Density	10+ artifacts per m^2
Medium Density	5-10 artifacts per m^2
Low Density	1-3 artifacts per $2m^2$
Site	2 artifacts per 10 m^2

Table 5-6. Locus and Site artifact density definitions.

Pin flags were used to delimit these features of interest, and generally in the case of most medium and high density loci, the result is a “fried-egg” model of artifact density polygons. In recording these polygon features, one generally went from the geographically largest to smallest entity because, as is also true in desktop GIS, features that are created later appear “on top” of features created earlier and thus larger, later features would visually obscure earlier features. This condition has to be corrected back in the laboratory and thus it was simply easiest to map largest to smallest. When a feature is mapped in Arcpad with the GPS then, subsequently, an attribute form appears that allows for explicit description of the feature.

5.5.5. Attribute Forms

Aside from the site datum points and site boundary polygons, three dominant feature types characterized the archaeological data set in the mobile GIS. Each archaeological data type had an attribute form associated with it that recorded information appropriate for a given feature. Page One of the digital forms comprised a unique ID number generated from a script and a range of numbers for digital photos (JPEG files) documenting a feature.

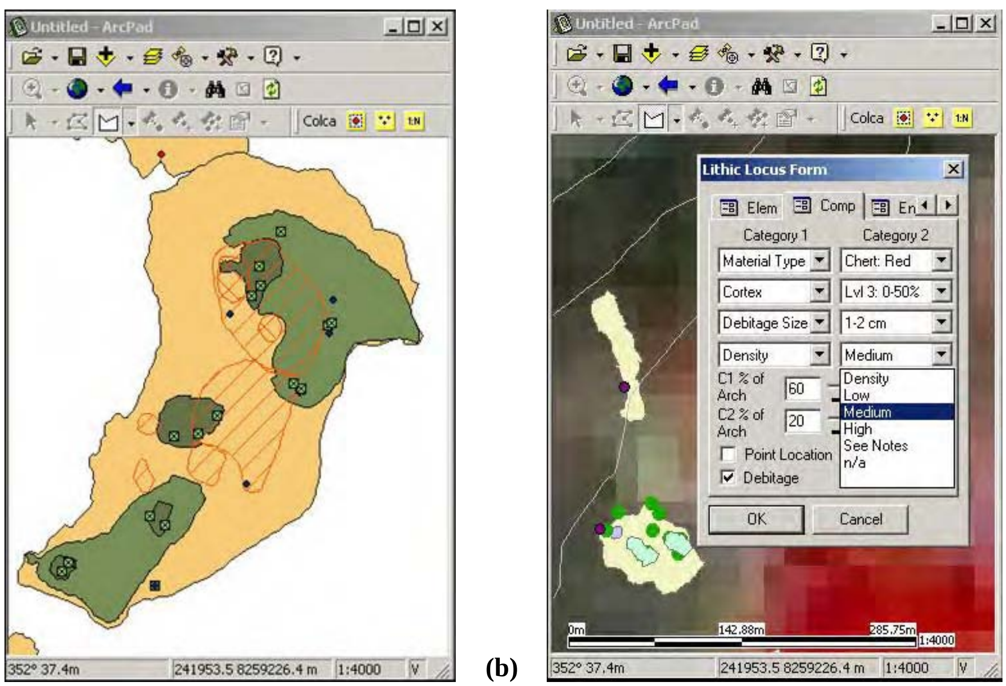


Figure 5-5. (a) Arcpad screen showing a large site with loci and points. (b) Example of page two of a lithic locus form in Arcpad showing Category 1 and Category 2 columns; in the background, two sites and contour lines are displayed on top of a 15m resolution ASTER satellite image.

Page Two of the attribute forms (Figure 5-5b) contained specific information about the feature type, such as Site, Locus, or Point information. The third page contained eight pull-down menus with environmental attributes for geology, exposure, and other local variables. These values were usually the same within a given site so that the values were "sticky"; they were stored in temporary memory between recording events, and the editable form was repopulated automatically unless a new site feature was being recorded. The final page contained a "Comments" field that accepted up to 255 characters and included a button that would open Pocket Word application with a text file named for the unique ID #, allowing the entry of additional notes if necessary. A link to a separate application that permitted MP3 compression of voice-based comments was available as well, but because the processor demands of sound encoding overly hampered the functionality of the Pocket PC for the GIS application, the feature went unused.

5.5.6. Variability within a Locus

A basic complexity of archaeological survey is that artifact concentrations frequently contain a variety of artifact types, perhaps dating to completely different occupations. This variability presents a particular challenge for a fast, mobile GIS based recording system because in lieu of sampling, all that the archaeologist has time to do is to document his or her rapid assessment of the artifacts that are found within individual loci geometry mapped into the GIS. Additionally, despite of the variability present within the locus, the archaeologist must attempt to generate data over the course of the field season that are consistent and comparable. During the

Upper Colca Survey this difficulty was addressed by estimating the characteristics of a primary and secondary attribute category, dubbed Category 1 and Category 2 (see Figure 5-5b), that best characterizes the locus using the custom interface developed for the project.

The problem: *How does one evaluate and map a scatter of, say, 5,000 stone flakes in less than one hour, as well as estimate the percentage of obsidian to another material type, such as chert?*

In order to achieve statistical rigor and reliability, a sampling strategy was needed. Sampling and collecting artifacts is time consuming, and sampling at every concentration of lithics near a quarry is also unrealistic because there are so many lithic artifacts in such areas. Sampling was therefore carried out at "High Density Loci" with artifact concentrations deemed most worthwhile given the research goals, while a less rigorous approach was applied for artifact distributions of lesser importance. A solution was devised that is geared for conducting cursory inventory, not an in-depth assessment. This solution captured variability by estimating the proportions of the two dominant attribute categories within a given polygon.

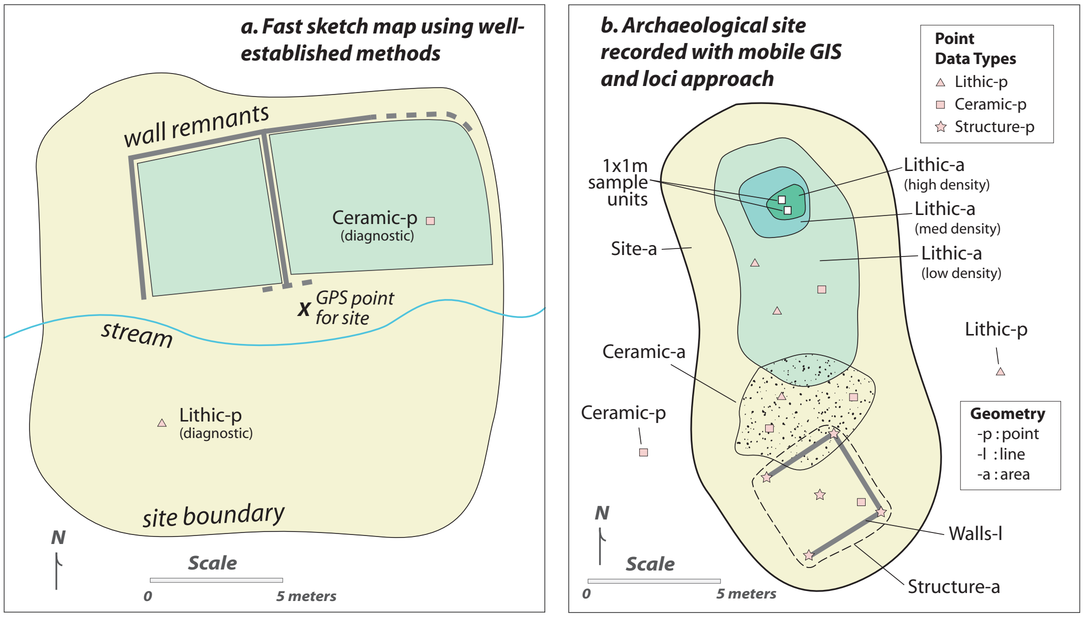


Figure 5-6. Maps for two different hypothetical sites recorded in less than one hour. (a) A conventional, low precision sketch map showing only major site features and perhaps subdivided into site sectors (b) Mobile GIS site map with 1-2m dGPS error. Internal distributions, such as the fried-egg density gradient model shown here, can be assessed and rapidly mapped.

(a) Shapefiles and forms appropriate to data type

Type \ Data	Point Position	Line / Polyline	Polygon / Area
Sites *Site-level features*	**Site-P** *Site datum, mapping sub-data.*	~	**Site-A** *Site boundaries.*
Lithics *Stone artifacts*	**Lithic-P** *Diagnostic projectile point locations.*	~	**Lithic-A** *Lithic locus boundaries.*
Ceramics *Pottery*	**Ceramic-P** *Diagnostic ceramic locations.*	~	**Ceramic-A** *Ceramic locus boundaries.*
Structures *Architecture or natural shelters*	**Structure-P** *Diagnostic structural features, structure map sub-data.*	**Structure-L** *Terraces, walls, rockshelter entrances, rock art panels.*	**Structure-A** *Enclosures, structures.*

(b) ID# Provenience System

105	**Site-A "Mayemeja"**
106	Ceramic-A, locus in 105
107	Struct-A, locus (corral) in 105
108	Lithic-P, Isolated Proj. Pt
109	**Site-A "Taukamayo"**
110	Struct-L, rock shelter in 109
111	Ceramic-P, fine rim sherd
112	**Site-A "Pokomoko"**
113	Lithic-A, High den locus in 112
114	Highest density in 113
115	Random Sample #1 in 113
116	Random Sample #2 in 113
117	Random Sample #3 in 113
118	Lithic-A, Med dens locus in 112

Figure 5-7. (a) Structure of the archaeological Shapefiles with names and descriptions. Each of the Shapefiles had a form associated with it that prompted the user with fields appropriate to that data type. (b) An example of a part of the ID # system that prioritizes spatial provenience in the field.

A hypothetical site description makes the site recording strategy more clear. This example takes place at a site with a large, low-density lithic locus (Figure 5-6b), where the concentration of stone artifacts was mostly obsidian material but also included artifacts made from chert, chalcedony, and quartzite. The mobile GIS user walks around the locus with the GPS running, and the area was recorded into the "Lithics–A" ShapeFile (Figure 5-7a). Lithic concentrations of medium and high density are found inside the locus, creating a 'fried-egg' density map. Subsequent to delineating the locus with a GPS, the custom form (Figure 5-5b) appears. Several steps are followed in filling out the form.

(1) The primary "axis" of variability is determined. In this case, it is stone material type.

(2) Using this variable, the largest group is characterized. This attribute category 1 (C1) was described as "Material: Obsidian," and other attributes of interest to lithic analysis such as amount of cortex, size of debitage, and artifact density in the attribute category, were rapidly estimated. In our case, the density was "Low."

(3) The second most represented group, attribute category 2 (C2), is characterized and its attributes are evaluated, again as quickly as possible. Any subsequent groups were disregarded for expediency and because of the error in estimation and low reliability of the method.

(4) The proportion of stone artifacts in the polygon estimated to meet the description of C1 is entered in the field labeled "C1% of Locus," and an estimate is also generated for category 2.

The method works for a rapid inventory, and it provides a general estimation of materials along with the characteristics and densities within loci. Using this system, archaeologists are encouraged to describe the variability between category 1 and 2 in terms of only one variable at a time. For example, if there were notable differences in both Material Type and Debitage Size in a particular locus, then a second polygon was created. Alternatively, the first polygon was copied, and the different “axes” of variability were distinguished independently. Instant types (i.e., attribute categories) were generated for each polygon by emphasizing the greatest variability within the locus, and this was considerably more spatially explicit than rapid archaeological survey had been in the past despite a relatively small investment in time. Time efficiency was a major objective of the Colca Survey with recording all but the very highest density lithic concentrations, and this approach allowed for rapid feature mapping. A variety of new possibilities for custom field applications are becoming available now that modern digital equipment, such as the mobile GIS used in this archaeological survey, can be modified and streamlined by the archaeologists to suit the needs of research without recourse to professional programmers.

5.5.7. Sampling High-density Loci

For the purposes of the Upper Colca project *High density loci* were defined as areas where the density of the artifact scatter appeared to exceed 10 artifacts per m^2. As with all loci, these concentrations were mapped using the mobile GIS interface, but then High-density loci were further characterized by collecting all artifacts within two or more 1x1 m sample squares for later analysis back in the lab. The Arcpad *SampleDesign* script was used to pseudo-randomly place, using an unaligned-grid method, a sufficient a number of square sample units to cover at least 0.01 of the Shape Area (m^2) of the locus as reported in Arcpad. This works out to a 1 m^2

collection area for every 100 m^2 of polygon area. The GPS indicator was used to navigate to the randomly generated point locations. When documenting each sample an overhead photo was taken of the 1x1m area from near-nadir for later georeferencing, and then artifacts were completely collected. One or more units were randomly placed somewhere within the polygon, and one unit was always placed right on the location of estimated highest density. During the 2003 season, such collections resulted in an average sampling fraction of 0.014 among the twenty-two samples that were collected during the course of the field season in this process of sampling high density loci.

5.5.8. Collection during survey

Traditionally, it has been impractical for archaeologists to retain precise spatial provenance for surface artifacts that are not particularly interesting or rare. Collected artifacts are aggregated by site, sector, or by locus. However, artifact collection is increasingly seen as a destructive practice. The collection strategy used in the Upper Colca Survey consisted of assigning a unique ID number (ArchID) from a single number series to all spatial proveniences, point locations, loci, or entire sites—very much like postal zip codes for street addresses. After four months of fieldwork, 1100 spatial provenance numbers had been assigned from the series. As described previously, individual artifacts collected from a given provenience were assigned key ID#s after a decimal point. An interesting alternative to handwriting the unique ID# on labels for sample bags collected in the field is to bring a sheet of pre-printed barcode stickers. As the sticker is placed on the sample container, a serial barcode scanning wand can scan the barcode value directly into the GIS record. The barcode scanner approach is somewhat restrictive, however, because the mobile GIS unit must to be available to scan every collection bag.

5.5.9. Other Data Types

As a systematic pedestrian survey of extensive areas, the Upper Colca Project survey presented an opportunity to collect other field data as well. During survey work a separate set of GIS data was collected that consisted of non-archaeological data. These included geological sources of stone material such as chert outcrops and natural obsidian flows. Similarly, fresh-water springs and other resources of use to past peoples were mapped in. Mountain summits, trails that may follow Prehispanic trade routes, and other such environmental features were also mapped. Thousands of digital photos were taken, including a number of stitched panorama photos. The location of these photos was mapped with the mobile GIS using a form to enter the JPEG file numbers, as well as the cardinal direction and an estimate of distance for photographs of distant objects. The variety of data types that were determined to be "worth recording" during this survey project underscores the need for individual flexibility in recording methods.

5.5.10. Processing steps with mobile GIS

The time investment in implementing the mobile GIS approach is still considerable, as it involved both pre-fieldwork and post-fieldwork processing steps. Pre-fieldwork tasks, discussed above, include acquiring and preparing regional datasets, and designing digital forms that are appropriate for the project. Post-fieldwork processing involved standard issues such as downloading all data to a laptop from various devices, tagging folders of digital photos with the associated ArchID, GPS post-processing, as well as analytical processing steps such as deriving meaningful indices from the digital data. Post-fieldwork tasks also involved some unanticipated and time consuming labor, such as cleaning inconsistent datasets to prepare them for general analysis, and other management issues. These inconsistent data include the records gathered during two periods when the system was not functioning smoothly as described in Table 5-7.

Issue	Problem	Resolution in future projects
Pre-fieldwork preparedness	During the first two weeks of fieldwork software and hardware debugging were still underway.	Allow sufficient time for designing and debugging fieldwork forms and equipment prior to work in remote locations.
Equipment failure	During the last 10 days of the field season the cable connecting the mobile GIS PocketPC to the GPS unit failed and all sites were recorded with older Trimble Geoexplorer GPS units.	Purchasing two similar mobile GIS units, with one acting as a backup device so that no break in data recording would have occurred in case of equipment failure.

Table 5-7. Sources of inconsistent data during the 2003 project, and means of avoiding these problems in future projects.

Some of the processing steps are the result of employing GPS based mapping, and are therefore largely inevitable. Despite post-processing, the polygons and polylines gathered using GPS in Streaming mode contained a lot of redundancy and required geometry validation. These redundant positions were especially abundant where the person mapping a feature had to slow down or stop in the process of delimiting the feature. In these cases a number of vertices would be gathered as a small cloud (within the positional error of the GPS) and this resulted in a line intersection and short segments. Processing the data to resolve these GPS derived problems was accomplished in ArcGIS 9 using the following processing steps

(1) The "Repair Geometry" function was used to resolve intersections in a single polygon or polyline.

(2) Polygons were converted to polylines and the ArcToolbox > Data Management > Features > Simplify Line operation with a 10 cm tolerance was applied the data. The 10cm range for simplifying the lines reflects the data quality. In this case, the post-processed accuracy of the spatial data was 1-2m as stated by Trimble Pathfinder Office.

More recent versions of Arcpad (v7) and other mobile GIS software such as Terrasync provide a movement filter for datalogging that allows the user to specify a minimum distance setting, so that data are not logged unless one continues moving. For example, during streaming mode in 2003 the GPS was logging a vertex from the average of every 2 positions for a smoother line (at a 0.5 second rate this resulted in a vertex every second). A feature of the newer Arcpad 7 allows the user to specify that a vertex should be logged only after 3m of movement.

This option would have resulted in cleaner data during the 2003 season, although with low real-time accuracy the movement filter is relatively coarse and it is probably accurate to only within 10-15m. In North America and Europe, where SBAS (WAAS or EGNOS) correction signals are available, real-time positions are approximately 5-10m and these movement filters for datalogging function adequately on low-cost receivers. However in South America SBAS correction will not be available in the foreseeable future and movement filters are probably most relevant for faster GPS mapping tasks such as mapping from a moving vehicle. It is conceivable that GPS movement filters will actually result in noisier data because exceptionally large position measurements are logged, but the majority of positions are filtered out because the distance of movement is not sufficient.

5.5.11. Implications of Mobile GIS for Fieldwork

For the Upper Colca Project the mobile GIS recording system produced both cartographic data for site report mapping, and GIS vectors for analysis. The results of these efforts are presented in chapter 6, where the cartographic output appears in local and regional maps. Automated cartography methods, such as one-to-many labeling through a VB script (discussed below), permitted the automated labeling of lab results based on field collections from polygons or points.

In the bigger picture, the incorporation of mobile GIS for scientific field research seems inevitable although the applicability of mobile GIS to specific applications depends largely on the extent to which mobile GIS meets research needs. Minor benefits of mobile GIS, such as the time and date stamp associated with every measurement, improve the data that are being gathered in unobtrusive ways. A more elaborate system might gather extensive metadata concerning research methods and data structure into an automatically generated digital log file. Additional tools, such as statistical summaries and visualization applications would have proved useful during the Upper Colca Survey but these are not yet available in a mobile GIS platform. The ability to estimate spatial variation measured on archaeological variables would have been useful for a more informed selection of sampling strategies, and perhaps for guiding the placement of test excavation units (Hodder and Orton 1976; Redman 1987). When researchers are able to investigate new spatial data in conjunction with existing datasets using the exploratory data analysis approach (Tukey 1977) while in the field it will open up original research strategies by combining information from new and existing digital datasets. Statistical indices, such as the degree of spatial autocorrelation among particular classes of data, would be useful to know in the field. Geostatistical methods such as kriging, familiar to archaeologists in lab analysis (C. D. Lloyd and Atkinson 2004), will have application in fieldwork contexts as well when these tools become available in future mobile GIS systems.

5.6. Test Excavation Methodology

Changes in the use of the Chivay Obsidian Source through time was a principal aim of this research project, and therefore test excavations were critical for acquiring temporal control. As per survey regulations in Peru in 2003, test excavations must be anticipated and planned, and specific permits acquired, prior to beginning the research project. A testing program was planned for the 2003 season at three significant sites in the research area targeting sites in each major ecological zone. A datum for each site was established either on a large, permanent rock or by placing a datum stake. A datum stake consists of a 1.5 x 20cm piece of rebar placed on the margin of each of the site being tested, and site datum stake locations appear in this document in the maps in Chapters 6 and 7. A subdatum was placed adjacent to each test exacavation unit to minimize the horizontal distance (and therefore the error) of measures during excavation proveniencing.

5.6.1. Excavation procedures

The test excavations were conducted in 1m x 1m units excavated in either natural or arbitrary levels of less than 15cm thickness. As a total station was not available for test excavation work in 2003, the team relied on string and line-levels for depth measurements from the excavation unit subdatum adjacent to each unit. In 2004 the group of returned to Q02002u2 and u3 (obsidian quarry) and to the Block 2 Pausa area with a Topcon total station and mapped in the positions of the site datum, subdatums, and the backfilled test unit corners with greater precision. This 2004 mapping effort also permitted the production of relief maps of features at each site such as the quarry pit, mounds, and rock ovals.

Prior to excavating each test unit level, the top of each level surface was cleaned and a digital photograph was shot from near-nadir with a visible nail in each unit corner in the photo that could be used for later georeferencing following Nathan Craig's (1999) method. Features were designated on the top of each level, and artifact proveniencing for each unit included level and feature. Carbon samples were point located from the south-west corner of the unit (in compliance with the UTM coordinate system), as well as in centimeters below the unit subdatum. Two liter soil and starch samples were gathered from each level, and from features of sufficient size. All dirt was screened through 1/4" framed metal screens loaned by CIARQ, and then through 1/16" fine green window screen except where noted in the unit description (a few levels of largely sterile soil in A02-26u1 were not fine-screened). Upon completion of the testing, all test units were backfilled.

5.6.2. Proveniencing of excavated materials

During the 2003 field season the Upper Colca team did not have digital proveniencing of sufficient accuracy (sub-centimeter accuracy) to permit digital records from excavation and therefore the team returned to using more traditional methods. Collections were bagged and tagged using the unit/level/feature spatial proveniencing that facilitates locating the units without referencing a computer database or a locus sheet. Arbitrary spatial units included levels (15 cm or smaller natural levels), 1x1m units, and 50cm quads with letters in reading orientation following a convention borrowed from Mark Aldenderfer's excavation methods.

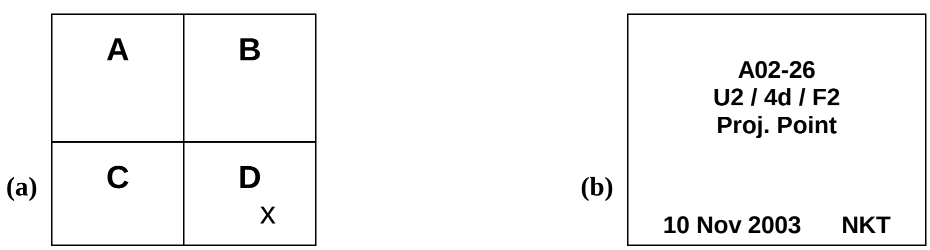


Figure 5-8. (a) Example of proveniencing for four 50cm quads within a 1x1m unit with an item in quad d, north is at the top of the page. (b) An example of a paper tag showing site name, unit/level and quad/feature number, artifact type, date, and excavator initials.

The advantage to these explicit field proveniences is that bags and artifacts being returned from screening can easily be relocated to their origin provenience in the field (in the excavation block) based on the unit coordinate system. The disadvantage is that these provenience values, such as U2 / 4d / F2 do not code easily into a database and while some method of geocoding of these addresses is conceivable, the technical advantage to doing so is slim. In such cases, the European locus system, or a lot number system based on integer key fields, is much more effective and computer-ready.

The Upper Colca project ended up using a system that resembles, in some ways, the postal service system: street addresses are akin to the unit/level/feature codes in the sense that they are field-useable (one can find a house without referencing a database). Street addresses are supplemented by a Zip code in the US, which in the form of a nine digit zip, is house specific. This small amount of redundancy minimizes error in the postal service, and in the Upper Colca proveniencing a similar system worked for minimizing error in collections from excavation.

Field proveniencing was supplemented by Lot numbers during the first phase of analysis and data entry in the laboratory. Consistent with the Arch ID <dot> RotuloID strategy, each spatial provenience was given an integer LotID number, and then artifacts within each spatial provenience received a RotuloID number in a sequence (*Rotulo* is Spanish for index number). Thus, for surface materials collected in 2003 a ***A03-****[ArchID]****.****[RotuloID]* code specifies spatial location and then item identity, whereas for materials from excavation in 2003 the ***L03-****[LotID]****.****[RotuloID]* code specifies excavation provenience (Lot) and artifact identity. As mentioned, the LotID number system was redundant with the unit/level/feature proveniencing system written on tags, but in reality it referred directly to the database unique ID # which is unavoidable in database organization. This redundancy was actually useful in a few circumstances and it serves to minimize error, as the digital ID# system appeared on the artifact ID# tags, and vice versa. Ultimately the Lot# system became the one that is referenced in queries after lab work was complete; it is the most up-to-date system in the database.

5.6.3. Proveniencing for database management and quantitative analysis

During quantitative analysis, individual artifacts needed integer unique ID numbers that followed through the entire analysis process and could be tracked back to the original artifact. The solution was to concatenate the two series for each artifact by moving the decimal point three units to the right and converted it into a long integer string. For example, for surface materials from ArchID# 1050 the tenth artifact collected would be coded as *A03-1050.10*. This provenience then became 1050000+10 and therefore 1050010 (a preceding zero was added to Rotulo ID number because in a few cases more than 99 artifacts came from one provenience). The unique artifact ID# solution was applied to excavated LotID.RotuloID numbers, such that Lot# 215 and artifact #15 would be coded as *L03-215.15*, and this became 215015. In order to avoid confusion between numbering for ArchID# (surface materials) and LotID# (excavated materials), 2,000,000 was added to the Lot numbers. The highest ArchID# recorded in 2003 was 1120 and therefore these coded to unique artifact ID#s as 1,120,000. Thus, in order to not overlap at all with the surface materials in the database system, the LotID# began at 2,000,000. Therefore in the previous LotID# example, the *L03-215.15* artifact would be coded as 215015 + 2,000,000 and therefore 2,215,015 which falls in a range that has no risk of overlapping with the ArchID# artifact example that is 1,050,010. While these numbers are cumbersome to type, they are managed easily in a database.

5.7. Lab analysis

Laboratory analysis followed on fieldwork with the aim of inventorying the collections from survey and test excavations, the examination of all diagnostic artifacts, and comprehensive analysis of a sample of all flaked stone artifacts recovered during fieldwork. Lab analysis took place in two stages in spring and summer of 2004 in collaboration with Willy Yepez, Alex Mackay (ANU), Randi Gladwell, Saul Morales, and Javier Morales, with additional assistance provided by Adan Lacunza, Guillermo Flores, and Tamara Flores Ramos.

These lab data contributed to the quantitative analyses that are presented in Chapters 6 and 7 of this document. In addition to ArcGIS 9, the software packages employed in this analysis \were SPSS 12 for boxplots, cluster analysis, principal components analysis, and Chi-Squared tests; and for data organization and display, principally through the indispensable Pivot Tables feature, the analysis depended on Excel 2003.

5.7.1. Phase I Lab work

An initial review of all field collections was performed as a distinct phase of lab work. While this phase of lab work is preferably performed during or immediately after fieldwork, this was delayed due to a lack of lab facilities in the Colca valley in 2003 and the time constraints of quarry area research.

Phase I lab work consisted of reviewing all items from fieldwork and standardizing the tag and bag structure in the collections. Lithics and ceramics collections were entered into an MS Access database using forms designed for this purpose. Lot numbers were assigned to the excavated collections based on a link between the spatial provenience and the database unique ID#, as described in the Proveniencing discussion above. Most collections were counted, although due to time constraints some collections (those with many small artifacts) were not counted. Additionally, all collections, including lithics, ceramics, bone, and other miscellaneous collections were weighed in their aggregate (by spatial provenience) using a lab scale with 1 gram accuracy. While the weight of ceramic and bone is not typically a meaningful measure, it is nevertheless useful measure of relative size per provenience for collections management, and weight serves as an expedient proxy for counting in large collections.

During Phase I lab work obsidian and “non-obsidian” lithics were segregated as this distinction reflected the priorities of the obsidian source research. In order to be more expedient during Phase I the non-obsidian materials were not sorted by material type although performing this sorting is a priority for future lab work.

5.7.2. Phase II Lab work

Detailed analysis of lithics, ceramics, and excavated bone occurred in the lab in Phase II. During this phase of lab work, individual artifacts were examined and the Rotulo (Index) ID# system was employed to track these artifacts through the database and later analysis stages. This analysis took place at the CIARQ facility in Arequipa in June 2004.

Phase II Lithics Analysis

The lithics analysis conducted by A. Mackay, S. Morales, and N. Tripcevich is largely based on a modified version of the lithics analysis strategies that Mackay employs in projects at Australian National University under the direction of Dr. Peter Hiscock. This methodology was tailored to meet the needs of the Upper Colca project and to be comparable with lithics analysis in Andes that often have a more typological orientation.

During Phase II lithics analysis, the following measures were taken when possible. A custom MS Access form was designed for the Phase II lithics analysis that functioned with digital calipers to expedite gathering metric attributes digitally.

Name	Description	Illustrated
Material	Obsidian, Chert, Chalcedony, Fine-grained Volcanics (Rhyolite, Andesite, Basalt), Quartzite, Fine-grained siliceous, Igneous	
Class and Type	Flake, core, heat shatter, hammerstone, groundstone, non-diagnostic fragment (NDF). Projectile Point, biface, retouched flake, perforator.	
Color / Shade	Shades of obsidian: Black, white, clear, clear-banded, grey, grey-banded, brown, brown_banded. Other material types also included: red, black-orange, black-tan, olive, orange, pink, red-blue, red-brown, cream, white-tan, white-pink.	
Weight (g)		
Complete	True/False	
Transverse snaps	Proximal, medial, distal - referring to existing segment.	
Longitudinal snaps	Left or right - referring to existing segment	
Percussive Metrics	Distance from Point of initiation to termination	Yes
Percussive Width	[Proximal, Medial, Distal] Distance across flake at 90 to force of application	Yes
Percussive Thickness	Distance from ventral to dorsal at midpoint of percussive length and percussive width (medial)	Yes
Platform width	Lateral distance across platform	Yes
Platform thickness	Distance across platform from dorsal to ventral	Yes
Platform preparation	Presence of overhang removal, faceting, or both (Whittaker 1994: 101)	
Platform angle	Angle formed by intersection of platform and dorsal face.	
Cortex percentage	% of cortex coverage in increments of 10. Flakes: dorsal and platform only, cores: whole piece.	
Cortex location	On flakes: Dorsal, platform or both.	
Cortex type	Rounded, tubular, irregular,	
Heat affected	Y/N	
Heat Type	Greasy luster, crazing, pot-lidding, shatter	
Termination type	Feather, hinge, step, plunging (outre-passé)	
Number of dorsal flake scars	Number of clear (with initation, termination or both) flake scars on dorsal surface of flake	
Number of rotations	N-1 where N is the total number of different directions from which previous flakes have been struck, sensu Clarkson et al. (2006). Increments of 45°.	
Retouched	Y/N	
Retouch Type	Dorsal Ventral, both	
# of retouched segments	Flake divided into 8 segments	Yes
Retouch data (8 segments)	P, PL, PR, ML, MR, DL, DR, D: Degree and Angle of Retouch for each. Marginal = .5, Invasive = 1 following Clarkson (2002).	Yes

Table 5-8. Measures on flaked stone artifacts during Phase II lithics analysis with measures depicted in Figure 5-9 indicated in "Illustrated" column.

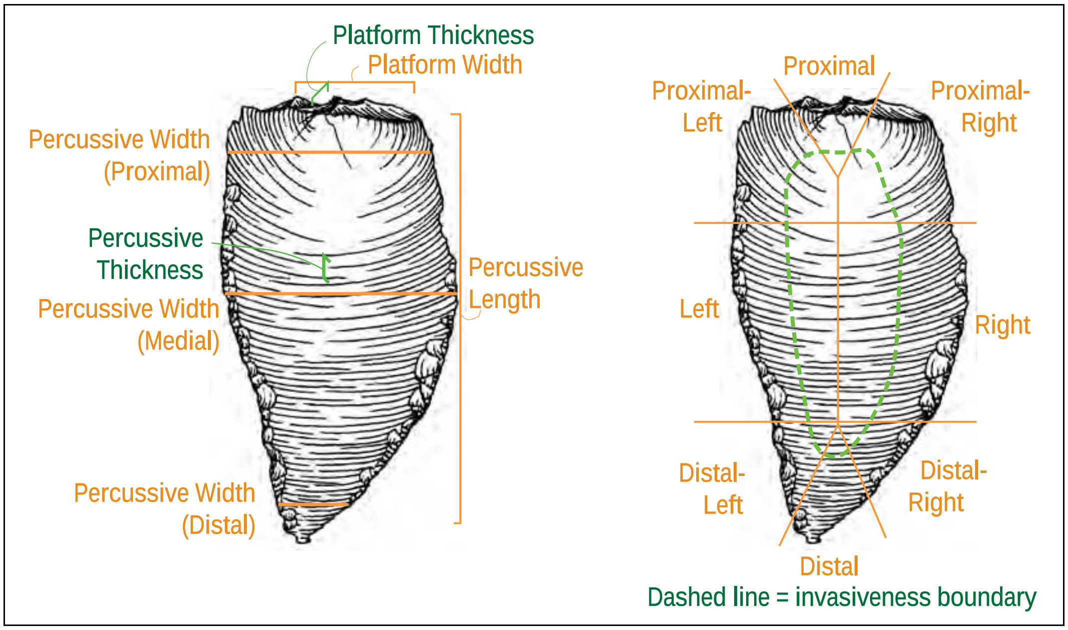


Figure 5-9. Showing some of the percussive metrics, platform metrics, and measures of retouch invasiveness for ventral side (after Clarkson 2002) used in the Phase II analysis. Dorsal features and platform angle not shown.

Metric measures (shown in Table 5-8 and Figure 5-9) were taken with digital calipers accurate to 0.01 mm. The percussive length measure, rather than total a flake length measure, was used. Approximately 3,050 flakes were analyzed with these criteria.

Projectile Point typology

The projectile point typology developed by Klink and Aldenderfer (2005) discussed previously (Figure 3-10) is applicable throughout the south-central Andean highlands. The authors state that in Arequipa the northern frontier of the region under consideration for this typology is the ríoOcoña or the Cotahuasi valley. The study used projectile points exclusively from excavated and dated contexts in order to identify elements of projectile points that changed through time. In Klink and Aldenderfer's (2005: 27-28) study, measures on points were measured in millimeters with a precision of 1/100th of a millimeter, and angles were measured with a goniometer. The measures used include Length (mm), Shoulder angle (°), Maximum tool width (mm), Haft length (mm), Blade length (mm), Haft angle (°), and Basal width (mm), as well as derivative ratios of these measures. The typology was thus constructed to differentiate stylistic features that reliably distinguish time periods. Following this typology, Series 1 through 4 projectile points types are (with two exceptions) diagnostic to the Archaic Period prior to the advent of predominantly pastoral economies. Series 5 projectile points are diagnostic to the later, pastoralist periods that include a wide variety of socio-political and economic changes in the Andes.

During Phase II analysis of the Upper Colca project lithics analysis, an emphasis was placed on Series 1-4 projectile points because these points are the only diagnostic temporal evidence from surface contexts for a broad swath of human history in the Chivay source area.

	All Points	Advanced analysis
Projectile Points	*No.*	*No.*
Not series 5	123	81
Series 5	201	76
Total	324	157

Table 5-9. Proportion of analysis by projectile point typological group.

These data show that Series 1-4 projectile points were analyzed disproportionately in the Phase II lab work and resolving this discrepancy is a priority for future analysis of the collection. However, in the exploration of the data concerning Ob1 vs Ob2 obsidian types (heterogeneity of material), as well as artifact color and other characteristics, the analytical bias does not overly skew the results and interpretations. During Phase II analysis diagnostic projectile points were illustrated by Yepez.

Phase II Ceramics Analysis

Ceramics analysis was performed by Yepez. Virtually all diagnostic ceramics were derived from surface collections during survey. The priority during Phase II ceramics analysis was in classifying these ceramics using a local ceramics typology, and vessel diameter estimates were attempted with rim sherds of sufficient size.

As part of his dissertation research Steven Wernke (2003, Appendix A) developed a ceramic typology that differentiates the later ceramic periods. Wernke's typology is derived from surface materials resulting from his extensive survey of the central part of the Colca river valley. Wernke incorporated ceramic data from prior research by Neira (1961), Malpass and De la Vera Cruz (Malpass and De la Vera Cruz 1986, 1990; de la Vera Cruz 1989, 1988), and Brooks (1998).

Phase II Faunal Analysis

Randi Gladwell examined the only significant faunal remains in the collections, which were bones excavated from unit 1 and unit 1x at A02-26 (Taukamayo) near Callalli. These were primarily camelid bones and Gladwell focused on diagnostic elements in this collection. She had access to a comparative collection at CIARQ, where the analysis was performed.

5.8. Sampling in Upper Colca work

Archaeologists use sampling routinely in order to make inferences about larger populations. Sampling takes many forms, both in the field and in the laboratory, and there is therefore an attempt here to be explicit about the major forms of sampling that were applied in this research.

5.8.1. Sampling during survey

The three major types of survey strategy applied in the Upper Colca Project, described in Section 5.4.2, were forms of sampling. In particular, surveying with a widely spaced surveyor interval is a type of spatial sampling. In general, a 15m surveyor interval was employed which resulted in a tight enough interval to capture a large proportion of smaller sites as well as larger sites.

During survey work, field collections largely consisted of unsystematic "grab bag" collections of diagnostic or otherwise interesting artifacts together with some proportion of representative or typical artifacts from the site or locus. High density lithic loci were sampled in two specific ways using 100% collection units. During the first step, a 1x1m total collection unit was placed on the estimated highest density area of the locus and all artifacts were collected within that 1x1. During the second step, additional 1x1m units were randomly placed throughout the locus in the strategy known as cluster sampling (see Section 5.4.5).

5.8.2. Sampling during excavation

Test excavations at A02-26 and A02-39 involved screening all collections through 1/4" mesh and 1/16" window screen with the exception of material from level 1 (plow zone) that was only coarse screened. Furthermore, the excavation at A02-26 (Taukamayo) was into a landslide margin and therefore a profile was available revealing that the unit was effectively sterile until level 3. Thus, a coarse 1/4” screen was used in level 2, except for one quad in levels 1 and 2 that were fine screened.

At Q02-2, the obsidian source, more stringent sampling was required for three reasons. First, at a raw material source researchers will inevitably find a great abundance of material and sampling is the preferred means of reducing that abundance to a manageable quantity. Second, fieldwork while camping at high altitude at the Chivay source was constrained by available time. Finally, collections were constrained because they had to be hauled out on the backs of mules, including all artifacts and soil samples, limiting the quantity that could be transported.

At Q02-2u2 (quarry pit) and Q02-2u3 (workshop) the units were virtually all flaked obsidian, although at the quarry pit much of the material was non-culturally fractured obsidian. The solution devised was to excavate a standard 1x1m test unit, as described in this chapter, however collection would include non-diagnostic flakes from one quad of the unit, resulting in collection of 25% of the flakes from u2 and u3. The remaining three quads (75%) of non-diagnostic material were used as backfill. This allowed the recovery of diagnostic artifacts, retouched artifacts, cores, and organic materials such as charcoal, from throughout the 1x1m unit.

5.8.3. Sampling during lab analysis

During lab analysis of surface collections from survey all diagnostic materials were analyzed, however only non-diagnostic lithics from select regions were investigated with the detail of the Phase II lab analysis. Non-diagnostic lithics from the obsidian source area were examined in Phase II, however in the collections from

Blocks 2 and 3 only non-diagnostic surface lithics from within 200m of the excavation units in each block were examined comprehensively. Additionally, collections of non-diagnostic materials were examined on a site specific basis outside of the 200m buffer.

Sampling in the lab was required of the collections from the Q02-2u3 (Maymeja workshop) excavation materials. Although only 25% of the 1x1m was collected, the unit was almost entirely made up of cultural material and consisted of flaked obsidian artifacts. At the lab facilities at CIARQ all cores and bifaces were removed that remained in the collections from Q02-2u3, and then the collection was further sampled down to 5% by weight of the 25% from the original 1x1m test unit. From this subsample (1.25% of the original 1x1m unit) all complete flakes were recovered and the resulting sample was between 150 and 300 complete flakes for each provenience from Q02-2u3, which was an appropriate number for the analysis.

5.9. Derivative indices

Field and lab measurements acquired during the Upper Colca project were transformed, in some cases, into indices and other measures that are more widely useable than the original measurement data. The indices that were generated using GIS data, primarily the vector to raster conversion and lab measurements, such as the Bifacial Thinning Flake index, are described below.

Fieldwork was largely conducted using a GPS receiver connected to a mobile GIS unit, resulting in a variety of vector datasets, however some of these phenomena are better examined using the raster data model. The vector → raster transformation is a basic concern for scientific fieldwork because it makes explicit the process of deriving spatial generalizations from detailed observations. For example, distributions of temperature or rainfall are interpolated from point-specific measurement locations where empirical evidence has been gathered by instruments. Similarly, in this project specific observations were generalized to produce continuous raster surfaces.

The spatial extent of surface archaeological features were recorded as bounded vectors using mobile GIS, as was described in the preceding chapter. Because mobile GIS involves the use of GPS to delimit features, all spatial features had to be recorded as discrete vectors, such as polygons, even when they are better investigated and represented as raster data. The following methodological explanations are all cases where field data were recorded in a vector form and then interpolated to raster for analysis and review.

The analysis of these raster surfaces took place in two contexts. The first was direct spatial queries against the raster in a GIS context. The second form was derived from the first: it was a tabulated query of all 1200 spatial features recorded during survey and the Mean, Standard Deviation, Min, and Max of the raster value for each feature. These tabulated data were linked using the ArchID reference number to their respective GIS and lab database records, and used in SPSS 12 and MS Excel 2003 for analysis and display.

Source	Data	Resolution	Destination Raster
GPS Vectors	Lithic Loci and collection: Density / material type variables	1m	Obsidian
			Non-obsidian
Raster	ASTER Imagery: VNIR bands	15m	Distance from NDVI calculated large bofedal
Raster DEM	ASTER DEM (Spaceborne remote sensing platform)	30m	Elevation (masl)
			Slope (degrees)
			Aspect (8 categories)
			Cumulative viewshed index
Raster DEM	SRTM DEM Topography	90m	Regional scale elevation

Table 5-10. Vector and raster layers used in analysis and derived raster output.

A variety of raster surfaces were created from source data layers used in the analysis. The creation of these non-standard raster layers is the subject of the next section.

5.9.1. Lithic density raster index

Concentrations of lithics and ceramics were delimited and recorded as low density loci when they exceeded 1 artifact per meter, medium density at 2-10 artifacts/m^2 and high density at 10+ artifacts/m^2. The resulting GPS polygons describe regions of increasing lithic density, which is the familiar ‘fried-egg’ distribution of archaeological artifact scatters. These polygons are based on estimates of artifact scatter density but the resulting GPS vectors with firm boundaries are not a suitable way to analyze data that had its origin as estimated artifact density scatters (Figure 5-6b). In order to examine lithic surface distributions as a statistical model of artifact density, the mobile GIS derived polygon vectors were converted to a raster data model with a 1m cell size.

Procedure

To allow for expedient field procedures, lithic loci were mapped in terms of two categories inside a given polygon: the dominant lithic artifact represented is attribute category 1 (C1), while the second most well represented lithic artifact group was attribute category 2 (C2). To separate lithic material types as recorded by the Arcpad interface the estimated percentage was used to differentiate, by weight, the calibrated material type for collections from that locus. Due to time constraints both in the field and in the lab only (1) *obsidian* and (2) *non-obsidian* were differentiated for material types during Phase I lab analysis.

This is keeping with the relatively expedient lithic recording strategy because time was not available to bend over and check a large number of light-colored flakes to see if each one was chert, chalcedony or quartzite. However, one should be able to differentiate obsidian from non-obsidian relatively consistently since obsidian procurement is the subject of this research. During Phase I lab analysis, obsidian from non-obsidian lithic material types were separated for the entire collection. Materials were not sorted and weighed into finer material type groups until Phase II analysis, which occurred for only a select portion of the total surface collection. As a result, it is only possible to calibrate the lithic loci by material type at the obsidian / non-obsidian level of specificity and thus only obsidian lithic concentrations and non-obsidian can be differentiated (primarily chert, but also quartzite, chalcedony, and aphanic volcanics) from the surface scatters for mapping and spatial analysis purposes.

Example

A site is identified and two low-density loci and one medium and one high density lithic loci are identified and mapped. The medium and high density loci are, by definition, inside one of the low-density loci in a layer-cake fashion. Additionally, as described above a 100% collection of two or more sample units ($1m^2$) per high density locus was conducted. Thus, returning from the field data consist of

(1) A site boundary polygon, two low-density polygons, and a medium and high density polygon mapped and attributed according to Attribute Category 1 (C1) and Attribute Category 2 (C2) variability (see Section 5.5.6 "Variability within a Locus").

(2) Representative surface collections from the site and from each of the loci were gathered by fieldworkers with common knowledge of the description being entered into Arcpad as attributes by the mobile GIS user.

(3) A minimum of two 100% collection units from each high density locus were gathered.

These sources of data were combined, when available, to produce an "obsidian" and a "non-obsidian" lithics density raster surface. When a locus has a C1 of Obsidian and a C2 of Chert (for example), the Estimated Percentage for C1 and for C2 of that locus could be used to estimate the density for each cell of the GRID, scaling the representation of C1 and C2 by the percentages of each returned to the lab.

However, if a locus has a C1 of Obsidian, big flakes and a C2 of Obsidian, smaller flakes (same material, different sizes), for example, the lab results can be examined to see if there are non-obsidian artifacts collected for that locus. If so, then the count of those non-obsidian artifacts, as a percentage of the count of the whole collection, is assumed to represent the percentage of, say, quartzite in that locus that was predominantly obsidian based on its description. In that way, the weight and percentage of a given material type from lab analysis was used to calibrate field recordings of artifact scatter composition.

Using the locus definition rules stated above (i.e., high density locus = 10+ artifacts /m^2) the polygons were converted to rasters and the following values were placed in the cells. The vector to raster conversion and the attenuation on the edges of each class were resolved by the mosaic command which averages the differences between raster surfaces along the contact boundaries between classes.

Polygon type – Density	Stated range	Value assigned in raster
Lithic-A – Low	.5 to 1 artifacts per m2	2
Lithic-A – Medium	2 to 10 artifacts per m2	8
Lithic-A – High	10+ artifacts per m2	15
Site-A area (entire site is a low density scatter)	When site has Lithic-A Med density with no Low.	1

Table 5-11. Loci to GRID conversion values.

The Density value therefore ranks the polygons by their number of flakes per meter for variability in either Material Type, Reduction Level or Flake Size, and the raster creation focused on material type differences, but rasters could have been created, theoretically for the other characteristics as well.

5.9.2. Cumulative Viewshed Analysis and Exposure Index

Introduction

A comparable measure of view was needed to better evaluate the locational properties of sites encountered on survey. Based on research for a Master's paper on Cumulative Viewsheds in the Ilave Valley (Tripcevich 2002), the work of Wheatley (1995) and Lake et al. (1998; Lake 2003), and using methods suggested by Nathan Craig (2000 pers. comm.), a surface was calculated that quantifies the visibility and, to some extent, environmental exposure of a given location.

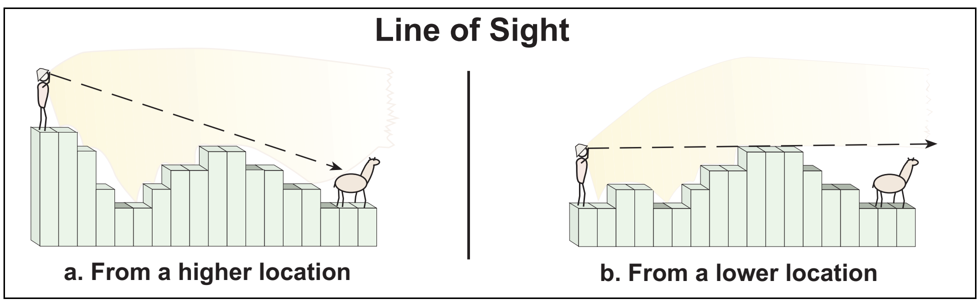


Figure 5-10. Line of sight across hilly terrain results in specific cells and targets being in view or out of view.

The basic concept to cumulative viewshed analysis is that a large number of viewsheds for random locations are calculated and overlaid on one another, and the locations that have a high incidence of visibility from random locations are likely to have both broad viewsheds and an unusually high environment exposure. Comparability between viewshed and exposure has been addressed more thoroughly by Kvamme (1988: 335-336; 1992: 26-27) where the exposure is considered in terms of the volume of a cylinder surrounding the point of interest, and thus exposure of a location to a greater variety of altitudes and directions is considered. This approach is more thorough than a visibility calculation, but given the relatively coarse resolution of the DEM, the index for Visibility was assumed to be essentially representative of climatic exposure.

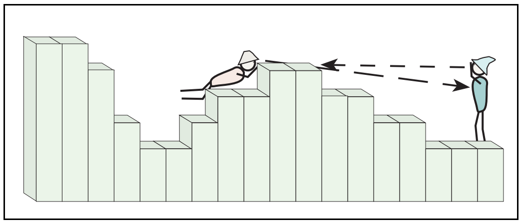


Figure 5-11. Viewshed is not necessarily reciprocal, as the individual and the left can see the person on the right, but the opposite is not true.

The assumption is that of *reciprocal visibility*: if person A can see person B, then person B can see person A. The resulting surface contains a value in each grid cell that indicates how many of the random observers can see that grid cell.

Procedure used in generating the mean Viewshed layer

(1) Defined the extent of the study area as 50 x 50 km square (2500 km^2) that includes a buffer of at least 5 km around the Upper Colca Project survey blocks in order to eliminate edge effects.

(2) Five thousand points were generated using the pseudo-random point placement function in “Hawth’s Tools 9” tool for ArcGIS 9. This produced approximately 2 observer points per kilometer in the viewshed study area. These points were converted to the Arc/info Coverage format.

(3) An observation target height of 1.5m (OFFSETB) and maximum distance of 10km (RADIUS2) were used.

4. The 30m resolution ASTER DEM was smoothed using FocalStatistics with a 3m kernel and converted to GRID.

5. The ArcWorkstation GRID command VISIBILITY was issued with the FREQUENCY flag which tallies the frequency at each location (this is, effectively, a cumulative viewshed analysis). Each view calculation took approximately 80 seconds on a P4 computer, for a total of 111 hours (4.6 days) of calculation.

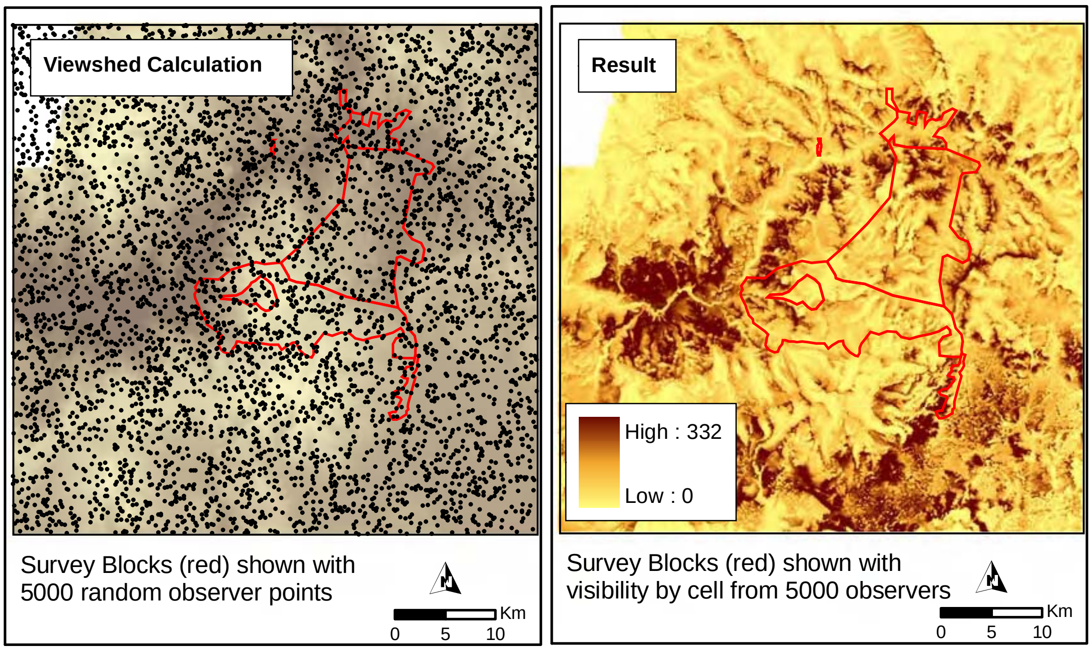


Figure 5-12. Cumulative Viewshed using 5000 random observers and 10 km viewing distance.

Variables

In conducting a cumulative viewshed analysis in the Ilave River valley in the Lake Titicaca Basin (Tripcevich 2002), the maximum view distance was defined as 5 km because a principal goal was to model the observability of camelids (wild or domesticated) and other people traveling in the Ilave valley. It was estimated that a distance of 5 km was the approximate distance that such objects could be seen, with a consideration for the great deal of variability in such situations, including:

- the visual acuity of the observer
- atmospheric conditions
- the amount of contrast between the target and the background
- whether the target was in motion.

Similar criteria exist in the Upper Colca viewshed study, however in this case a 10 km maximum radius was selected for this situation. The rational for doubling the maximum radius from 5 to 10 km was as follows. The goal here is to model ancient visibility, but also environmental exposure. In the much higher relief terrain of the Upper Colca area, observation distances are potentially much greater, and exposure is similarly greater. In order to avoid artificially limiting the amount of view / airspace adjacent to high visibility sites, a 10 km buffer was issued to the RADIUS2 variable for all 5000 random points. Also, a OFFSETB (target) height rather than OFFSETA (viewer) height was raised to 1.5m to simulate the assumed eye level of an Andean adult because the reciprocal viewshed was being calculated in this process.

Results

The visibility study output offered two forms of output data that were used with a Zonal Query in ArcGIS Spatial Analyst in assessing the visibility and exposure of archaeological features encountered during survey work, and these data presented with the survey results in Chapter 6.

5.9.3. Bifacial Thinning Flake index

An index of Bifacial Thinning Flakes (BTF), also known as a Flake of Bifacial Retouch, was developed for this project. This index is defined for complete flakes that have measures for both medial width and thickness. Additional characteristics of BTF that occur in relatively low frequencies, such as platform lipping, were not incorporated in this index (Sullivan and Rozen 1985:758).

In the course of lab work, twenty-three flakes were noted that were "possible thinning flakes" and these were used to assess the BTF index described above. Using the BTF index, 18 of the 23 flakes (78%) flagged as possible BTF were 7 or greater on the BTF index.

Being a general measure, a cutoff of 7 or larger is used to identify "possible BTF" in the following analyses.

When rotations > 0 and Cortex ≤ 10%, BTF = $\left(\frac{Width\_Medial}{Thickness\_Medial}\right) * rotations$

This index was applied to general collections in the analyses presented in Chapters 6 and 7.

Calibrated projectile points counts, and why they were not used in this study

Time-sensitive projectile point distributions from survey can be used to produce "calibrated counts" for sites in a given region as has been applied in studies in the Titicaca Basin (Craig 2005:453-468; Klink 2005; Tripcevich 2002) and in other regions. Calibrated counts are valuable measures because time periods assigned to projectile point styles are of different durations, and thus direct comparisons between site counts for a given time period can be misleading. For example, the Middle Archaic is 2000 years in length while the Terminal Archaic is only 1300 years in length, therefore there were more years by a factor of 1.53 for sites to occur in a given time period.

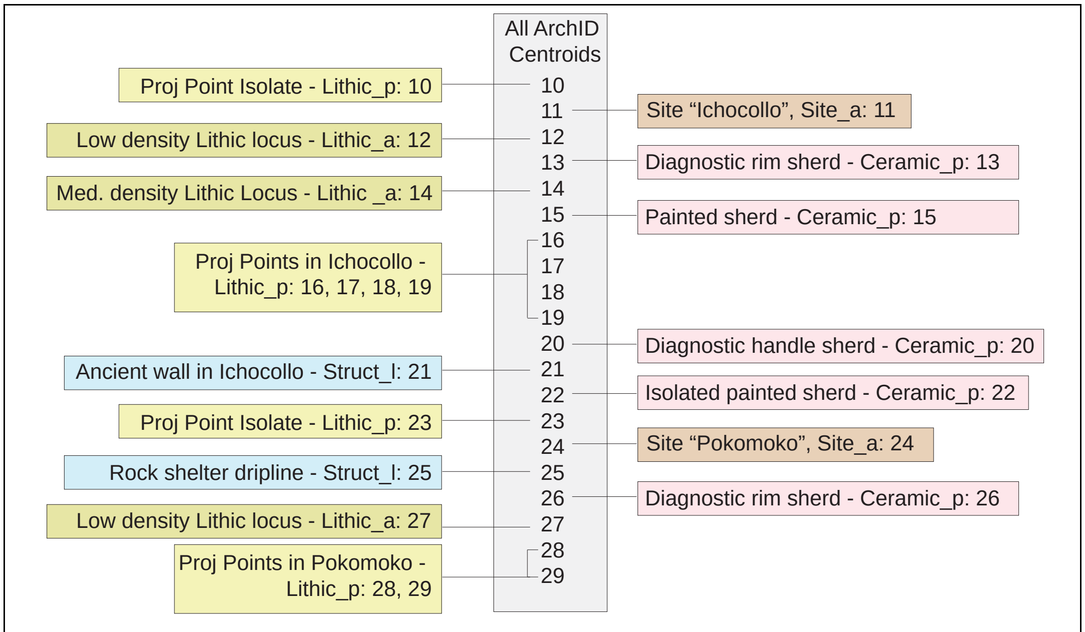
However, in the Upper Colca study, site counts were not systematically calibrated for two reasons. First, as mentioned above, there were virtually no single-component sites identified in this survey. Due to the aggregation of settlement around water sources and sheltered places in the higher altitude portion of the survey, virtually all sites with more than two diagnostic artifacts were shown to be multicomponent sites. Second, this research was conducted in the vicinity of an obsidian source and the evidence from this study and work elsewhere in the region show that obsidian is strongly correlated with Series 5 projectile points belonging to the later Prehispanic time periods. Therefore projectile point style and length of time are not independent variables such that one could be used to calibrate the other, because obsidian was increasingly in demand and further circulated during the Series 5 time period.

5.10. Database structure and 1:M labeling

A basic challenge to organizational structure in GIS is database normalization. As per the first and second normal forms in database structure (Codd 1970), One to Many (1:M) table relationships should be used to eliminate redundancy in tabular data. The 1:M relationship is common-place in archaeological research because it is often very efficient to map many artifacts to geographical features represented as a single point or polygon. Managing data that are distributed through 1:M relates brings added complexity, however, both in locating particular references to data, and in graphical representation. Current capabilities of GIS are limited in the representation of data accessible through a 1:M relate, symbolically or through labeling, and most require a restructuring (make-table query) of the data for each mapping effort.

5.10.1. The All ArchID Centroids file

The added complexity of managing data through 1:M relates and distributing the recording of archaeological feature types among multiple GIS feature layers can be alleviated by creating a single file reference dataset. The concept is based on the ArchID numbering system described above (Section 5.3.5). Because all archaeological features that were individually mapped, including lithics, ceramics, and structural loci, shared a single number series, then a number list could be generated that is comprehensive and serves as a “backbone” against which to structure Many-to-Many relates.



Example of a row in the ArchID_Centroid table:

ArchID	LocusID	SiteID	SiteName	X_cent	Y_cent	Z_cent	Block	PhotoURL	GPSDate	GPSTime
14	12	10	Ichocollo	242010	8257921	4010	2	http://www.mapaspects.org/a03-14/	03_11_15	12:40:31

Figure 5-13. The All_ArchID_Centroids table provides a single reference layer for all the ArchID numbers used in the project, and allows relates to occur between disparate data layers. This figure shows the structure of these different layers using artificial data.

Many-to-Many (M:M) relates consist of a series of 1:M relates linked through a file structure that contains key fields in held common by the different tables, and this structure allows for relates to move across different file types. An example of queries moving between different layers would include the following: one needs to know if there is a statistical association between the percentage of obsidian among simple flakes in lithic assemblages in Ichocollo (Figure 5-13), and the rim diameter of LIP painted ceramics at that site. All the lab results from the archaeological features within Ichocollo showing obsidian percentage can be selected and related to the ArchID numbers, which in turn are related to the Ceramic_p layer containing the rim sherd diameter information. The problem is that some of these features are lines and polygons, while others are points, thus a single lookup table reconciles all these differences and allows relates to occur.

This file, referred to as All_ArchID_Centroids, is a single point-type file containing the point locations, and in the case of lines and polygons, the centroids of these features. This GIS layer is a single comprehensive list of all geographical proveniences, although the spatial detail and topology of lines and polygons is obviously lost when centroids are used. The table from the All_ArchID file can accompany lab data into statistical software packages to allow very general geographical queries on lab analysis results, such as patterns by common Locus, by Survey Block, and other queries that do not require GIS.

In sum, this post-fieldwork processing step involves creating the comprehensive list of ArchIDs that were used throughout the field season from the multiple file types described above in Figure 5-7a and creating a single GIS point geometry file from the cumulative list. The All_ArchID_Centroids file proved to be extremely useful in later GIS and lab analysis. The point location centroids for all feature types contains sufficient detail for many of the later geoprocessing steps, and the All_ArchID_Centroids layer was used as single location for labeling and for providing a structure for linking to photos on external website URLs.

5.10.2. VB Script for One-to-Many labeling

Labeling through a 1:M relationship is not currently supported in Arcmap 9.1. To resolve this limitation, the script presented below iterates through all the artifacts collected from a given spatial location and places their values in a text box. Text boxes can then be converted to annotation and moved around the map as needed.

```
' This command is issued from the Label Properties "Text String" Expression, and with the Advanced button checked.
' In this case Feature:ARCH_ID and Table:Arch_ID are Strings and they hold an ID common to both records in both
' the Feature, and the Table Litico_II is the name of the table C:\gis_data\colca_data\colca.mdb is an MDB or GDB
' Recursive Label function for labeling 1:Many from a table in a Access / GDB file.
' Modified from code by Mohammed Hoque 2005 in http://www.esri.com/news/arcuser/0705/files/externaldb.pdf
Function FindLabel ( [ARCHID] )
  Dim strLblQry, strInfo
'  strLblQry = "SELECT * FROM Litico_II WHERE ArchID = '" & [ARCHID] &"'"
  ' if ARCHID were a String then the line would look like the above
   strLblQry = "SELECT * FROM Litico_II WHERE ArchID = " & [ARCHID]
  Dim ADOConn
  set ADOConn = createobject("ADODB.Connection")
  Dim rsLbls
  set rsLbls = createObject("ADODB.Recordset")
    ADOConn.Open "Provider=Microsoft.Jet.OLEDB.4.0;Data Source=C:\gis_data\colca_data\colca.mdb;"
  rsLbls.Open strLblQry, ADOConn, 3, 1, 1
  'If no record is found, return label only
  Select Case rsLbls.RecordCount
    Case -1, 0 ' no matching records in table
      strInfo =  "A03-" & [ARCHID] & "." & trim(rsLbls.Fields("Rot_Inicio").Value) & ": No Artifact Data!"
    Case 1 ' just one matching record
      if  cint(rsLbls.Fields("Diag14").Value) > 0 then ' checks before labelling this record
          If cint(rsLbls.Fields("Rot_Inicio").Value) =  1 then
            ' Don't show Dot-Rotulo for only one label
            strInfo =  "<CLR black = '100'>" & [ARCHID] & "</CLR>"
            Else strInfo =  "<CLR black = '100'>" & [ARCHID] & "." & trim(rsLbls.Fields("Rot_Inicio").Value) & "</CLR>"
                End if
          ' use the TRIM function so that no error is returned in case of NULL
      End If
    Case Else
   'Loop through all records in Table with same Arch_ID
        Dim i
       For i = 0 to rsLbls.RecordCount + 1
             if  cint(rsLbls.Fields("Diag14").Value) > 0 then  ' checks to see if we should label this record
                 strInfo = strInfo & "<CLR black = '100' >" & [ARCHID] & "." & trim(rsLbls.Fields("Rot_Inicio").Value) & "</CLR>"
                 end if
            i = i + 1
            rsLbls.MoveNext
            Next
  End Select
  'closing connections, this is a must
  rsLbls.Close
  ADOConn.Close
  Set rsLbls = Nothing
  Set ADOConn = Nothing
  FindLabel = strInfo  ' This is where the string is returned for labeling
End Function
```

Table 5-12. VBA Script for labeling through a One-To-Many relate in ArcMap 9.1.

Cartographic capabilities of future GIS software likely will include a similar feature in the symbology and labeling function. Table restructuring merely to represent relationships that are inherent to the database structure, as is currently required by the off-the-shelf software, is highly inefficient.

5.11. Conclusion

Methods implemented in this research project were complicated by the fact that the 2003 season combined a regional survey, test excavation work, and recently developed geographical technology into a single project in a remote location. This chapter discussed data recording, sampling, lab analysis methods, together with methods for integrating digital data from these distinct steps. The integration of GPS and mobile GIS technology permitted feature recording at a scale that was impractical in archaeology until very recently. The project used adaptable archaeological feature recording methods that emphasize the recording of artifact clusters by expediently mapping areas of similar material types, debitage sizes, or ceramic types. Many of the specifics of these methods will rapidly become obsolete as digital methods develop, however the larger issues surrounding objective and subject data recording, and the relative benefits of the vector and raster data models for analysis, relate to larger questions linking method and theory that will be remain important issues for years to come.

– Chapter 6 –

Survey Results from

Research in the Upper Colca

6.1. Introduction to data presentation

The results of systematic survey in the Upper Colca study area are presented in this chapter with an analysis of the distributions of sites, features, and artifacts that were encountered in the course of the 2003 field season. Using methods detailed in the preceding chapter, materials from six survey blocks were mapped, collected, and analyzed in the vicinity of the Chivay obsidian source. This systematic survey work was complemented by test excavations at three sites, and the results and analysis of the testing program are presented subsequently, in Chapter 7. The research strategy included three principal survey areas (Blocks 1, 2, and 3) and a smaller separate tract (block 6) and in these four areas intensive, systematic survey was conducted that amounted to 33 km^2. In addition, specific areas of interest in two extensive reconnaissance areas (Blocks 4 and 5), were evaluated in a region that measured 239 km^2.

In this chapter, the data from three intensive survey blocks are presented. As the 20 km x 30 km project area consisted of the three separate blocks with different ecological conditions, and distinct social and economic histories, the project was, in some ways, three separate surveys. Prehistoric activities were distinct in the three major ecological zones: (1) the quarry area, (2) the high puna, and (3) the upper valley zone. In order to integrate these survey areas towards the common goal of documenting changes in the production and circulation of Chivay obsidian on a regional scale, the results of survey work will be presented here following prehistoric chronology, rather than spatially in terms of survey blocks. In other words, the execution of the survey work was largely guided by the geographic and logistical realities of working in three distinct zones linked by reconnaissance areas, but in terms of interpretation, the focus here is on large scale change through time in the vicinity of the Chivay source by considering all three zones simultaneously for each major time period.

The survey data is considered here in three temporal periods that were introduced in Chapter 3 – Archaic Foragers (10,000–3,300 BCE), Early Agropastoralists (3,300 BCE–AD 400), and Late Prehispanic (AD 400– 1532) – and within each period the evidence geographically by survey block. One consequence of considering all survey blocks by time period is that the variability within the study region at any given time is brought to the fore. The larger trends, and the variability, evident in each time period are explored here through a combination that includes: (1) summaries of raw data; (2) summaries of generalized data; (3) groupings by site, loci, and artifact type; (4) comparisons by environmental criteria; and, (5) specific descriptions for particular sites, loci, and artifacts.

These summaries were largely derived from quantitative information produced by the mobile GIS field methods described in Chapter 5, combined with lab analysis results that were linked to spatial provenience. This chapter begins with an introduction of cartographic conventions used in this chapter. Subsequently, specific evidence for variability of obsidian throughout the source area is explored, and finally the survey results are chronologically by moving through time from the Archaic evidence to the Inka period. These data are complemented by evidence from test excavations and lab analysis that are reviewed in Chapter 7.

6.1.1. Data presentation and cartographic conventions

Artifact abbreviations used in maps

Survey data and lab results from survey collections are presented in this chapter using a series of maps that strive to maintain spatial associations while representing the archaeological significance of particular artifacts and features. In order to convey lab results in their spatial context the following abbreviations were used.

Code	Material Description
Ob1	Homogeneous obsidian with conchoidal fracture
Ob2	Variable obsidian with heterogeneities such as bubbles and inclusions.
Ob1c, Ob2c	…Clear
Ob1cb, Ob2cb	…Clear banded
Ob1g, Ob2g	…Grey
Ob1gb, Ob2gb	…Grey banded
Ob1b, Ob2b	…Black
Ob1br, Ob2br	…Brown
Che	Chert
Cal	Chalcedony
Qtz	Quartzite
Vol	Aphanitic volcanic (andesite, basalt, rhyolite)

Table 6-1. Abbreviations for lithics used in maps, figures, and tables.

Characteristics of the Ob1 and Ob2 groups of obsidian raw material are described in more detail in Section 4.5.1. The decoration and origin tags are appended on other abbreviations as needed. The abbreviations are combined into label codes as in the following example

25.2 Ob1g 4d, L.Arch	ArchID.Artifact#: Material Projectile Pt Type, Period

Table 6-2. Example of a map abbreviation label for a diagnostic lithic.

Ceramics were likewise abbreviated for efficient presentation in map form. The following condensed codes were used in maps and tables throughout the document to display lab results from ceramics analysis.

Group	Abbreviation	Description
Measure	D: #	Diameter: Rim diameter in centimeters
Style	Ql	Possible Qaluyu
	Ca	Colla
	Ch	Chiquero
	Cg	Collagua
	Cg1,2,3	Collagua1, 2, or 3
	Cg-Ik	Collagua-Inka
	Ik	Inka
Period	MF	Middle Formative
	F-MH	Formative - Middle Horizon
	MH	Middle Horizon
	LIP	Late Intermediate Period
	LH	Late Horizon
	Hs	Historic
	Md	Modern
Part	Rm	Rim
	Bd	Body
	Hdl	Handle
	Hdl-Rm	Handle and Rim
	Bs	Base
Form	Ol	Olla
	Osc	Olla sin Cuello (Neckless Olla)
	Jr	Jar
	Pl	Plate
	Bw	Bowl
	Bk	Beaker
	Tt	Tortero (grittle)
Decoration	-p	Painted
	-i	Incised
Origin	-l	Local
	-nl	Non-local

Table 6-3. Abbreviations for ceramics used in maps, figures, and tables.

54.2: Cg2,LIP D16: Rm,Bw	ArchID.Artifact#: Style,Period Diameter(cm): Part, Form

Table 6-4. Example and explanation of a map label for a diagnostic ceramic.

Conventions used in site descriptions, cartography, and scale in field photos

Sites, loci and point locations were used to record archaeological features in the course of this survey. The presentation of survey data in this chapter will be organized around set of site typologies by time period were generated from fieldwork observations and through subsequent data analysis. The hierarchy of presentation is generally as follows: (1) larger time period, (2) site type grouping with general data, (3) individual site descriptions with ArchID numbers listed, (4) particular loci, points, or data tables relevant to the site. Thus, individual features were assigned ArchID numbers, but in the process of interpretation for this report the features (loci and points) were assigned to sites which were, in turn, assigned to a larger typology and time period. In this presentation, each principal site description will begin with the ArchID number for a given site followed by its text name in quotes, and finally in brackets the range of ArchID numbers associated with the site.

Maps in this dissertation are all in the modern WGS 1984 datum and UTM zone 19 South metric coordinate system and the Transverse Mercator projection. Most existing maps in the central Andes are in the Provisional South American Datum of 1956 (PSAD56) or “La Canoa” and transformations between these coordinate systems for the Central Andes were discussed in Chapter 5 (Mugnier 2001, 2006). By using WGS1984 datum, the spatial data conform to the native GPS coordinate system, as well as to newly available spatial data available from government agencies and private data sources.

Another convention used consistently throughout this research involves photos. In photos of features where the tape measure is visible, the visible tape is always stretched to exactly one meter unless otherwise indicated. In artifact photos, the grid behind the artifacts consists of one centimeter squares.

6.2. Obsidian variability in the study area

The organization of prehispanic obsidian procurement at the Chivay source is clearest when the data is explored geographically, expanding out from the source area in Block 1. In order to become oriented to the Chivay source and vicinity, this section will begin by exploring summaries of obsidian artifact distributions in contrast with non-obsidian lithic materials in the vicinity of the source.

6.2.1. Material type by survey block

Lithic raw material in the vicinity of the Chivay source

Variability in material type throughout the survey area make clear the basic structure of lithic procurement in the area of the Chivay source.

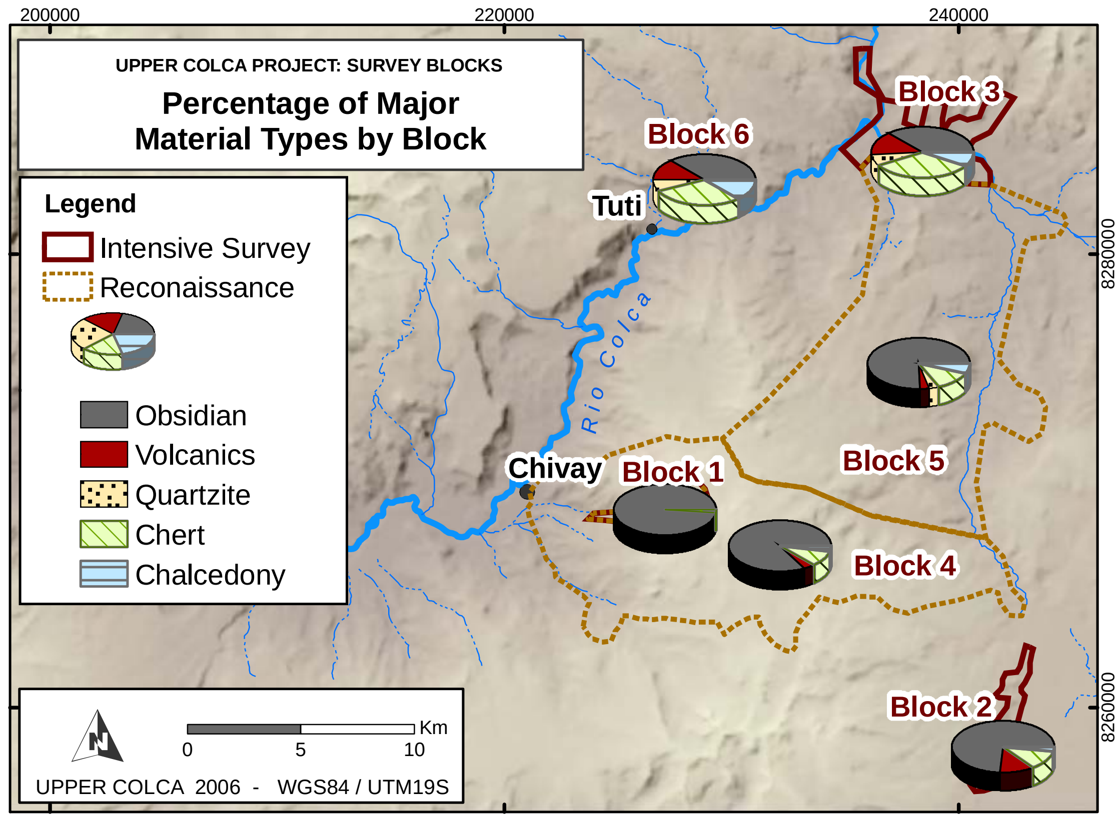


Figure 6-1. Artifactual lithic material types in the Upper Colca Project study region.

	Obsidian		Volcanics		Chalcedony		Chert		Quartzite		
Block	No.	%	No.	%	No.	%	No.	%	No.	%	Total No.
1	381	97.9	2	0.5		0.0	6	1.5		0.0	389
2	369	72.9	71	14.0	11	2.2	50	9.9	5	1.0	506
3	149	39.3	45	11.9	26	6.9	139	36.7	20	5.3	379
4	190	85.2	9	4.0	6	2.7	18	8.1		0.0	223
5	235	75.6	13	4.2	15	4.8	36	11.6	12	3.9	311
6	22	39.3	6	10.7	6	10.7	19	33.9	3	5.4	56.
Total	1346	72.2	146	7.8	64	3.4	268	14.4	40	2.1	1864

Table 6-5. Counts of artifactual lithics material types throughout the study region.

The availability of raw material throughout the region is inferred from the variability by material type from artifact collections throughout the study region. In the volcanic region of Block 1 and Block 4, obsidian is the principal locally available material. Block 4 extends into lower elevations regions on the east and west, and chert may be available in streambeds in those regions. Block 2 has larger quantities of fine-grained volcanic stone, mostly andesites, and these were heavily used in Late Archaic. Chert is relatively abundant in Block 2 as well, which suggests that there is a chert source not far from that block. Blocks 3 and 6 show the abundance of chert and chalcedony available in the upper Colca valley area, and multicolor chert cobbles were observed in several stream beds in Block 3. Quartzite is also used in Block 3, a material that was observed eroding out of the ridgetops. Block 5, as with Block 4, appears to contain a variety of raw material types within its boundaries.

Nodules of obsidian had their geological origin entirely in the Maymeja area of Block 1 and the adjacent areas of Block 4. The only other exposure of Chivay type obsidian encountered in the course of this research was the Pulpera / Condorquiña flow – a small exposure of Ob2 obsidian nodules, all measuring less than 5cm, at the toe of a long Barroso lava flow near Pulpera in Block 5. The Condorquiña flow probably saw very little use in prehistory due to small size and poor obsidian quality.

Based on the assumption that the survey was comprehensive and that there are no other exposures of Chivay type obsidian in the Ancachita – Hornillo area, it is proposed that culturally-modified of obsidian was transported radially from the source area in Block 1 and Block 4.

Why quarry for obsidian when it can be found on the surface?

A quarry pit was located on the south side of Block 1 in the Maymeja area of the Chivay source. This quarry will be described below, as well as in Chapter 7 where the quarry pit is examined and the results are presented from a test unit placed in the debris pile associated with the pit.

(1) Larger nodules could be acquired through quarrying.

Energy was evidently expended in digging to extract obsidian at the quarry pit in Maymeja and the motivation behind this effort an important question. Looking at the general patterns over the entire study area is instructive because it reveals some general patterns that were counter to expectations of this research project. If the original nodules from the Block 1 area were of a larger size it may account for the quarrying activity observed in Maymeja.

	Points and Tools			Cores			Simple Flakes			
Block	No.	μ Ln	σ Ln	No.	μ Ln	σ Ln	No.	μ Ln	σ Ln	Total
1	4	38.2	10.0	110	48.5	8.7	88	38.7	14.9	202.0
2	3	27.0	4.7	8	38.9	7.7	26	23.8	10.9	37.0
3	3	27.8	2.4	9	41.9	8.0	14	26.3	11.1	26.0
4	-	-	-	33	41.6	7.5	34	34.9	12.2	67.0
5	1	28.0	-	11	36.9	11.8	82	22.0	9.9	94.0
Total	11	31.8	8.2	171	45.8	9.5	244	30.2	14.5	426.0

Table 6-6. Lengths of complete obsidian artifacts with > 30% cortex by survey block surface collections, showing means and standard deviations.

In Table 6-6 the length of cortical obsidian artifacts from surface collections from throughout the study region with a minimum threshold of 30% cortex are shown. It should be noted that tools and flakes must have 30% covering of *dorsal* cortex to qualify for this table, whereas cores need only have 30% cortex anywhere on the exterior surface to be included here.

The first indicator of differential activity in Block 1 is the sheer number of cortical cores in these surface collection data. Table 6-6 reveals that the mean size of cortical artifacts in all three technical classes is notably longer in Block 1, and that the second largest mean lengths are from Block 4, adjacent to the Maymeja area. The artifacts from Block 2 are surprisingly small considering that the Chivay source is only one day's travel from this location. The fact these cortical artifacts are small suggests that they did not have access to large starting nodules. Table 6-6 also shows that the cortical artifacts from Block 3 were slightly larger than one would expect considering that Blocks 5 and 2 are equidistant, if not closer, to the Maymeja area of the obsidian source than is Block 3.

(2) Obsidian from the quarry pit had more transparent coloration.

In the course of this research it was observed that there is variability in the transparency and color of culturally-modified obsidian throughout the study area and the spatial distribution is related to the appearance of natural obsidian in geological contexts. Chivay obsidian is renowned for its clarity and it is possible that material from one survey block had a greater frequency of transparency than did material from surrounding survey blocks. If clarity was a desirable characteristic of obsidian artifacts then the evidence may show a greater focus on production in areas where transparent obsidian was common. Much of the obsidian contained dark banding as well, and this banding was more visible with clear obsidian than when the obsidian matrix was a darker coloration.

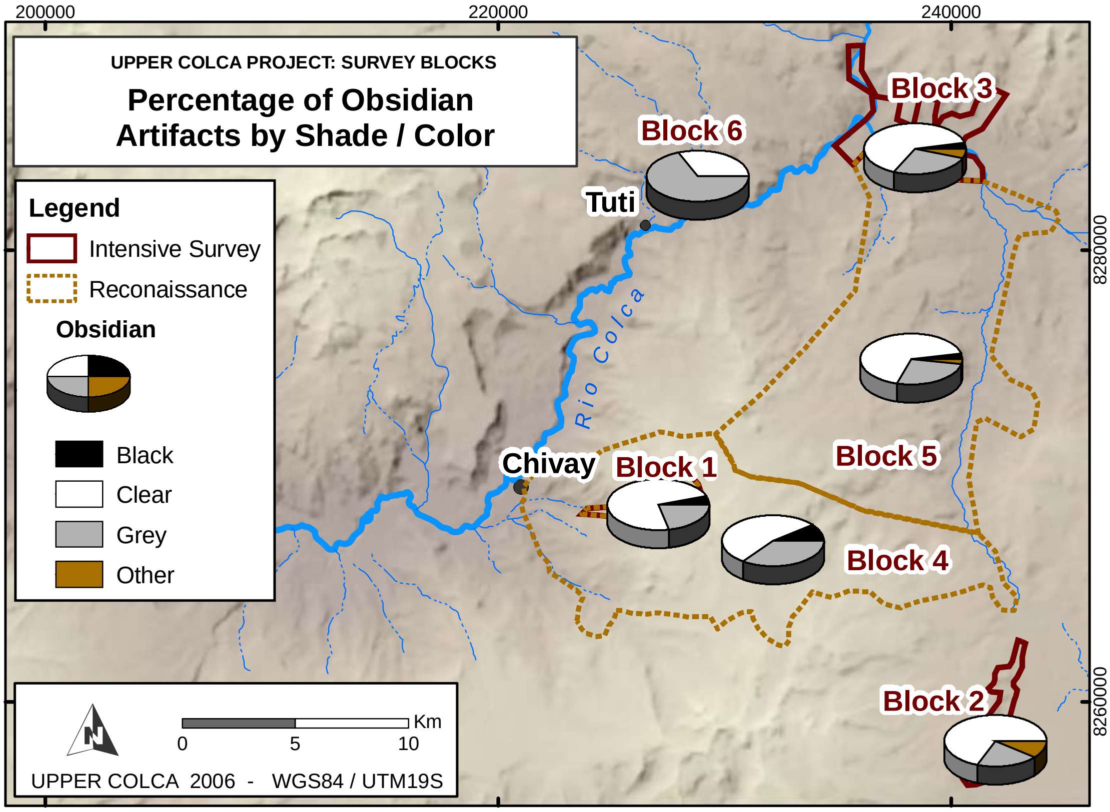


Figure 6-2. Proportion of obsidian for four colors (shades) of glass, by count.

	Black		Clear		Grey		Other	
Block	No.	%	No.	%	No.	%	No.	%
1	13	4.0	245	74.9	66	20.2	3.0	0.9
2	1	0.6	111	66.9	40	24.1	14.0	8.4
3	3	2.7	71	63.4	33	29.5	5.0	4.5
4	12	8.2	79	54.1	55	37.7		0.0
5	5	2.4	141	66.5	61	28.8	5.0	2.4
6		0.0	7	33.3	14	66.7		0.0
Total	34	3.5	654	66.5	269	27.3	27.0	2.7

Table 6-7. Obsidian artifact color (shade) by survey block surface collections. Includes obsidian with bands and without bands.

As shown in Table 6-7, Block 1 indeed has a higher fraction of clear obsidian than other blocks in the survey. The high incidence of clear obsidian at Block 2 (67%) further suggests that whoever was quarrying and reducing obsidian at the A03-126 workshop in Block 1 was also associated with the settlements in Block 2, as there is no naturally occurring obsidian in Block 2. As Block 2 is on the direct transport route towards the Lake Titicaca Basin, this evidence suggests that some of the clear obsidian from Block 1 was being consumed in Block 2 en route to the larger consumption zone of the south-central Andean highland region and the Titicaca Basin where Chivay obsidian was purportedly prized for its clarity. It should be cautioned that the distinction between grey and clear obsidian appears to be correlated with thickness. That is, a "clear" artifact is more likely to be considered "grey" if it is thicker because it appears to be less transparent as a result of thickness.

(3) Block 1 had more homogeneous Ob1-type obsidian.

A further line of inquiry relates to the question of presence of heterogeneities in the obsidian. The Block 1 area with both the quarry pit, and the greatest abundance of large nodules, did not entirely consist of Ob1 homogenous obsidian. Investigating all the artifactual obsidian collected from surface contexts in the course of this project by survey block, a number of general patterns emerge.

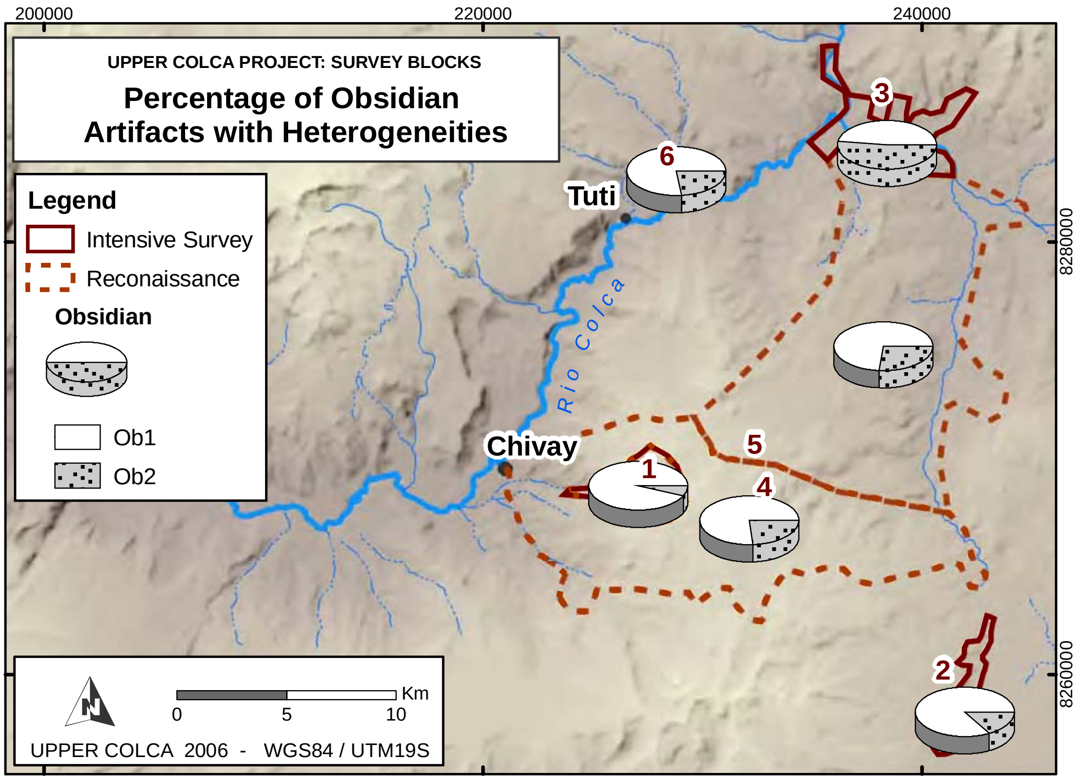


Figure 6-3. Proportion of obsidian material as Ob1 and Ob2 (heterogeneities), by count.

	Homogeneous: Ob1			Heterogeneous: Ob2			
Block	*No.*	*%*	*μ% Cortex*	*No.*	*%*	*μ % Cortex*	*Total*
1	355	93.2	36.6	26	6.8	35.4	381
2	329	90.6	6.1	34	9.4	15.9	363
3	96	64.9	15.4	52	35.1	10.2	148
4	140	73.7	23.0	50	26.3	31.2	190
5	172	73.2	30.8	63	26.8	22.5	235
6	17	77.3	1.2	5	22.7	2.0	22
Total	1109	82.8	22.6	230	17.2	21.7	1339

Table 6-8. Obsidian artifact material type by Survey Block surface collections.

Table 6-8 reveals that a small percentage of Ob2 material was actually found to have been used in Blocks 1 and 2, although the representation of Ob2 material was considerably higher in the other blocks in the survey. On the whole, Ob2 cores are decorticated to the same extent as Ob1 cores, although further upon exploration in Table 6-8) reveals that in Block 2 there appears to be a distinct preference for Ob1 obsidian as cores of this material have only 6% cortex while those of Ob2 have nearly 16% cortex. This is a pattern that might be expected, as the Ob2 obsidian has flaws that both negatively affect knapping quality and affect the visual appearance. However, the pattern is reversed in Blocks 3 and 5 where the Ob2 obsidian is decorticated to a greater extent than Ob1 material. There is a link between the color of the obsidian and the material quality because 45% of the grey obsidian is the Ob2 material, whereas for the other shades of obsidian the Ob2 ratios are smaller (10%–25%).

It was noted that in the Maymeja area of Block 1, unmodified obsidian nodules on the surface were often Ob2 material because they had small gas bubbles in them. Accordingly, it appears that some fraction of the obsidian that was knapped in the Maymeja area was made from this Ob2 surface material because it represented 6.8% of the collections from Block 1. The distribution of Ob1 and Ob2 material at the Chivay source will be further explored below prior to examining the results of the survey work in detail.

Further analysis of Ob1 and Ob2 obsidian types at the Chivay source

(a) (b)

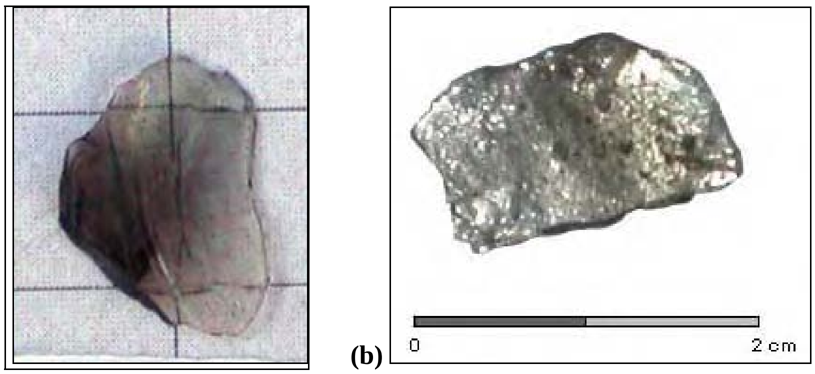


Figure 6-4. Photographic comparison of the homogeneous Ob1 obsidian and the Ob2 obsidian with heterogeneities.

Building on the overview of the use of Ob1 and Ob2 obsidian in the preceding section (see Figure 6-3 and Table 6-8 above), further exploration of Ob1 and Ob2 distributions follows. The results show that Ob1 and Ob2 obsidian artifacts in the area of the Chivay source assume patterned distributions over space, and these distributions are probably linked to the use of obsidian for export and for bifacial tool production.

Projectile points made from Ob2 obsidian

Eleven obsidian projectile points (4%) were made from Ob2 obsidian; a surprisingly high number under the operating assumption that fracture and visual quality of the material were important characteristics in bifacial tool production. Briefly exploring these eleven Ob2 projectile points may shed light on the characteristics that guided material selection in prehistory.

Ob2 materials form a much higher percentage (15%) of the obsidian flake surface collection than do Ob2 bifacial tools (4%) of the obsidian tool collection, which suggests that Ob2 material was being knapped but apparently not bifacially retouched.

The projectile points made from Ob2 material tend to have small or low-density heterogeneities that do not appear to greatly affect knapping quality, although visually the pieces appear mottled. These points were found in the south-eastern part of the study area in the San Bartolomé area (including one from a Late Formative excavated context), and in the reconnaissance blocks 4 and 5.

ArchID	Block	Period	PPt Type	Weight (g)	Length (mm)	Retouch Index
953.1	2	M. Archaic	2c	4.1	38.28	0.9375
820.1	2		3b	4.1	45.82	1
918.1	5		2c	6.9	48.73	0.96875
818.1	2	Late(2) – T. Archaic	4f	2.9	31.13	1
231.10	4	T. Archaic – Late Horizon	5	5.3	37.62	0.84375
994.1	2		5d	0.5	21	1
1014.3	2		5	2.5	25.52	0.9375
1026.9	2		5	1.9	Broken	1
1038.3	2		5	11.3	19.9	
2061.3	2		5d	1.2	Broken	

Table 6-9. Projectile Points made from obsidian containing heterogeneities (Ob2).

Period	Ob1	Ob2	Percent with Heterogeneities	Total
Middle Archaic	18	3	14.3	21
Late Archaic	4	1	20	5
T. Archaic – Late Horizon	221	7	2	227
Total	243	11	3.9	253

Table 6-10. Ratio of Obsidian Projectile Points with heterogeneities.

Due to low cell counts, conducting a chi-squared test required aggregating the counts from the Middle and Late Archaic Periods. A chi-squared test on the aggregated table (Table 6-10) showed that the difference between projectile points from Group 1: *Middle and Late Archaic* and Group 2: the *Terminal Archaic through the Late Horizon* with respect to the use of obsidian with heterogeneities is very significant ($\chi^2 = 9.976$, $.005 > p > .001$). It appears that Ob2 was very significantly less used for point production in the later time period.

Note that the material used for projectile point production in Block 2 was at times the cloudy Ob2, and it is likely that this reflects, in part, the availability of this material on the southern and eastern flanks of Cerro Hornillo. However, the vast majority of the Ob2 obsidian flakes are actually found in Block 3, at the site of Taukamayo.

Obsidian source material with and without heterogeneities

A number of the lag gravel deposits encountered in Blocks 4 and 5 of the survey are Ob2 material. Accordingly, obsidian artifacts from these blocks are higher in heterogeneities, indicating that there was a utility for this type of obsidian despite the imperfect matrix of the material. Investigating the distribution of Ob1 and Ob2 material across all obsidian artifacts (primarily flakes) shows that the Ob2 make up approximately one half of the obsidian artifacts even in Block 3 some distance from the Maymeja zone where Ob1 was observed in situ.

The mean size of Ob1 flakes is notably smaller, which suggests that more advanced reduction was occurring on the Ob1 material. There may be some size bias occurring with observations of heterogeneities because small flakes struck from Ob2 nodule will often appear relatively homogenous and clear if few bubbles or particles are included in the glass in that portion of the flake.

	Homogeneous (Ob1)			Heterogeneous (Ob2)			Total count
Block	*No.*	*μ Length (mm)*	*μ Weight (g)*	*No.*	*μ Length (mm)*	*μ Weight (g)*	
1	315	40.6	18.8	24	40.5	25.4	339
2	240	25.7	3.6	21	33.8	10.5	261
3	62	30.1	12.4	32	30.1	6.2	94
4	104	35.1	18.3	38	36.8	20.7	142
5	134	23.2	6.2	43	25.5	6.5	177
6	12	25.2	3.1	3	31.7	6.0	15
Total	867	30.0	10.4	161	33.1	12.6	1028

Table 6-11. Obsidian: mean sizes of complete Ob1 and Ob2 artifacts, by Survey Block.

These data, show patterns in terms of the mean length and weight differences between Ob1 and Ob2 artifacts. In all blocks, Ob1 artifacts are on average lighter than their Ob2 counterparts except for in Block 3. Furthermore, in most blocks the mean lengths of Ob1 and Ob2 material are very close but as the weights are different and therefore width or thickness must vary between Ob1 and Ob2 material. Further investigation of the metric data shows that, indeed, Ob1 artifacts have narrower and thinner medial measures, on average, than do Ob2 artifacts except for in Block 3 where Ob2 materials are thinner.

It appears that throughout the study region, Ob1 materials were preferentially knapped into artifacts that were narrower and thinner, but not necessarily shorter, than the Ob2 materials except for in Block 3. Ob2 material was much more common in Block 3, as will be discussed below, and it appears to have been used for more immediate butchering needs rather than for production of bifacial tools, a pattern that is consistent with the later date of the Callalli occupation. There is also a possibility of size bias where smaller Ob2 flakes are classified as Ob1 because no heterogeneities were evident in that particular small flake.

Discussion

The larger patterns revealed by these surface collections can be summarized as follows. First, the Ob1 material appears to have been available in the largest sizes in the Maymeja area of the Chivay source. Second, knappers in the Block 2 area appear to have made greater use of the Ob1 material, but for some reason they had smaller starting nodules as is evident from the smaller artifacts with ≥ 30% cortex. The fact that cortical materials in the immediate consumption area have much smaller sizes than those being derived from the Chivay source suggests that the largest Ob1 nodules were *not* being consumed in Blocks 2 and 3, and one possible explanation is that they were being exported to the larger consumption region.

We can gain further insights into the differential use of obsidian through the patterns associated with Ob1 and Ob2 material. These data relate to question of the importance of transparent, homogeneous obsidian. In Chapter 3 the relative use of Chivay and Aconcagua obsidian at Asana was discussed because it was inferred that later pastoralists may have been satisfied with Aconcagua material because they were less concerned with the aesthetic qualities of obsidian and more focused on its utility for shearing and butchering. The assumption being that visual quality was less significant for utilitarian applications. For projectile point manufacture, however, Ob1 obsidian appears to have been much preferred by pastoralists. In the pre-pastoral Archaic the use of homogeneous, Ob1 obsidian for projectile point manufacture was less prevalent.

The use of Ob2 can be considered in terms issues of access, aesthetics, and economy.

(1) Access: The obsidian with heterogeneities was found scattered across a larger region on the east and south-east flanks of Hornillo, as well as intermittently on surface elsewhere in the Blocks 1, 4, and 5 survey areas. In contrast, the Block 1 Maymeja area was the only zone with large nodules of Ob1 obsidian available, and under modern conditions the majority of these are beneath a layer of ash. These data suggest that obsidian procurement during the Middle and Late Archaic may have involved more frequent exploitation of surface materials simply because these groups did not have knowledge of, or need to, excavate to obtain Ob1 obsidian. Alternately, during the Terminal Archaic and onwards, quarrying for clear obsidian in the Maymeja zone was developed and greater quantities of clear obsidian were circulating.

(2) Aesthetics: The Ob1 obsidian appears, to modern eyes, that it would have had more value in cultural and prestige related functions. From a biological adaptationist perspective, Ob1 obsidian has higher costly-signaling value (Craig and Aldenderfer in press), and one would expect both hunter-gatherers and pastoralists to emphasize obsidian free of heterogeneities for its signaling value. As was discussed previously, exchange of objects between individuals or groups as symbolic tokens is documented among hunter-gatherers as well as pastoralists. However, during the pastoralist period social hierarchy increases rapidly and under these circumstances it is possible that the social importance of Ob1 obsidian to a competitive leader during a period of dynamic transegalitarian is considerable.

(3) Economics: Pastoralist producers of projectile points could afford to be selective in the material that they used because projectile points were not necessarily

“consumed” by subsistence hunting. If obsidian points are to be used as the principal means meat procurement, points will be broken and lost during hunting forays and there is therefore a need for less costly and easily replaced projectile points. During the pastoralist period, however, hunting for meat is supplementary to the meat available from the herd. Therefore, projectile point use becomes more discretionary because points are used for activities such as non-essential hunting, warfare, or symbolic exchange.

An additional economic component to the use of clear obsidian concerns the economy of projectile point production. Evidently obsidian was predominantly used for Series 5 (concave base, triangular) projectile points styles, and Series 5 points are much smaller on average than other projectile points. When only unbroken projectile points are considered, the mean weight of series 1 through 4 projectile point types is 5.69 g, sd = 4.92, while for Series 5 points the mean weight is 2.08 g, sd = 1.80. On average, Series 5 points are 2.89 times smaller than the other point styles, and therefore one could produce many more projectile points from a single nodule of clear, Ob1 obsidian if one were to make Series 5 points as opposed to an older, larger type of projectile point.

6.2.2. Production Indices

In his introductory chapter to an edited volume on quarries and lithic production, Ericson (1984: 4) proposed a number of indices for the study of lithic production systems. These indices are relatively general and therefore of limited use in this study, but they are included here because they provide comparable indices between quarry areas on an inter-regional scale. The indices were calculated for artifacts collected in the course of survey in 2003, and the indices were also derived for every level of the five test excavation units that will be discussed in Ch. 7. In these indices "Flakes" (a.k.a. debitage) are taken to be unretouched, flaked obsidian, while "Tools" includes retouched flakes, bifacially-flaked items such as projectile points.

Debitage Index is calculated from the (Flakes) / (Flakes + Tools) using count, weight, or size ratio. This calculation is of limited value because obsidian "Debitage", or simple flakes, are widely used as cutting tools, and therefore as a measure of production "by-products" an index that considers simple obsidian flakes as "waste" is questionable because these so-called waste flakes are potentially razor sharp tools.

Cortex Index (Flakes ≥20 % cortex)/(All Flakes) is indicative of the importation of raw material on site. Cortical flakes were defined here as those flakes having greater than or equal to 20% cortex.

Core Index ("Spent Cores" with ≥3 rotations)/(All Cores and Tools) to evaluate the degree to which cores are transported or are a medium of exchange. Here, spent cores are defined as those with greater than or equal to three rotations.

Biface Index (All Flakes with BTF ≥7) / (All Flakes) for measuring biface production. BTF are defined here as those with a BTF Index of greater than or equal to 7.

Survey Block	No. Flakes	Debitage Index	Cortex Index	BTF Index	Core Index
1	158	0.635	0.627	0.133	0.160
2	71	0.203	0.394	0.183	0.049
3	65	0.492	0.246	0.123	0.134
4	51	0.381	0.765	0.020	0.188
5	151	0.699	0.596	0.026	0.077
Total	496	0.450	0.548	0.095	0.110

Table 6-12. Obsidian production system indices for surface survey.

Using only obsidian artifacts from surface collections, these indices show changing strategies in obsidian use with increased distance from the source. The Blocks 4 and 5 areas were inconsistently surveyed and sampled, and therefore the comparability of indices from those two blocks is limited. The Debitage Index shows that many more flakes than tools were collected in Blocks 1 and 5. Curiously, Block 4 is relatively low in the Debitage index (reflecting sampling bias), and Block 3 relatively high perhaps because Taukamayo has a relatively high number of flakes (but consisting of Ob2 obsidian) for the consumption zone. The Cortex Index in Blocks 1, 4, and 5 show that primary reduction was occurring with greater frequency near the Chivay source than it was in the residential blocks of 2 and 3. The BTF index shows that biface production was occurring at the highest rate in Block 2 (18.3%), but biface production was also occurring in Block 1 and 3 as well. The Core Index shows that cores were being reduced more frequently in Block 1 and 4, and remarkably low Core Index values resulted for Block 2 and 5. The low value in Block 5 for this variable probably reflects the lack of large residential occupations in that block.

6.2.3. Projectile Points and obsidian variability

Breakage of projectile points

Obsidian has low compressive strength and the behavior of the material is often characterized as “brittle” (Section 4.4), resulting in a high incidence of breaks in tools that inform as the use of the tool. Latitudinally snapped tips and midsections are typically associated with breakage in use, perhaps upon impact as a projectile. In contrast, broken haft elements, shoulders, and longitudinal breaks are commonly associated with breakage during manufacture or retooling. The evidence for breakage during manufacture is reinforced when the point has incomplete scar coverage because it suggests that the point was discarded during production.

Projectile Points and Material Types through Time

Temporally diagnostic projectile points can be used to look at changes in material type through time in the vicinity of the Chivay source using a time sensitive typology such as the projectile point typology developed by Klink and Aldenderfer (2005). Andeanists have observed that obsidian projectile points were more widely used with the advent of the small, triangular style recognized as belonging to later time periods (Burger et al. 2000: 294). This style is referred to as the Series 5 point type and it is associated with the Terminal Archaic and onward. It is likely that the frequent use of obsidian for production of the smallest point styles, type 5D, was due to a change in technology, such as the adoption of bow and arrow technology (Klink 2005: 52). This interpretation is supported by the predictable knapping quality of obsidian and the ease with which pressure flaking can be used to produce small points that do not unbalance the arrow in flight, and because the precise pressure flaking also allows resharpening of arrow points with a minimum of loss of material.

Evaluating the entire Upper Colca Survey area, the diagnostic projectile points were found in the following material types. As described in chapter 5, the Series 5 points have not yet been analyzed as closely as the Series 1-4 points because the Series 5 points are not temporally sensitive to the same degree. Therefore Series 5 points are excluded from some tables below where these data are not yet available (as shown in Table 5-9).

Period	Point Type	Obsidian	Volcanics	Chalcedony	Chert	Quartzite
Archaic (General)	3d	489	449, 1019		394	
Early Archaic	1a	355, 379, 380, 941, 1015, 1037, 1044.2		384		
	1b	398, 411, 493, 522, 945, 956.3, 1026.3	444, 514, 956.2		469, 1034	
E. – M. Archaic	2a	512, 949				
Middle Archaic	2c	517, 873, 953, 1016, 1023, 1035, 1036, 1044, 1062	822, 1021	790.3		
	3b	386, 820, 944	958, 1051		509, 942	951
	3e		519		395	
Latter part of M. Archaic		1002				
Late Archaic	3f	490	390, 480			
	4d		960, 963, 964, 1017, 1018, 1024.4, 1024.5, 1048, 1067	94	38	
Late2 – T. Archaic	4f	407, 450, 463, 818, 943, 954, 1031	364, 1057	486		
Middle Horizon (?)	Poss. 4e	472				

Table 6-13. ArchID numbers for diagnostic projectile points, Series 1-4 only.

Type	Obsidian			Volcanics			Chalcedony			Chert			Total
	No.	*μ Wt*	*σ Wt*	*No.*	*μ Wt*	*σ Wt*	*No.*	*μ Wt*	*σ Wt*	*No.*	*μ Wt*	*σ Wt*	
1							1	6.00	-				1
1a	7	3.14	1.68										7
1b	7	3.14	1.57	3	4.00	0.00				2	4.50	0.71	12
2a	3	2.67	1.53							1	8.00	-	4
2b	1	1.00	-										1
2c	12	4.55	1.92	3	4.00	1.73	1	3.00	-				16
3a	1	6.00	-	1	4.00	-							2
3b	9	7.78	6.08	2	7.00	0.00				5	4.40	0.89	16
3d	6	3.17	2.04	4	7.50	4.12	1	9.00	-	5	18.00	13.40	16
3e				2	5.50	2.12				1	4.00	-	3
3f	5	3.00	2.00	2	8.00	1.41							7
4d	3	11.00	8.54	11	6.27	3.35	1	4.00	-	1	9.00	-	16
4d / 3b or 3d	9	2.89	1.83	1	3.00	-	1	5.00	-	3	7.00	4.58	14
4e?	1	1.00	-										1
4f	11	3.45	2.54	2	2.50	0.71	1	2.00	-				14
Series 1-4 Totals	75	4.20	3.66	31	5.68	2.91	6	4.83	2.48	18	9.06	8.92	130
5	87	1.63	0.95	2	5.00	2.83	2	6.00	2.83	1	4.00	-	92
5a	6	2.17	1.60							1	7.00	-	7
5b	16	1.63	0.89	1	5.00	-							17
5c	2	2.50	0.71										2
5d	78	1.40	0.54							1	1.00	-	79
Other	35	3.06	2.31	7	4.29	1.98	4	7.25	2.36	5	9.20	7.40	52
Grand Total	299	2.39	2.38	41	5.39	2.73	12	5.83	2.52	26	8.50	8.14	379

Table 6-14. Projectile point mean weights by point type and material type for Upper Colca project. Two quartzite points were excluded.

Table 6-14 shows the weights of all projectile points found on the surface of the project area. It shows that obsidian points were much smaller and much more common in the Series 5 types, and that the few type 5 that are not made from obsidian are relatively heavy. Two quartzite points that were excluded from Table 6-14 include a quartzite point of type 3b that weighted 7g, the other was a probable type 4g (Cipolla 2005) with an excurvate haft and a convex base, and it weighed 14g.

The changing use of a particular material type in association with projectile points is informative in any study region with diagnostic point styles. In the vicinity of an obsidian source these data also have the potential to inform about whether obsidian was used for projectile points out of preference or out of need.

For example, there is a type 3B projectile point, diagnostic to the Middle Archaic, made out of quartzite found in Block 2. This point was found only 16.3 km from the obsidian source, and it was found in a zone rich in obsidian, andesite, and chert, yet the coarsest material in the region was used for producing this point. Heavy materials such as fine-grained volcanics and quartzites known to have been used for projectile when mass rather than sharpness and penetrating power was being prioritized (Ellis 1997), and this is perhaps the explains the use of quartzite in this instance.

	Series 1-4		Series 5		Total
Block	*No.*	*% Column*	*No.*	*% Column*	
1	8	10.67%	11	5.21%	19
2	44	58.67%	141	66.82%	185
3	8	10.67%	19	9.00%	27
4	8	10.67%	30	14.22%	38
5	4	5.33%	9	4.27%	13
6	3	4.0%	1	0.5%	4
Total	75		211		286

Table 6-15. All obsidian projectile points by survey block.

The evidence from all obsidian projectile points (survey and excavation) from the project area shows the prevalence of obsidian projectile points in Block 2. Proportionally, there are relatively few obsidian projectile points in Block 1 which suggests that obsidian was not undergoing advanced reduction in the quarry area. This pattern becomes even stronger in the Series 5 projectile points. While neither

Series 1-4 nor Series 5 appear to be involved in advanced reduction in the proximity of the obsidian source, these data suggest that by Terminal Archaic, when Series 5 points were first produced, obsidian acquisition was perhaps more of a special purpose provisioning activity rather than an embedded activity.

Are the changes in material type for projectile points significant?

The degree to which material type is more commonly used in later time periods is informative and the counts of projectile point raw material type by time period can be used to explore whether the apparent patterns in raw material use through time are the result of random chance. The data from Table 6-14 above must be aggregated and simplified to allow a Chi-Squared test.

Periods	Obsidian	Fine-Grained Volcanics	Chert & Chalcedony	Total
Early Archaic	16	3	3	22
E-M & M. Archaic	26	8	9	43
Late Archaic	7	13	2	22
Term Archaic – Late Horizon	227	10	17	254
Total	276	34	31	341

Table 6-16. Aggregated Projectile Point Styles by Material Type for the project area.

The differences between aggregated cultural periods as indicated by diagnostic projectile points and their respective material types are extremely significant (χ^2 = 85.959, $p > .005$). This analysis is complicated by the fact that obsidian projectile points were very small in comparison to the non-obsidian points because obsidian points were used predominantly to make very small types of projectile points: the Series 5 group of points (Klink and Aldenderfer 2005: 47-53). If Series 5 projectile points are excluded material types can be compared more consistently by weight and length throughout the Archaic and across space. Table 6-14 under row "Series 1-4 Only" displays the count and weight of the comparable more projectile point types. Error bars for size measures on these Series 1-4 points are shown below.

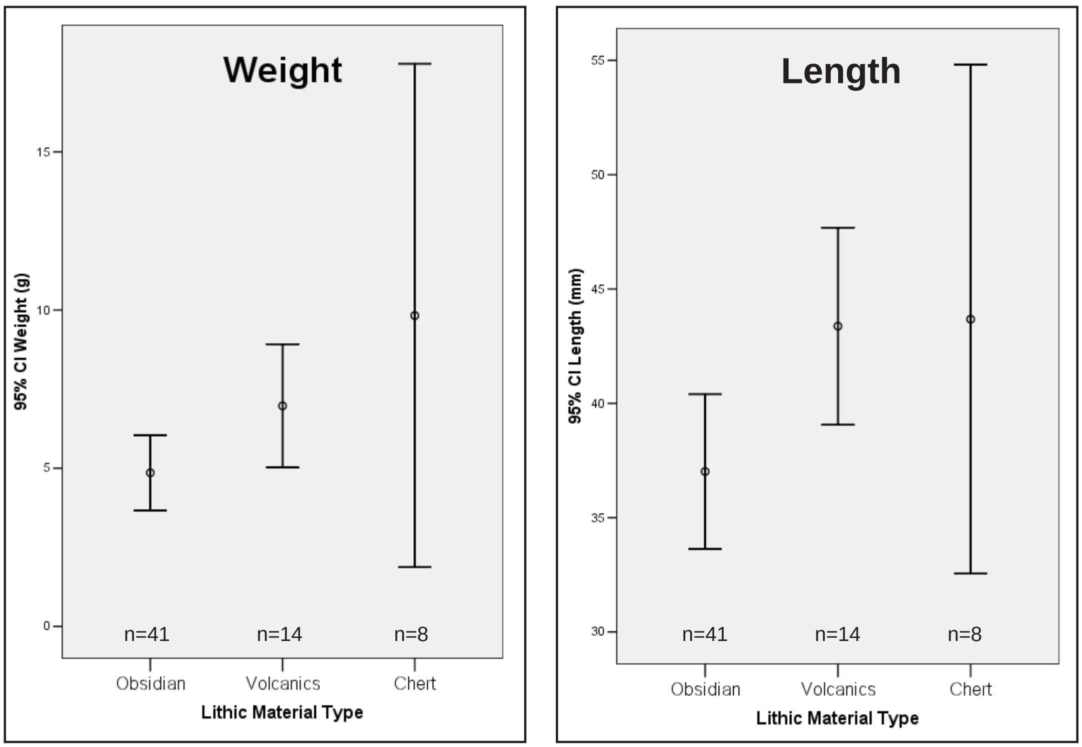


Figure 6-5. Complete projectile point weights and lengths by material type for the entire project area. Series 5 projectile points are excluded and chalcedony is combined with chert.

The significance of the differences in mean length and weight between material types was evaluated statistically. An analysis of variance was conducted on these distributions comparing obsidian, fine-grained volcanics, and chert projectile points. The ANOVA test revealed that the difference observed in the mean weight between the three material type groups was extremely significant (F=5.152, p > .0005).

Such comparisons between obsidian and other material types bring up a host of issues that may be influencing the analysis. These issues include the fine knapping quality of obsidian and the likelihood that the material would be retouched and recycled. Additionally, pressure flaking was most often observed on obsidian artifacts, and along with the fine conchoidal fracture of obsidian, allowed smaller pieces of obsidian to remain viable tools. Finally, a sampling bias during survey might have been introduced by the high observability of obsidian by archaeologists.

All things being equal, distance-decay models would predict that in the immediate vicinity of a source of raw material the artifacts that have complete scar coverage and are apparently "completed" would be larger, on average, than other material types. Curiously analysis shows that even close to the obsidian source obsidian projectile points are smaller than non-obsidian points. Distance-decay models also predict that far from the obsidian source obsidian tools and flakes will be consistently smaller than mean tool weights made from locally available lithic materials. Data from the consumption zone including the Qillqatani rock shelter (data presented in Chapter 3 (Section 3.4.2), as well as other lithic evidence from the Ilave Valley (Section 3.4.4), show the expected pattern: obsidian tools are significantly lighter than tools of other, more locally available, material types.

6.3. Survey Results: Archaic Foragers Period (9000–3300BCE)

This temporal period spans the calendar years ~9,000 – 3,300 BCE and includes the preceramic periods of Early, Middle, and Late Archaic, but it specifically excludes the preceramic "Terminal Archaic" time when pastoralism began to constitute an important part of the economy. The Archaic Foragers period in the Upper Colca region refers to the time that begins with the first diagnostic artifact production in the region through to the adoption of a predominantly food-producing economy with the Terminal Archaic. This discussion will consider the first peopling of the region as well, although data from surface survey cannot address those events directly for lack of diagnostic materials. Survey results show that during this time all three survey blocks were important parts of the local economy, but the puna rim area of Block 2 appears to have presented the greatest opportunities for foragers.

In reviewing the survey results below, Archaic components encountered during survey are isolated by the following characteristics:

(1) The presence of lithic reduction debris

(2) The natural shelter potential or other locational characteristics

(3) An absence of ceramics

(4) The presence of projectile points diagnostic to an Archaic chronological period

(5) An absence of late (Series 5) projectile points

As was previously mentioned, because of the high incidence of multicomponent occupations at large sites in this volcanic region, it is relatively difficult to isolate the archaic component of larger sites.

Archaic site classifications

Sites occupied by foragers in the Upper Colca survey area were approached using site type classifications based on those used by Aldenderfer (1998b: 52-75) in the Osmore drainage. These types of sites include residential bases, logistical camps, hunting blinds, and procurement locations. With very high rates of site reoccupation, discerning the Archaic occupation of any particular site was challenging, and the reoccupation and formation processes of sites strongly impact the older, Archaic component of multicomponent sites. Evaluations were based on the preliminary surface investigations in the course of a larger survey, and therefore the temporal component affiliations and site type assignments presented here should be treated as provisional. Furthermore, many of the sites identified in the Upper Colca were light surface scatters or deflated sites and therefore it is unlikely that archaeological knowledge will become significantly better concerning these sites.

Type	Description	Expectations
Residential Base	- Long term occupation or regular reoccupation by entire families. - Apparently formalized use of space with artifact distributions. - Typically associated with shelter and reliable water source.	Diversity in raw material types and in stages of manufacture in high density reduction loci. Multiple low density lithic scatters apparent throughout site. Artifacts associated with domestic and food preparation activities.
Logistical Camp	Short term but regular reoccupation by special task groups. Spatial location puts a priority on tasks.	Medium-Low assemblage diversity in material types but cores and range of reduction stages evident. Projectile point production failure may appear as tips and midsections in mid to late stage manufacture, and latitudinal snaps. Bases of projectile points from retooling.
Hunting Blind	Small, infrequently used or single-use area.	Low material type diversity. Resharpening and minor retooling.
Procurement and initial production	Associated with raw material source. Frequently exposed or otherwise non-optimal camp location.	High incidence of initial production stages with cortical material. Abandoned cores and decortication flakes.

Table 6-17. Classifications for Archaic components of sites.

These site type classifications were not assigned in the course of field work. Rather, the classifications are a combination of subjective observations during fieldwork by experienced team members and quantitative results from field mapping and from collections and subsequent analysis. Final classifications into site types as portrayed in Table 6-17 occurred in the course of the later analysis of survey data.

The environmental characteristics of these site type classifications have been evaluated using GIS data and it is possible to generalize about these site types in comparison with "average" values for each survey block.

6.3.1. Block 1 – Archaic Source and adjacent high puna

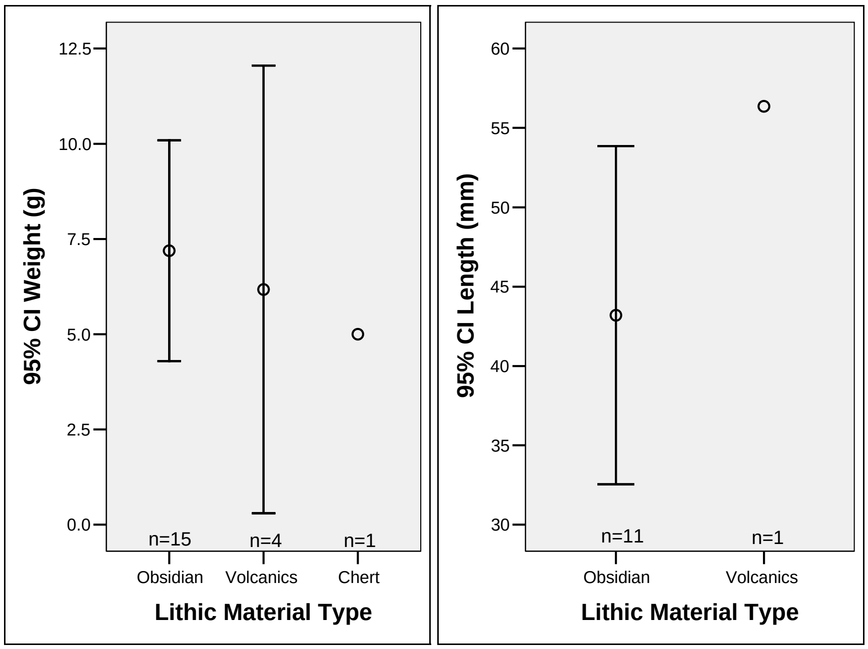


Figure 6-6. Projectile Point weights and lengths (when not broken) by material type for Block 1 and adjacent high puna areas of Blocks 4 and 5. Series 5 projectile point types excluded.

Relatively few Archaic Period projectile points were identified in the Block 1 area. The obsidian points that were found in Block 1 are, unsurprisingly, relatively large and nearly all are incompletely flaked. This is consistent with the relative paucity of obsidian points among the Series 1-4 projectile points overall where Series 1-4 obsidian points were only 25% by count of all the obsidian points as shown in Table 6-14. This pattern is even more pronounced when one considers that Series 1-4 point styles were used for over 7000 years while the Series 5 types were used for only

4800 years, or 7/10 as long. Furthermore, as was discussed above, many of these Series 1-4 obsidian points were Ob2 material which further reduces the probability that they were procured in the Block 1 Maymeja area.

The Archaic Forager sites in Block 1

In the Maymeja portion of the Chivay source all surface archaeological materials diagnostic to time periods prior to pastoralism belonged to multicomponent sites with a substantial pastoralist component. This settlement pattern reflects the exposed, windy nature of the Chivay source: all sheltered areas that may have had overnight occupation were reused. No sites that could be termed “residential bases”, using the same criteria as the other blocks of the Upper Colca project survey, were identified in this area.

Projectile points dating to the Archaic Foragers period were located in course of the survey of Block 1. Unsurprisingly, these points were virtually all obsidian, and most appeared to have been broken during manufacture with longitudinal breaks and incomplete scar coverage. In addition, it appears that broken non-obsidian bases were occasionally abandoned at the obsidian source, perhaps in the process of reusing the haft with newly fashioned obsidian points. For example, the base of a chert point with evidence of pressure flaking [A03-122] was recovered on the southern slopes of the Maymeja area during the survey work.

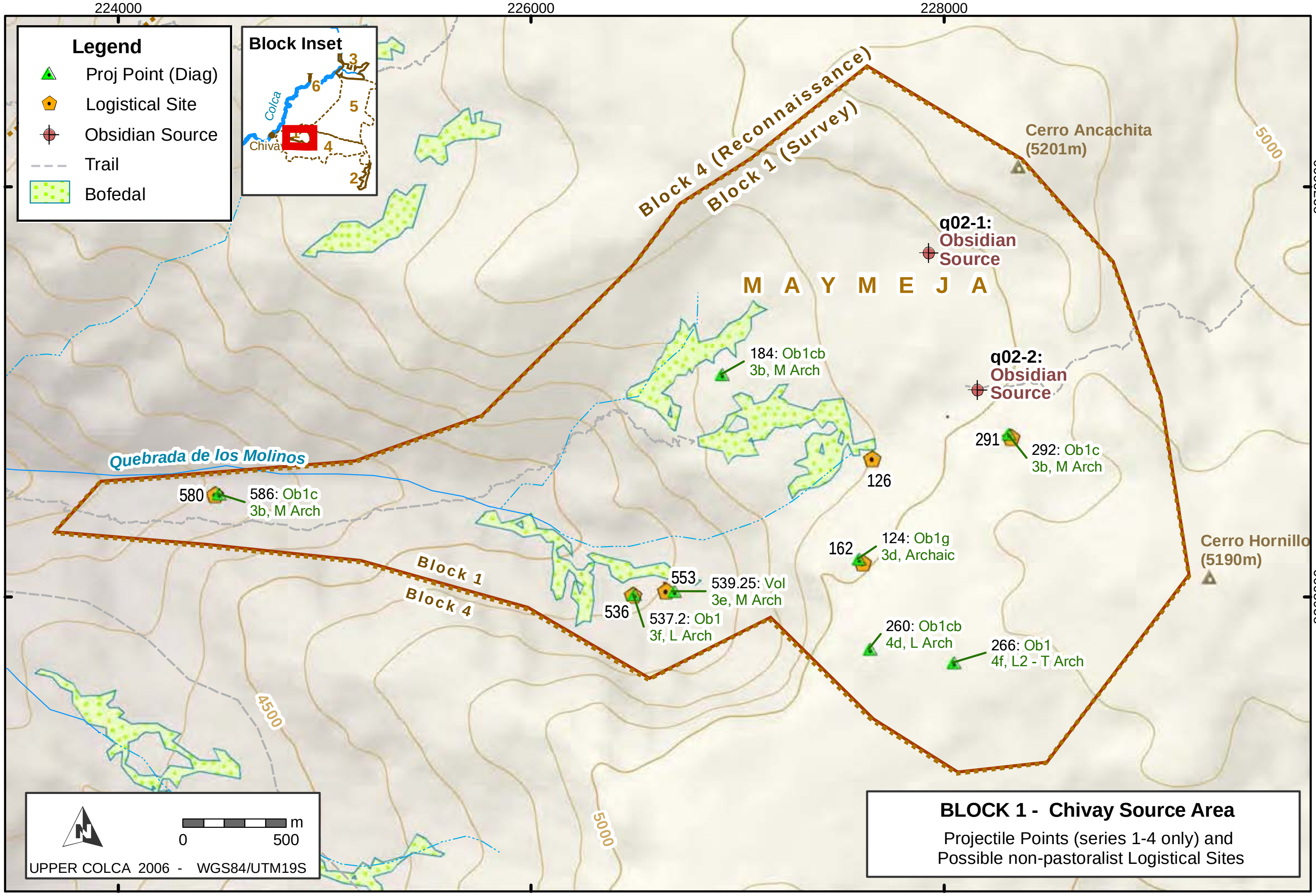


Figure 6-7. Possible Chivay obsidian source camps during Archaic Forager times.

Problems with isolating Archaic Foragers sites

One of the principal problems in isolating Archaic Foragers sites is that many of the artifactual indicators used in this research to designate sites as potentially belonging to the Early, Middle, or Late Archaic are not relevant in the obsidian source area. Of the three indicators that might potentially be used to designate sites from the Late Archaic or earlier, all three indicators have limitations.

(1) Aceramic sites. The use of ceramics in the high altitude obsidian source area appears to have been limited through the Formative Period (described in Section 6.4.1). Thus, the lack of ceramics is not evidence for a site dating to the preceramic.

(2) Material type ratios. A higher percentage of non-obsidian lithic material, primarily fine-grained volcanics, was used as an indicator of possible Archaic Foragers occupation in Block 3 of the survey area. This indicator doesn’t apply to the obsidian source area, however, because virtually all flaked stone is obsidian in this area throughout prehistory.

(3) Diagnostic projectile points. Time sensitive projectile point styles continue to serve as indicators of temporal affiliation in the obsidian source area. However, as Block 1 consists of a lithic production area the projectile points found there were often incompletely flaked or broken during manufacture. As a result, a number of the projectile points did not belong to a particular point style.

The vast majority of scatters in the Maymeja area consisted of non-diagnostic scatters of obsidian with a high frequency of cortical flakes. It is possible that some of these scatters date to the period before the Terminal Archaic, and indeed many of these sites contain no ceramics. However, in this relatively high area remote from population centers, the fact that a site is a-ceramic cannot be taken as evidence that the site dates to the *pre*-ceramic. Given the intensification on obsidian production that occurred during the Terminal Archaic and onward, these non-diagnostic obsidian scatters are evaluated here as by-products of pastoral period intensification in the area.

Projectile Points

The human use of the Maymeja area dates to Middle Archaic (7000 – 5000 cal BCE) as is demonstrated by the presence of three transparent (one banded) obsidian projectile points of type 3b and one andesite point of type 3e depicted in Figure 6-6. The presence of 21 type 3b points in Block 2 (eight of them type 3b) indicates that the Middle Archaic occupation was predominantly a puna occupation. One of the type 3b points collected in the course of survey work was at "Molinos2" in the Quebrada de los Molinos at an elevation of only 4216 masl, suggesting that Molinos was used to travel between the lower elevation Colca Valley and the high altitude obsidian source and puna during the Middle Archaic.

Strong evidence of Early Archaic use of Chivay obsidian exists in the form of obsidian Early Archaic projectile points discussed among the data from the Block 2 and Block 3 areas of the survey, and in the early part of the Early Archaic at the site of Asana almost 200 km to the south-east. However, no Early Archaic projectile points were found in the Maymeja area of the Chivay source.

Figure 6-8. Middle Archaic obsidian projectile point from Maymeja area [A03-184].

The type 3B Middle Archaic obsidian point [A03-184] found on a moraine between two bofedales is the strongest evidence of early use of the Chivay source from the Maymeja area itself (Figure 6-8). A foliate point was identified that has one spine, pressure flaking, and it was found on a moraine at 4824 masl on the northern side of Maymeja that was perhaps glaciated during the Early Archaic. This projectile point represents the earliest date, judging from stylistic attributes, in Chivay source area. A ^{10}Be date was acquired from a quartzite sample collected from moraines at 4650 masl (Figure 4-15) that suggests that the entire Maymeja area was glaciated until circa 9000 cal BCE (Sandweiss, 2005 pers. comm.).

Period	Point Type	Obsidian	Volcanics	Chert
Archaic	3d	124, 231.17	231.16, 780.3	
M Arch	2c	110, 112	780.2	
	3b	111, 184, 292, 586		780
	3e		539.25	
L Arch	3f	231.12, 537.2		
	4d	260		
L2 – T Arch	4f	118, 266		

Table 6-18. Diagnostic Projectile points Series 1-4 from Blocks 1, 4 and high altitude areas of Block 5, identifed by ArchID number.

Evidence from diagnostic projectile points suggest that during the Late Archaic, the use of Block 1 actually decreased because artifact counts drop from nine Middle Archaic projectile points to three Late Archaic points. Evidence from the entire survey area shows that the use of obsidian for projectile point production drops, beginning in the Late Archaic, from 65% to 52% of diagnostic projectile points. An alternative explanation for the reduced presence of diagnostic projectile points at the obsidian source is that the manufacture shifted to less advanced stages of reduction at the source such that diagnostic point styles were not recognizable in the source area.

		Obsidian	Volcanics	Chert	Column Total
E., M., and L. Archaic (Series 1-4)	No.	13 (27.7%)	4 (100%)	1 (100%)	18 (34.6%)
	μ Wt (g)	11.0 (n=6)	11.4 (n=1)	5.0 (n=1)	10.3 (n=8)
	σ Wt (g)	6.2	-	-	5.6
	by Sum Wt	76	100	100	79.8
T. Archaic onwards (Series 5)	No.	34 (72.3%)	-	-	34 (65.4%)
	μ Wt (g)	1.74 (n=12)	-	-	-
	σ Wt (g)	1.1	-	-	-
	by Sum Wt	24	-	-	20.2

Table 6-19. All Diagnostic Projectile Points from Blocks 1, 4, and Block 5 upper puna. Weights included for unbroken points only.

Comparing projectile points between the Archaic Foragers period and points belonging to the later periods demonstrates that, while counts are low for Series 1-4 points, the mean weight of projectile points (11g) is 6.3x larger than the mean weight of Series 5 projectile points. It should be noted that variability in Series 1-4 points is also much higher, with a standard deviation of more than one-half of the mean weight. This is consistent with size differences in the point types as described by Klink and Aldenderfer (2005) but it underscores the different quantities of material invested in point production at the obsidian source.

Site Type: Logistical Camps

Based primarily on the distribution of diagnostic projectile points and associated environmental data in the Maymeja area, it appears that "logistical camps" are prevalent in the settlement organization of the Chivay source area during the Archaic. Foragers likely visited the Maymeja area as an embedded strategy, combining obsidian procurement with hunting as the high relief area and talus boulders shelter a relative abundance of wildlife. Today, hunters visit the area to shoot *viscacha*, and a small population of *vicuña* are occasionally seen in the area.

Site size estimates for logistical camps were not included in this portion of the study because all of these sites are multicomponent and, in most cases, obsidian scatter sizes more accurately reflect later periods with greater intensification of production.

	Logistical Camps μ	Logistical Camps σ	All Data B1 μ	All Data B1 σ	All data in B1μ - Archaic Sites μ
No.	6	137			
Altitude (masl)	4723.8	286	4806.8	215.1	-83
Slope (degrees)	13.15	3.3	11.5	5.9	+1.65
Aspect (degrees)	NW (83%)		NW (45%), W (18%), SW (16%)		
Visibility/Exposure	8.5	7.1	15.1	11.9	-6.6
Dist. to Bofedal (m)	257.7	223	219.7	275.3	+38

Table 6-20. Environmental characteristics of potentially Archaic Foragers logistical camps in Block 1.

The sites identified as possible Archaic Foragers logistical camps in this study are, on average, lower in elevation because the sample is small and one site in the low portion of Quebrada de los Molinos pulls down the average elevation. The sites are on slightly steeper slopes and they are predominantly on slopes with a northwest aspect at roughly twice the rate of the entire dataset of archaeological features in Block 1. The pattern of settlement location that prioritizes steeper slopes with a northwest aspect would ensure the maximum of afternoon sun and therefore higher temperatures. The viewshed analysis indicates that these locations are slightly lower visibility and exposure than is typical in the Block, although the standard deviation on these measures is quite high. Finally, the logistical camps are slightly further from bofedales than is typical in the Block 1.

The land-use patterns of these six potential logistical camps in the obsidian source area are consistent with models of forager behavior (Kelly 1992). In these models, access to water is not a top priority, as short stays at dry camps are common. Expedient shelters were probably used at these obsidian source logistical camps due to relatively high mobility and short stays. According to this locational model, places with higher ambient temperature would have been a top priority for logistical camps because of the generally cold environment and the limited built shelter offered in logistical camp construction. These settlements contrast with the later pastoralist settlement pattern that prioritizes access to pasture and water for the herd. It is sometimes difficult to differentiate small forager logistical camps from the common small pastoralist camps that were encountered on the tops of moraines and other exposed locations that have commanding views of bofedales where the herd was presumably grazing through much of the day.

However, as is apparent in Figure 6-7, only one pre-pastoralist projectile point style [A03-184] was identified on these exposed moraine sites in the center of the Maymeja zone, and this point was located relatively close to the obsidian exposures at 4900 masl. The point was found at an area later used by pastoralists (with good views of bofedales to the north and south), the site had no other features consistent with forager logistical sites in the area, and therefore it was not interpreted as such.

A03-580 "Molinos 2" [A03-580 – A03-586]

The lowest elevation site in Block 1 is "Molinos 2" [A03-580], at 4216 masl. It is located below a large breccia boulder that came to rest on a terrace on the south bank of Quebrada de los Molinos. The site is located along the principal trail that climbs up Molinos from the town of Chivay. The north side of the boulder serves as a small rock shelter with the following dimensions: width 5.5m, depth 2.1m, height 0.8m. The site has been bisected by a stream that has become heavily incised from torrential runoff events, perhaps most recently from the El Niño – Southern Oscillation of 1997-1998. The effect of this runoff on the archaeological site is twofold. First, the rock shelter has been filled in with debris, as is visible in Figure 6-9a, and the overall dimensions of the rock shelter have been greatly reduced as it was probably higher and perhaps deeper prior to the infilling. Second, the downcutting of the stream has revealed hundreds of flakes of obsidian and chert in profile in the terrace below (Figure 6-9b).

(a)  **(b)** 

Figure 6-9. (a) Small rock shelter at "Molinos 2" [A03-580] is filled with debris from heavy runoff. (b) A density of flakes, predominantly of obsidian, are found in profile in the flood channel.

This site appears to have represented a regular travel stop between the obsidian source and the main Colca valley below. Projectile point evidence from the Early and Middle Archaic are relatively scarce elsewhere in the lower elevation portions of the survey, although 7% of the projectile points recovered during the Block 3 (Callalli) survey were characterized as Early and Middle Archaic. Steven Wernke's (2003: 541-542) survey in the main Colca valley found evidence of Early and Middle Archaic occupation at twelve sites in the form of diagnostic projectile points, and only one site (YA66) was below an altitude of 4000 masl.

A03-536 "Mamacocha 3" and A03-556 "Mamacocha 5"

These two sites share the characteristics of being located on lateral moraines that parallel the east-west direction of the Molinos drainage. Lithic scatters associated with large blocks of tuff that serve as small rock shelters are the principal features of these sites. A broken (longitudinally snapped) Middle Archaic 3e projectile point [A03-539.25] was found in one of these moraine sites; interestingly this point was made of andesite and was the only non-obsidian artifact found in this cluster of sites. A Late Archaic 3f obsidian point was also found in this area. Corral features and ceramics were identified here as well, indicating that the sites are multicomponent.

Figure 6-10. Lithic scatters are associated with shelter provided by large boulders located along moraines [A03-539]. One surveyor that is visible in blue provides scale.

The occupation of these sites was likely related to the use of resources in the upper Quebrada de los Molinos valley, although the moraines are not an obvious place for site locations. The sloping moraines are far from level and there is little open space between boulder, however the sites are probably located on these moraines due to factors that include insolation on these north-west trending moraines, the availability of water descending from Maymeja and the flanks of Hornillo, and the shelter offered by the large boulders.

A03-291 "Hornillo 9"

This high altitude site consists of an obsidian scatter that parallels a lava flow that trends northwest-southeast. The scatter is located in the sheltered area below the flow on ashy soil and while water is not presently available in this area, the site is level, it is relatively sheltered, and insolation is high.

Figure 6-11. Obsidian scatters were found on benches along the base of these viscous lava flows at 5040 masl [A03-291].

This site, and a neighboring site 70m downslope [A03-295] consist of obsidian scatters in areas sheltered by lava flows and the sites are adjacent to the lowest cost route out of the Maymeja area. The “Camino Hornillo” road [A03-268], described elsewhere, passes only 60m south-east of this area but, interestingly, no diagnostic artifacts were found that might connect these sites with the road. The only diagnostic artifact found at this site is A03-292, a possible 3b Middle Archaic projectile point with incomplete scar coverage made of clear Ob1 obsidian. At 5040 masl this projectile point represents the highest altitude diagnostic artifact found in the course of the survey. In some ways it is unsurprising that the only diagnostic point found at this site is from a time that predates camelid domestication: the camp offers no water or grazing and it would make little sense for herders to camp in this location when ample water and grazing opportunities lie on either end of Camino Hornillo.

A03-163 "Maymeja 4"

As shown in Figure 6-7, several diagnostic projectile points were found to the south-west of Maymeja. This access to the Maymeja area follows a trail that descends the lava flows from the western plateau of Cerro Hornillo. This trail is one of the most direct routes between the heavily traveled Escalera corridor to the south (in the Block 4 survey zone) and Maymeja. Just below the rim of the western plateau an obsidian scatter was found, along with one obsidian 3d projectile point [A03-124]; 3d is a style that is only diagnostic to the Archaic Period, generally.

At A03-255, another site approximately 500m to the south and on the broad rim of the Cerro Hornillo western plateau, another diagnostic obsidian projectile [A03-260] was found along with a number of ceramics. This area was a minor egress to the Maymeja area and perhaps was used by groups that were primarily interested in exploiting the bofedal in the lower part of Maymeja, and then crossing over to the Escalera area. It is also worth noting that the Camino Hornillo road [a03-268], along with a 4f Terminal Archaic projectile point [a03-266] were found just 500m east of here, but these features are interpreted as belonging to the Early Agropastoralist period described later.

Blocks 4 and 5 Reconnaissance Areas

The expansive Block 4 and 5 areas were evaluated opportunistically rather than systematically in the course of the 2003 fieldwork; and these blocks were examined to a limited extent during preliminary research in 2002. The targeted nature of this work in these blocks precludes any systematic evaluation of site distributions and settlement patterns because of biased survey coverage, however hiking across these reconnaissance areas provides a measure of the variety in each block. Data from the survey of these reconnaissance blocks provide insight into the access that these zones offer to the Chivay source, as well as the initial obsidian production activities that occurred there.

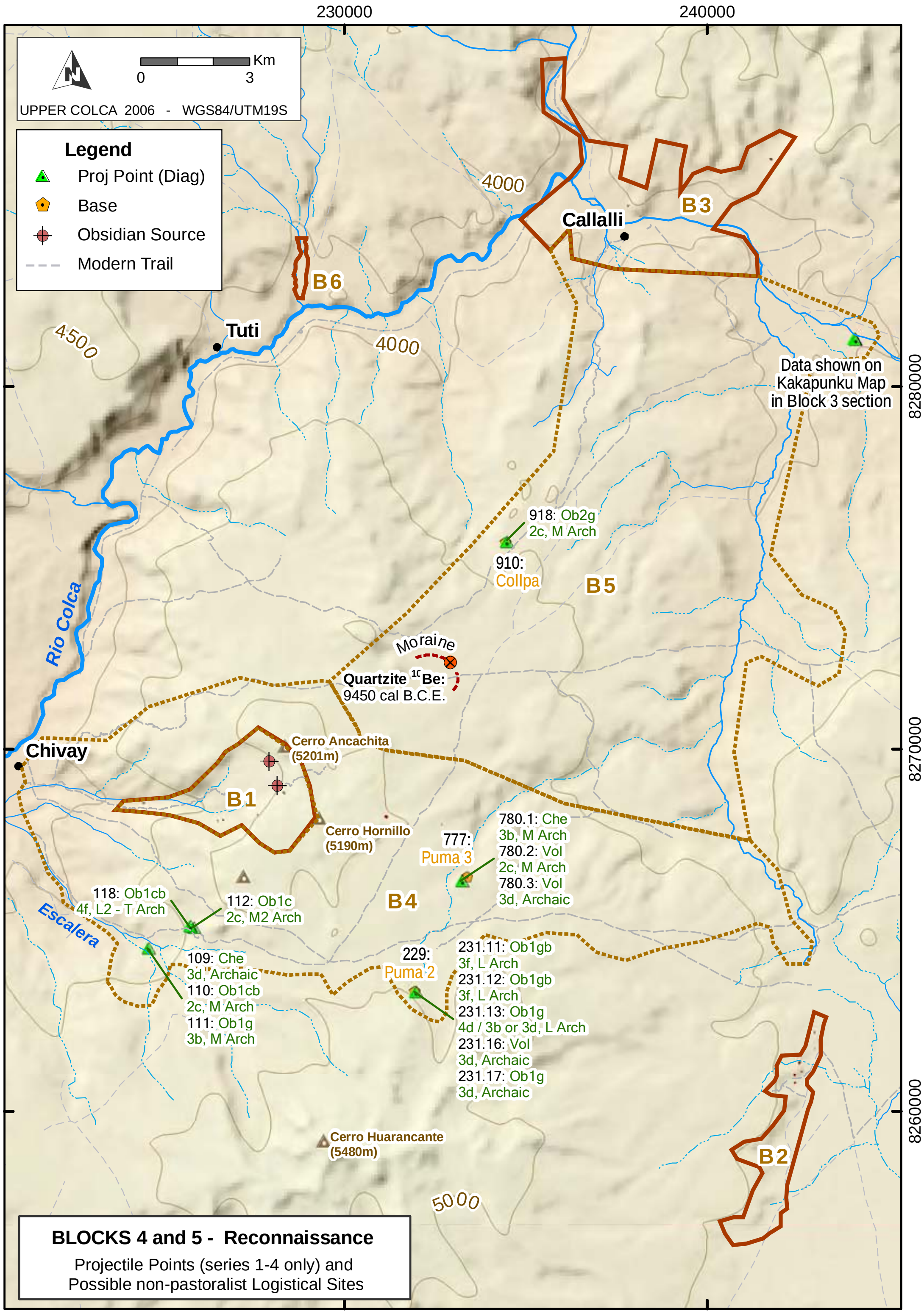


Figure 6-12. Map of project area showing Reconnaissance Blocks 4 and 5 with diagnostic projectile points and logistical sites from the Archaic Foragers period.

As with the settlement pattern in other lava rock areas of in the study zone, the arid and patchy environment of these blocks resulted in a relatively high rate of site reoccupation. The prevailing occupation pattern for the Archaic in Blocks 4 and 5 appear to consist of a few relatively large camps that are typically less than a few hundred meters from water, and often close to some kind of topographic prominence that offers both shelter and a view of the surrounding terrain. Isolated finds are also relatively frequent as should be expected of distributed subsistence, based on foraging.

The evidence points to an Early Holocene deglaciation of the Chivay Source area. A ^{10}Be date acquired from a quartzite erratic on a moraine to the east of the Chivay source area (data courtesy of Daniel Sandweiss, 2006), suggests that the terrain surrounding the source was glaciated at the 4650 masl level and higher as late as the Early Holocene (Figure 6-12 and Figure 4-15). Establishing the rate of deglaciation for the different areas that may have been exposed in a given time period will require further glaciological study.

A03-229 "Puma 2" [A03-229 – A03-232]

This rock shelter, and the slopewash below it, is one of the more effective shelters occupied during the Archaic in this area. The shelter is above an active corral and immediately south of a medium sized estancia owned by the Puma family. At this rock shelter, a longer incidence of occupation is suggested by a higher density of lithics. The rock shelter itself is something of a tunnel with two entrances as a result of a collapse in the center portion of the shelter. Both entrances have had walls constructed across them, and the northern of the two walled entrances is visible in Figure 6-13.

Figure 6-13. Rock shelter [A03-229] passes behind the collapsed margin of the grey lava flow in the center of the photo. Walls are built to partially close off both of the two entrances.

This shelter faces the morning sun and perennial water is available in a stream approximately 300m east. Unfortunately the construction of a large corral, on a relatively steep (10°) slope (the upper wall of which is visible in Figure 6-13), has resulted in a great deal of disturbance for artifacts just below this shelter. The many projectile points identified here were found among the stirred-up debris at lower end of this sloping corral.

	Ob1	Ob2	Volcanics	Chert	Total
Biface		1			1
Biface Broken	2	3			5
Flake Broken				8	8
Flake Complete	1			1	2
Flake Retouched				1	1
Flake Retouched Broken	1			1	2
Proj Point			1 *(3d)*		1
Proj Point Broken	5 *(3f,3d,unk)*	1 *(unk)*			6
Total	9	5	1	11	26

Table 6-21. Lithic artifacts from site A03-229 excluding eleven Series 5 projectile points.

This site contained a substantial number of points that are possibly Late Archaic, although the site also contained eleven Series 5 Term Archaic - Late Horizon points made from homogeneous Ob1 obsidian (that accounted for 60% of all projectile points by weight), but these were excluded from Table 6-1 because they are not Archaic. Based on the condition of the partially worked artifacts, much of this surface assemblage appears to have been abandoned during middle stage reduction in point production. One of the points was fine-grained volcanic, and had incomplete scar coverage. Of the obsidian artifacts, 45% of the projectile points and other bifacially flaked implements had incomplete scar coverage, and 66% were broken. These data suggest that this area, within a day's travel of the obsidian source, represented an intermediate stage in the lithic reduction trajectory as one departs the source. Interestingly, only 16% of the obsidian artifacts contained heterogeneities (Ob2) and these implements were nearly all classified as bifaces rather than as points. Ob2 obsidian was observed occurring as surface gravels only 4 km from this site, and the Maymeja source of Ob1 obsidian is nearly double that distance as the condor flies. Although this may be a signal from the later pastoral period, when shearing and other expedient uses for obsidian expanded, there appears to have been an emphasis on the use of Ob1 obsidian for point production while Ob2 obsidian was used for other bifacial tools.

Unfortunately, due to the disturbed state of the slope from the corral, and the artifact breakage that can result from animal trampling, further analyses of these data does not appear to be worthwhile. Future test excavations in the rock shelter may offer more insights into activities in this intermediate zone.

A03-777 "Puma 3" [A03-777 – A03-780]

As with the Puma 2 [A03-229] site higher in the valley, this site consists of a small shelter on the edge of a lava flow with improvements through the construction of rock walls.

	Ob1	Ob2	Volcanics	Chert	Total
Biface	1				1
Core		4			4
Flake Broken		2		1	3
Flake Complete	1	7		1	9
Flake Retouched				1	1
Heat-shatter				1	1
Proj Point				1 *(3b)*	1
Proj Point Broken			2 *(2c,3d)*		3
Total	3	13	2	5	23

Table 6-22. Lithic artifacts from site A03-777 excluding 1 Series 5 projectile point.

Two patterns emerge from the lithic materials encountered at this site. First, the Pastoral period signature is weak as there is only one Series 5 point (and it was completely flaked, Ob1 material). The Archaic Foragers points are all Middle Archaic and they were made of volcanics and chert, not obsidian. A second notable pattern about these lithics is that it appears that there was reduction of primarily Ob2 obsidian at the site based on cores left at the site. These cores were not exhausted, one weighed 47 g and measured 4.5 x 4.1 cm. This is consistent with the evaluations of Ob2 obsidian more generally, in that it is used because it is widely available, yet there appears to have been a preference for Ob1 material and, in particular, for projectile point manufacture. This site is only 3 km from the exposures of surface gravels of Ob2 obsidian on the south-east flanks of Hornillo, but over 6 km from the Maymeja zone with the Ob1 material.

A03-910 "Collpa" [A03-910 – A03-925]

Collpa [A03-910] is approximately 9 km from the Maymeja area of the Chivay source, and it is also 8 km from Callalli to the north, therefore it is roughly equidistant between Block 1 and Block 3 survey areas. Collpa is an important site in this study because due to its position between the two survey blocks, it provides an opportunity to observe lithic consumption patterns midway between the obsidian source and the B3-Callalli zone. In fact, both the modern owner of Maymeja and his hired herder are from Callalli and this site of Collpa lies directly along their path from Callalli to Maymeja.

This site is located among a cluster of unusual-looking tuff outcrops that occur at the western extension of the Pichu formation to the south of Callalli (Ellison and Cruz 1985). This cartographic unit is described by the INGEMMET study as crystalline tuffs and ignimbrites. These outcrops are potentially in the same formation as the tuffs described and dated recently by Noble et al. (2003) as the ash flow sheets belonging to the "Upper Part" of the Castillo de Callalli section, a formation that was described above (Section 4.3.2). If so, then these tuff outcrops date to the Early Pliocene and are probably associated with volcanic activity at the Cailloma caldera to the north of the Colca valley.

Figure 6-14. Multicomponent site of A03-910 "Collpa" among crystalline tuff outcrops. Two dark figures are visible, standing apart in the right and center-right half of the photo, providing scale.

The site of Collpa [A03-910] contains predominantly Series 5 projectile points and is potentially, then, a pastoralist occupation however several projectile points dating to the Archaic Foragers were also found here. The reduction strategies applied in this area are summarized below, although it is difficult to establish if these data on reduction activities at Collpa reflect the Archaic Foragers time or to the later pastoralist period.

The site contains several small rock shelters but the principal lithic scatter is located on a high point in the grassy center of the Collpa area. The site has distinctive concentrations of obsidian and high intrasite variability, however the temporally diagnostic artifacts are not patterned such that one can differentiate components in these scatters. Thus, the site will be considered in one group here.

	Ob1	Ob2	Volcanics	Chert	Quartzite	Total
Biface	4	6		1		11
Core	11	5		4		20
Flake	98	32	8	29	2	167
Retouched Flake	18	7		5		30
Hammerstone			1			1
Heat-shatter			1	2		3
Perforator Broken		1				1
Projectile Point	6 *(2c,unk)*			1		7
Kombewa Flakes	5	1		1		7
Bifacial Thinning	8	1		1		10
Total	190		10	42	2	244

Table 6-23. Lithic artifacts from site A03-910 excluding five Series 5 Ob1 projectile points.

The site contained a relatively high frequency of Kombewa flakes (also known as Janus flakes), a flake with bulbs of percussion on both ventral and dorsal surfaces that appears to have served as blanks for a Series 5 projectile point production. This is an artifact type that will be discussed in more detail in the discussion of the Q02-2u3 test unit at the Maymeja workshop in Chapter 7. Collpa contained a relatively high frequency of bifacial thinning flakes (n = 10) as per the calculated BTF index.

The material types in use at Collpa are consistent with the geographical position of this site as it lies half-way between the Maymeja zone of the Chivay source and Callalli. The Maymeja zone contains Ob1 obsidian, the eastern flanks of Hornillo contain Ob2 obsidian, and the area of Callalli in Block 3 contains abundant use of quartzite and chert that had often been heat treated. At Collpa [A03-910] a number of cores of both Ob1 and Ob2 chert were recovered.

	No.	μ Length	σ Length	μ Weight	σ Weight
Ob1	10	39.33	7.82	25.46	19.41
Ob2	5	34.26	13.67	15.98	19.72
Chert	4	36.55	2.18	19.55	7.60

Table 6-24. Complete Cores at Collpa [A03-910].

Reduction in the Collpa site shows that there was provisioning occurring from both Maymeja and the eastern flanks of Hornillo where Ob2 obsidian is found, as well as chert being used that perhaps came from the Callalli area where chert is abundant. Ob1 cores are clearly dominant at this site. Ob1 is more common, larger, and heavier despite the greater distance to the Maymeja area where this study shows that Ob1 obsidian is found. It is difficult to establish the antiquity of the Callalli ownership of Maymeja, but if movement between Callalli and Maymeja is a pattern that has a long history, then perhaps the greater presence of Ob1 obsidian reflects this larger mobility pattern.

A03-109 through A03-118 "Escalera" Area

A number of Middle Archaic points, as well as other Archaic points, were identified along the major travel route climbing up from the Chivay area of the Colca valley to the puna; hence the name "Quebrada Escalera". This was a route out of the Colca valley that was widely used until the 1940s when alternative roads were improved. These projectile points are essentially isolates although the A03-109, 110, 111 projectile points were found in a small cache adjacent to a large corral – possibly due to salvaging and aggregation by the pastoralists that use the large corral.


Figure 6-15. Photo of moraines and bofedales of Escalera south-west of Chivay source.

The region of Escalera contains extensive moraines interspersed with large bofedales due to the runoff from the glaciers of Nevado Huarancante. A major thoroughfare that bypasses the Chivay source to the south climbs through this valley following the moraines. This area contains varied habitat that probably offered relatively rich hunting throughout Archaic, as well as serving as a transition zone between valley and puna ecological zones.

Discussion

Distributions of diagnostic projectile points present the strongest surface evidence of Early, Middle, and Late Archaic activities at the Chivay source, and therefore inference about this period is strongly influenced by the production and discard of Series 1-4 point types in prehistory. Many of the obsidian projectiles found in the Block 1 survey and the Block 4 and 5 reconnaissance area had incomplete scar coverage, which is consistent with the reduction pattern one would expect near the source. The preferential use of Ob1 over Ob2 obsidian is evident from the core discard and the tendency to use Ob1 for projectile point production. The presence of Chivay obsidian at consumption sites, both locally and regionally, during the Early

Archaic suggest that the source area was accessible during this time, there is no evidence of the use of the Maymeja area until the Middle Archaic.

6.3.2. Block 2 – Archaic San Bartolomé

The Block 2 survey area parallels the edge of the Huarancante lava flow where geological features include the contact between the toe of a Pliocene lava flow and the open pampa. The pampa consists of ignimbrites weathering into a sandy soil and surface water in this area creates grassland with bofedales. Considering the study area on the whole, the greatest intensity of occupation during the pre-pastoralist Archaic appears to have taken place at San Bartolomé (Block 2). Sites in the area were surface collected in previous years by students from field classes at the Catholic University of Santa Maria in Arequipa (José-Antonio Chávez Chávez, Sept 2002, pers. comm.), but nevertheless a high density of projectile points was found in this area.

The evidence for long duration and diversity of activities comes primarily from the spatial distributions of projectile points and their material types. The San Bartolomé area was also an important zone during the subsequent pastoralist periods, due in large part to the rich bofedales mentioned above, that make differentiating pastoralist from Archaic Foragers (Early, Middle, and Late Archaic) occupations difficult. For foragers during the Archaic Period the area contains a rich mixture of reliable hunting opportunities and access to lower elevation vegetative resources in the Colca valley, two days travel away.

Projectile point distributions

Block 2 contained an abundance of projectile points diagnostic to the Archaic Foragers period. The wide variety of point types probably reflects the mobile strategies of Archaic foragers and the variable geology of the larger region.

Period	Point Type	Obsidian	Volcanics	Chalcedony	Chert	Quartzite
Archaic	3d	489	449, 1019		394	
E Arch	1a	355, 379, 380, 941, 1015, 1037, 1044.2	384	384		
	1b	398, 411, 493, 522, 945, 956.3, 1026.3	444,514, 956.2		469, 1034	
E-M Arch	2a	512, 949				
L Arch	3f	490	390, 480			
	4d		960, 963, 964, 1017, 1018, 1024.4, 1024.5, 1048, 1067			
Late Arch - T Arch	4f	407, 450, 463, 818, 943, 954, 1031	364, 1057	486		
M Arch	2c	517, 873, 953, 1016, 1023, 1035, 1036, 1044, 1062	822, 1021			
	3b	386, 820, 944	958, 1051		509, 942	951
	3e		519		395	
MH	4e	472				

Table 6-25. Diagnostic Projectile points Series 1-4 from Block 2 identifed by ArchID number.

Obsidian projectile points are extremely well represented in this area, but fine-grained volcanic material, primarily andesite, is also relatively abundant among the projectile point types except the Series 5 points. Chert and chalcedony points were present in Block 2, as well as chert knapping debris in low densities throughout the area, suggesting that chert nodules are available in relative proximity as well.

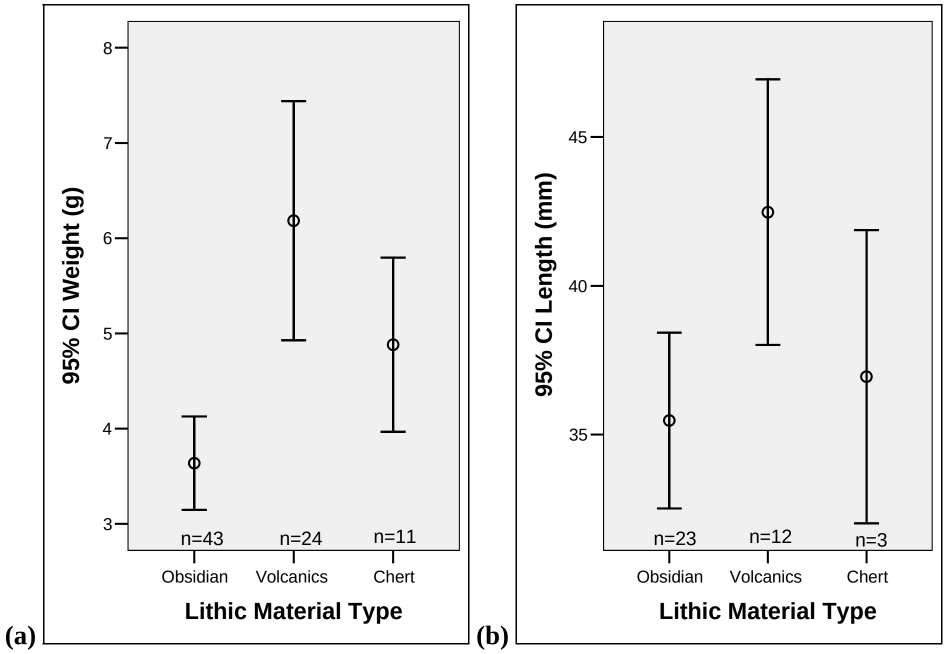


Figure 6-16. Projectile Point weights and lengths (when complete) by material type for Block 2. Series 5 points are excluded, chalcedony is included with chert, and quartzite is described separately.

Obsidian is well represented by count, but obsidian is typically smaller regardless of material type, even if the small, triangular Series 5 point types are excluded. An analysis of variance of material type showed that these differences between mean weights was extremely significant (F = 11.511, *p* > 05). Remarkably, even in this region, which is a day's travel from the Chivay source, obsidian appears to be used in the smaller size range of projectile points of the larger types.

Comparing the counts for weights and lengths in Figure 6-16 reveals that approximately one-half of the projectile points made from both obsidian and fine-grained volcanic materials are longitudinally snapped (and therefore no length measurement was taken). Thus, this difference in weights between obsidian and volcanics does not reflect differential breakage by obsidian points as it appears that the mean lengths of non-broken obsidian points are also roughly 8cm shorter than the mean lengths of fine-grained volcanic points. Other possible explanations for the smaller obsidian projectile points include the in-haft resharpening and other forms of recycling that would result in smaller sized obsidian points in the styles of larger types. The was evidence of resharpening noted on some projectile points, but a restudy would be required to examine resharpening evidence consistently in the collection.

Block 2 Archaic Foragers Settlement Pattern

Archaic Forager sites in the Block 2 portion of the survey fall into two major categories as indicated by the surface materials. One category of site consists of large sites that are sheltered in at least one sector of the site, and the other type of site appear as more diffuse scatters along the edge of the grassy plain that are largely intermingled with the pastoralist settlement pattern. These two kinds of sites will be discussed below, along with the characteristics of the artifacts found in each type of site.

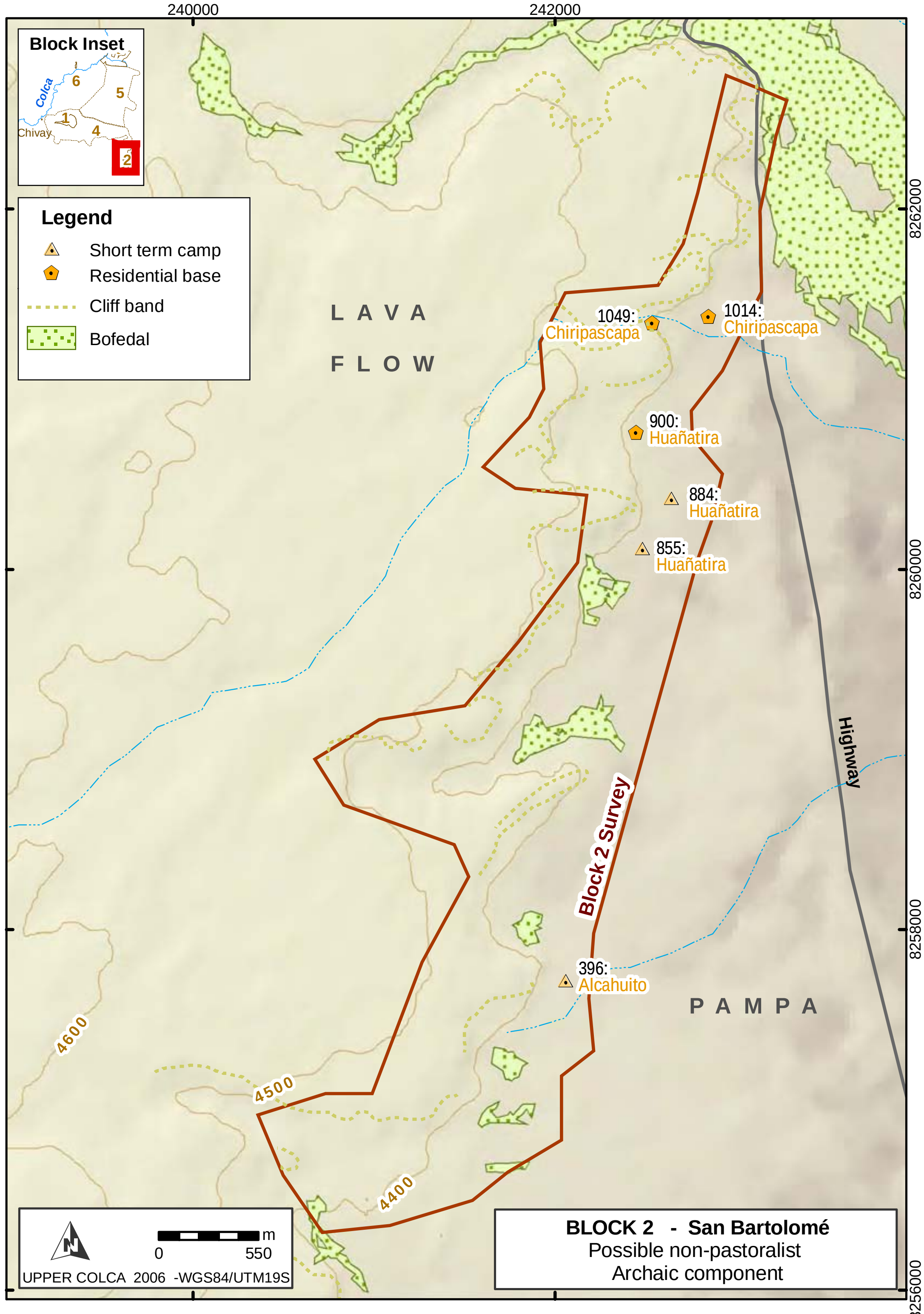


Figure 6-17. Archaic Forager sites in Block 2: Major sites described in the text.

Site Type: Residential Base

Archaic Forager period sites take two principal forms in this survey block. Residential bases, with what appears to be a great deal of redundancy of occupation, were encountered in a few locations with distinctive attributes (like shelter from wind). Projectile points styles diagnostic to Archaic Foragers time periods are encountered in a variety of contexts that include some areas near bofedales that were later intensely utilized by pastoralists, and some areas that show more spatially distributed occupational histories.

A03-1014 "Chiripascapa" [A03-1014 – A03-1057]

Chiripascapa was recorded as three sites due to variability in the artifact distributions and the differences in topography. Due to downslope movement in the steep talus zone in one portion of the site, and deflation in the lower site complex, the Archaic Foragers component of this site complex will be described as one group.

ArchID	SiteID	FileType	Description	Area (m^2)
1014	1014	Site_a	"Chiripascapa"	24,550,334
1023	1014	Lithic_a	Medium Dens, 100 Obs	38,785
1024	1014	Lithic_a	Medium Dens, 89 Obs	124,943
1025	1025	Site_a	"Chiripascapa2"	27,927,630
1026	1025	Lithic_a	High Dens, 100 Obs	2,470,331
1038	1025	Lithic_a	High Dens, 30 Obs	1,086,213
1041	1025	Ceram_a	Painted LIP	186
1043	1025	Lithic_a	Medium Dens, 100 Obs	9,484,728
1045	1025	Struct_a	Wall Bases Only, Cave	128
1052	1025	Lithic_a	Medium Dens, 100 Obs	888,906
1049	1049	Site_a	"Chiripascapa3", Rock shelter	3,657,074

Table 6-26. Loci in Chiripascapa

Description

The upper part of Chiripascapa consists of one medium sized rock shelter and three small rock shelters at the base of an east-north-east facing portion of the Huarancante volcanic breccia lava flow escarpment. Below the rock shelters a sloping talus field (a 25° slope), littered with lithics as well as ceramics, leads to a small intermittent stream 20 vertical meters below the rock shelter. On the banks of this stream is a scatter of lithics and ceramics from a variety of time periods that extend downstream for approximately 300 m. The south bank of the stream has a modern estancia (Pausa) and a large corral below the associated buildings, seriously disturbing any artifact scatters on the south bank. The north bank of the stream is also disturbed. Large scars from bulldozers scraped off the topsoil in certain areas. The resident at the Pausa estancia explained that during the 1970s highway improvement for the Majes Project the road crews caused these impacts as they were looking for gravel sources in that area. Just north of this site complex is a large, active gravel pit.

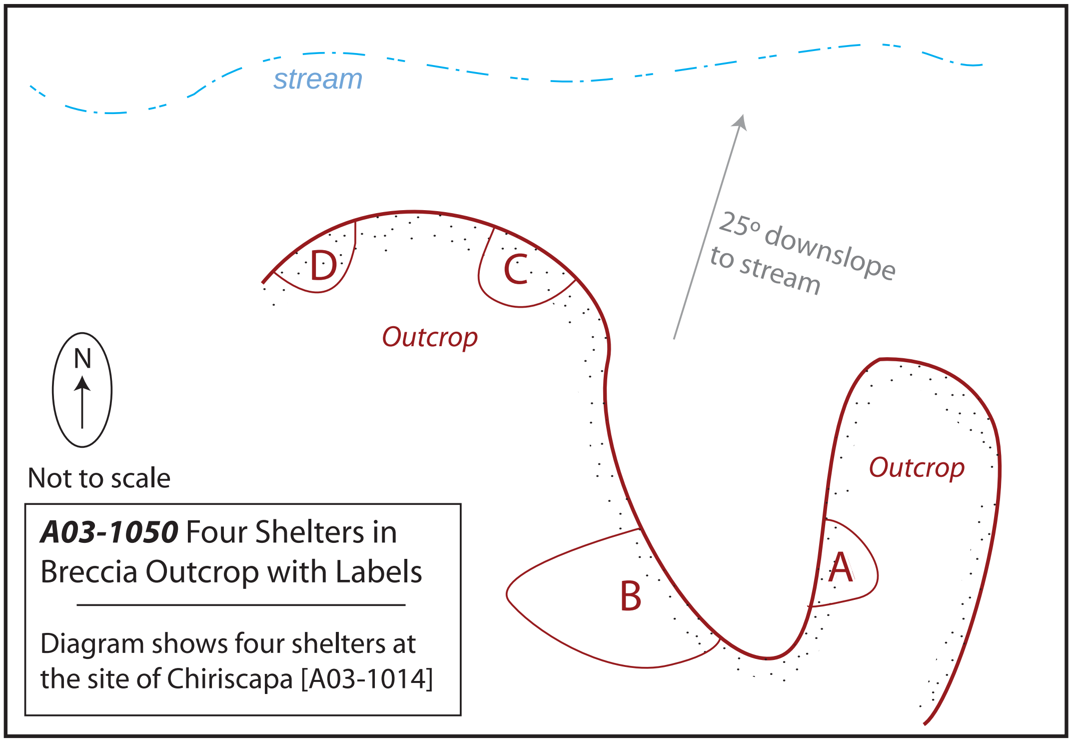


Figure 6-18. A03-1050 consists of four rock shelters: A, B, C, and D.

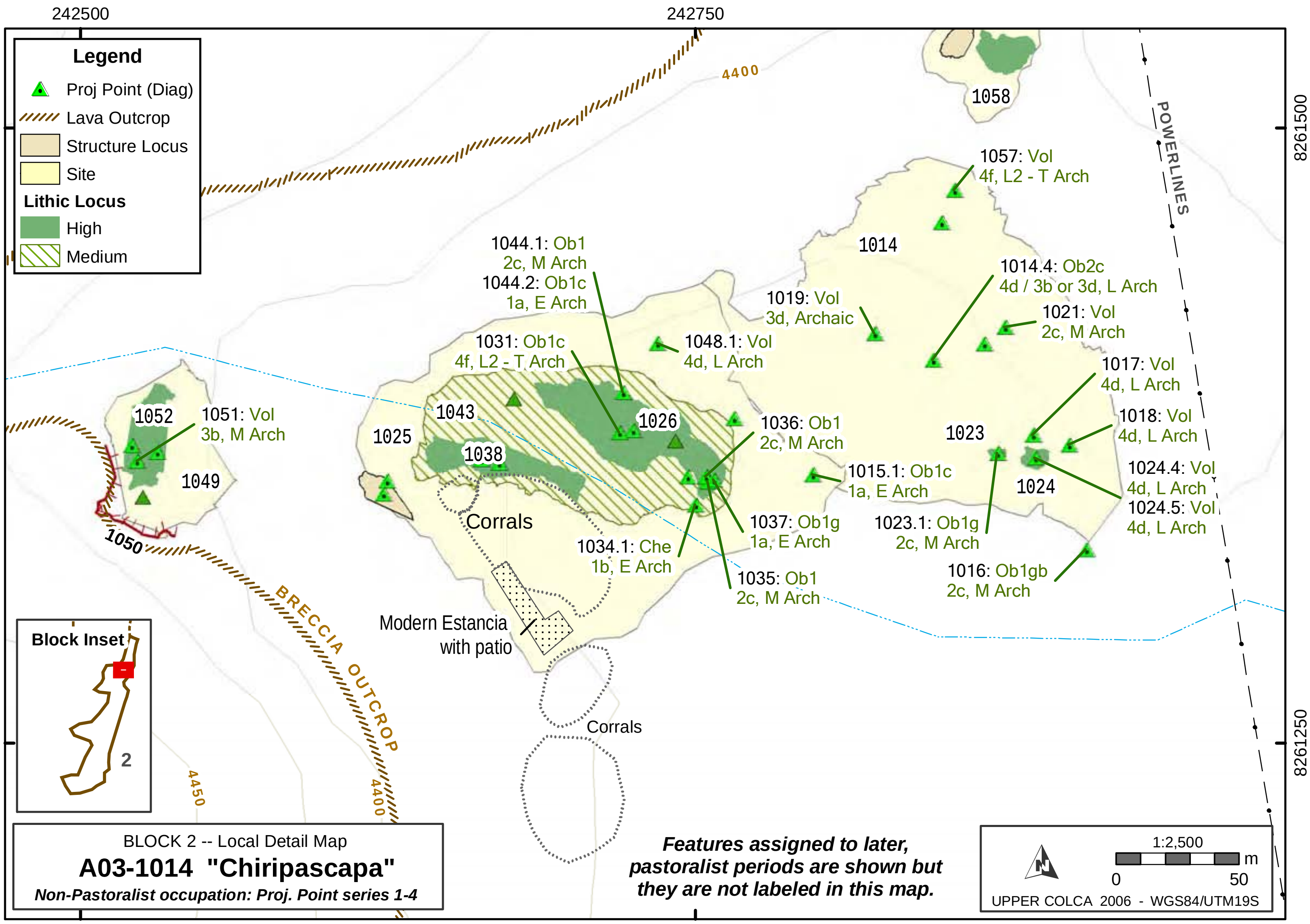


Figure 6-19. Chiripascapa [A03-1014], Archaic Foragers occupation.

A03-1050 – Four rock shelters of Chiripascapa

These rock shelters appear to be well situated with respect to the surrounding geography. The shelters face east-north-east and so despite being in a dark and slightly damp corner of the lava toe they catch the morning and midday sun. It is worth noting that the *estancia* depicted in the center of the map appears to be deliberately built with the same aspect. The rock shelter is relatively well-hidden because it lies about 50m up a side quebrada and therefore goes unnoticed unless you climb the quebrada. Despite the concealed position, this location actually offers a partial view of the most important resource in the zone: the bofedal one km to the north-east. It would also be possible to monitor travel through the Ventanas del Colca access to the upper Colca from this hidden location. The stream below the shelters was dry at the end of the dry season, but probably flows most of the year.

Due to low GPS reception in the rock shelter area the four rock shelters were mapped as a single Struct-L line "A03-1050" and differentiated as A, B, C, and D. Only one shelter, the one designated as A03-1050B, had the characteristics of a residential shelter. The dimensions of this shelter are as follows. *Height:* 2m, *Depth:* 6.5m, *Width:* 7m. Due to the overhanging roof formed from the lava flow, a considerable area is dry outside of the walls of the cave. This area shows signs of having been improved as a patio and the "patio" area extends the depth of the dry zone by another 12.5m. The rock shelter 1050A was large but wet, and 1050C and 1050D were very small but dry.

Below the rock shelters a talus slope extends approximately 20 vertical meters to the stream. A variety of lithics and ceramics were identified on this slope, though only one projectile point was diagnostic to a period that falls in the Archaic Foragers timespan. This point [A03-1051] was a Middle Archaic andesite point and it had a transverse snap and missing its haft element, suggesting that it was broken in use.

Features and Artifacts

The stream enters the open, sandy soils of the pampa and on either bank of the stream, though primarily on the north bank, projectile points from throughout the Archaic sequence were found. Preservation is relatively poor on this section of the pampa. In addition to the bulldozer impacts mentioned above, the soils appear deflated and this partly explains the high density of projectile points, from virtually every time period, found in this area. It seems possible that the entire site scatter was formerly more aggregated on the western part of this map, and with riverine transport the artifacts have been scattered over the pampa.

ArchID	Artif. #	Material	Form	Type	Temporal
1015	1	Obsidian	Proj Point Broken	1a	Early Archaic
1016	1	Obsidian	Proj Point	2c	Middle Archaic
1017	1	Volcanics	Proj Point Broken	4d	Late Archaic
1018	1	Volcanics	Proj Point	4d	Late Archaic
1019	1	Volcanics	Proj Point	3d	Archaic
1021	1	Volcanics	Proj Point Broken	2c	Middle Archaic
1023	1	Obsidian	Proj Point	2c	Middle Archaic
1024	4	Volcanics	Proj Point	4d	Late Archaic
1024	5	Volcanics	Proj Point Broken	4d	Late Archaic
1026	3	Obsidian	Proj Point	1b	Early Archaic
1031	1	Obsidian	Proj Point	4f	Late–Term. Archaic
1034	1	Chert	Proj Point	1b	Early Archaic
1035	1	Obsidian	Preform	2c	Middle Archaic
1036	1	Obsidian	Preform	2c	Middle Archaic
1037	1	Obsidian	Proj Point	1a	Early Archaic
1044	1	Obsidian	Preform	2c	Middle Archaic
1044	2	Obsidian	Proj Point	1a	Early Archaic
1048	1	Volcanics	Proj Point	4d	Late Archaic
1051	1	Volcanics	Proj Point Broken	3b	Middle Archaic
1057	1	Volcanics	Proj Point Broken	4f	Late–Term. Archaic

Table 6-27. Diagnostic Series 1 through 4 projectile points from Chiripascapa [A03-1014].

The temporal distribution of projectile points from Chiripascapa shows that virtually every time period is well represented. One distinction worth noting is that obsidian is used almost exclusively in the later time period, while about 50% of the projectile points (by count) are made from obsidian in the early time periods presented by Series 1 – 4 points.

Projectile Points	Obsidian	Volcanics	Chalcedony	Chert
Series 1 – 4	10 (48%)	9 (43%)	1 (5%)	1 (5%)
Series 5	24 (96%)	1 (4%)	0	0
Total	34	10	1	1

Table 6-28. Representative proportions of material types by projectile point styles.

The medium and high density lithic loci along the creek banks are difficult to temporally isolate because there are later period diagnostics, including twenty-six

Series 5 projectile points and ceramics dating from the Middle Horizon, LIP, and Inka periods found in the A03-1038 lithic locus. Most of the flakes observed at this site were obsidian and chert. A small concentration of andesite flakes on the south bank of the stream in locus A03-1038 was observed, despite the fact that all andesite projectile points came from the north bank of the stream.

Material Type	Obsidian	Volcanics	Chalcedony	Chert	Quartzite
No.	88 (62%)	32 (23%)	5 (4%)	15 (11%)	1 (0.7%)
Mean Wt (g)	5.05	18.28	16.7	10.91	11.5
% by Sum Wt	34.5%	45.6%	6.7%	12.3%	0.9%

Table 6-29. All lithic artifacts from Chiripascapa.

The surface materials included bifaces, cores, and flakes of all local material types except quartzite, which was rare at the site. Based on the mean flake size and the percentage of the total contribution by weight, fine-grained volcanics appear the most local to the area. Isolating any one of the lithic concentrations to a particular time period is difficult, but when viewed collectively including the point scatters in A03-1014 and A03-1025, and the rock shelters in A03-1049, the site complex is one of the oldest residential areas in the larger study area. The rock shelter A03-1050B and the built up patio has a high probability of containing a stratified intact deposit that extends into the earlier parts of the Archaic.

A03-900 "Huañatira"

Huañatira is a horseshoe-shaped valley with escarpments of lava flows of volcanic breccia on three sides and a small rise in the center where a single toe of lava extends down lower towards the pampa. The result is a sheltered, circular valley with a sloping ramp that climbs towards the top of the lava flow to the east of the valley. The Huañatira valley provides a moderately sheltered area with good views of the surrounding pampa, and it is defensive because it provides means of escaping to the higher lava flow terrain without being observed by pedestrians approaching from the pampa.

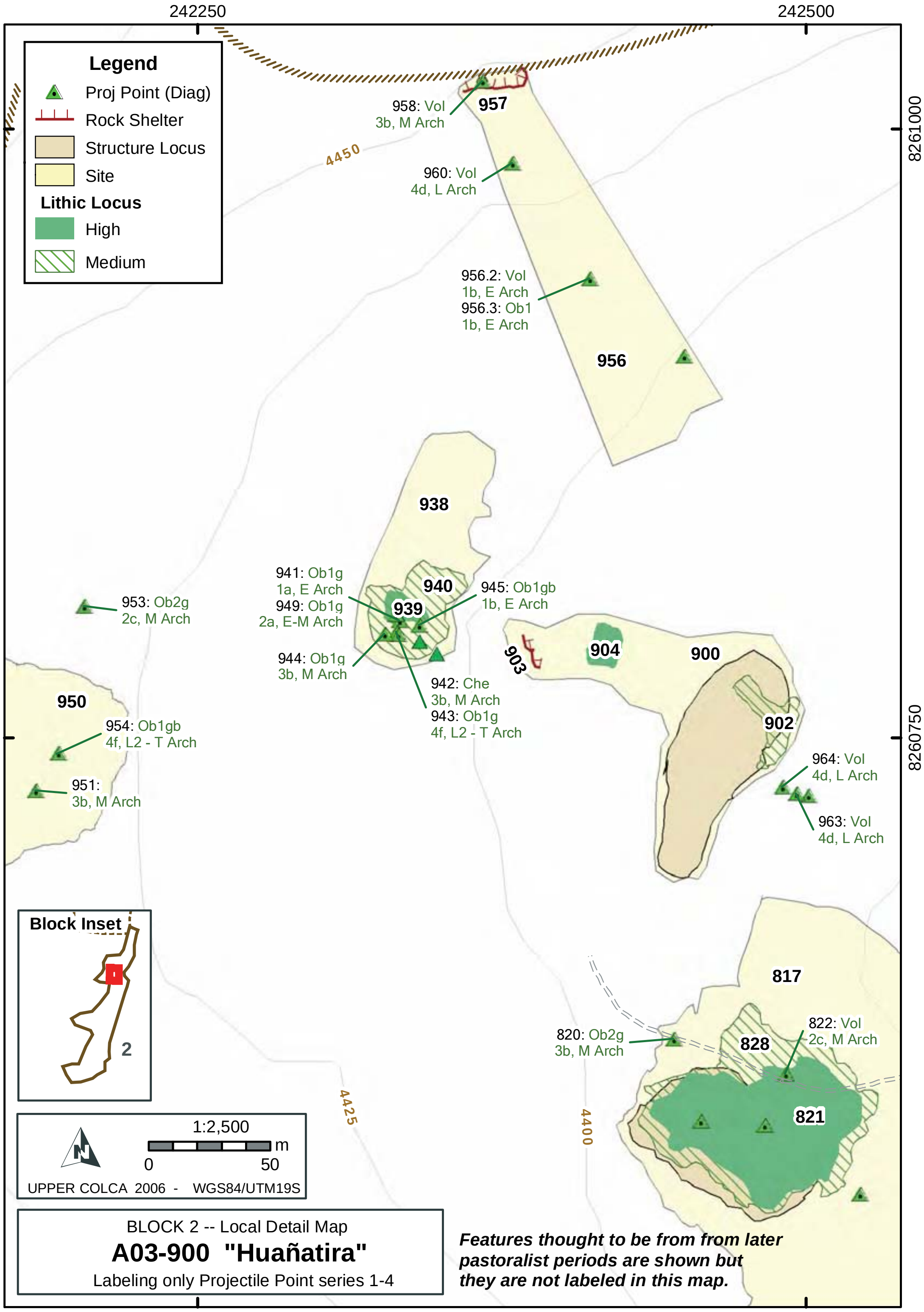


Figure 6-20. Huañatira [A03-900] and vicinity, Archaic Foragers occupation.

Description

The area has evidence of occupation from virtually every time period from the Early Archaic to the modern period. A maintained estancia is found just to the west of the study area shown in Figure 6-20, and a small driveway is shown on the map accessing the area from the east. A worn trail departs the estancia to the west; a travel route that probably dates to the pastoral period if not earlier. Projectile points were found scattered around the valley that date to all periods, however most of the large scale archaeological features in this area appear to be from the pastoralist period. The circular or oval features shown as structural loci (not labeled on Figure 6-20) are most likely of pastoralist origin. A rock shelter offering partial protection was found in the center of site 900 overlooking the pampa [A03-903]. This immediate valley area belongs to a very small local watershed, and during the dry season there was no apparent surface water. This small watershed prevented a great deal of surface runoff; a factor has probably helped to maintain artifact positions in their original contexts in this local valley more than at other sites from the survey.

ArchID	File Type
817	site_a
820	site_p
821	lithic_a
822	site_p
823	site_p
824	site_p
825	site_p
826	site_p
827	site_p
828	lithic_a
830	struct_p
831	site_p
900	site_a
902	lithic_a
903	struct_l
904	lithic_a
905	lithic_p
906	site_p
907	site_p
938	site_a
939	lithic_a

ArchID *(cont.)*	File Type
940	lithic_a
941	lithic_p
942	lithic_p
943	lithic_p
944	lithic_p
945	lithic_p
946	lithic_p
947	lithic_p
948	site_p
949	lithic_p
951	lithic_p
953	lithic_p
954	lithic_p
956	site_a
957	struct_l
958	struct_a
960	lithic_p
961	lithic_p
962	lithic_p
963	lithic_p
964	lithic_p

Table 6-30. Non-consecutive ArchID numbers at Huañatira [A03-900], an Archaic Foragers site.

A03-957 – Rock shelter

This is a relatively large rock shelter overlooking the pampa and the valley of Huañatira. Contrary to most residential rock shelters in the region, this shelter faces south-east and it is therefore not exposed to the warming sun and was probably a shelter that was cool in temperature nearly all year reducing its potential as a residential structure in the altiplano. The shelter offers a relatively large amount of residential space inside the dripline; the rock shelter is 7m deep from the dripline, 12m wide, and over 3m high. Virtually all of the interior space of the shelter is clear of rubble and useable for residential activities. Four projectile points from the Early, Middle, and Late Archaic Periods were found associated with this shelter. A recessed tomb dominates this shelter today, but given the size of the feature and the pattern of cave burial during the Late Intermediate Period, the mortuary feature in this shelter is interpreted as a LIP cist tomb. These features are described in the Late Prehispanic – Block 2 discussion (Figure 6-76), close to the end of this chapter.

Figure 6-21. Rock shelter of Huañatira with circular mortuary feature visible inside. One meter scale showing on tape resting on rock along dripline (see also Figure 6-76).

Features and Artifacts

Some cases of disturbed artifact provenience are obvious, such as the three projectile points in a wash at the base of the valley shown as the three points on the eastern edge of Figure 6-20. Also the points below the Huañatira rock shelter on the north end of this site were found in the colluvial zone below the shelter and were apparently displaced.

ArchID	Index#	Material	Form	Type	Temporal
820	1	Obsidian	Proj Point	3b	Middle Archaic
822	1	Volcanics	Proj Point	2c	Middle Archaic
941	1	Obsidian	Proj Point	1a	Early Archaic
942	1	Chert	Proj Point Broken	3b	Middle Archaic
943	1	Obsidian	Proj Point	4f	Late - Terminal Archaic
944	1	Obsidian	Proj Point	3b	Middle Archaic
945	1	Obsidian	Proj Point	1b	Early Archaic
949	1	Obsidian	Proj Point	2a	Early-Middle Archaic
951	1	Quartzite	Proj Point	3b	Middle Archaic
953	1	Obsidian	Proj Point	2c	Middle Archaic
954	1	Obsidian	Proj Point	4f	Late - Terminal Archaic
956	2	Volcanics	Proj Point Broken	1b	Early Archaic
956	3	Obsidian	Proj Point Broken	1b	Early Archaic
958	1	Volcanics	Proj Point Broken	3b	Middle Archaic
960	1	Volcanics	Proj Point	4d	Late Archaic
963	1	Volcanics	Proj Point Broken	4d	Late Archaic
964	1	Volcanics	Proj Point	4d	Late Archaic

Table 6-31. Diagnostic Series 1 through 4 projectile points from Huañatira [A03-900].

Artifact proportions are consistent with other Archaic Foragers sites in the area, with approximately 50 of the projectile points and 65 of all collected lithic artifacts being of obsidian. A number of bifaces and flakes were found at this site, primarily of fine-grained volcanic stone and obsidian, and one obsidian core.

Material Type	Obsidian	Volcanics	Chalcedony	Chert	Quartzite
No.	50 (64%)	14 (18%)	3 (4%)	9 (12%)	2 (3%)
Mean Wt (g)	4.97	99.8	31.4	49.5	111.1
% by Sum Wt	10.4%	57.8%	4.2%	17.6%	9.9%

Table 6-32. All lithic artifacts from Huañatira.

As with other residential areas in Block 2, it is difficult to differentiate the Archaic Foragers component in this area of heavy reoccupation. The area contains a large rock shelter and it provides a measure of shelter on the border of the pampa, as do the other shelters in the area. Several Late Archaic projectile points are dark fine-grained volcanic rock, akin to the Late Archaic (4d) points found at that Chiripascapa [a03-1014] a short distance to the north.

Site Type: Sites with majority non-obsidian lithics

A substantial Archaic presence in Block 2 takes the form of diffused, low density scatters with associated diagnostic projectile points along the edge of the pampa and frequently close to water sources. These finds are very difficult to differentiate from the pastoralist site occupation pattern and therefore these features will be described as a group, followed by generalizations about the characteristics of the environmental and cultural features of sites of this type in Block 2.

While the Archaic Foragers use of space largely overlaps with pastoralist occupation areas in Block 2, the use of lithics appears to differentiate the two. As was discussed in Chapter 3 (Section 3.4.4), the use of obsidian for projectile points expands dramatically at the end of the Archaic Foragers period both near the Chivay source and in the consumption zone.

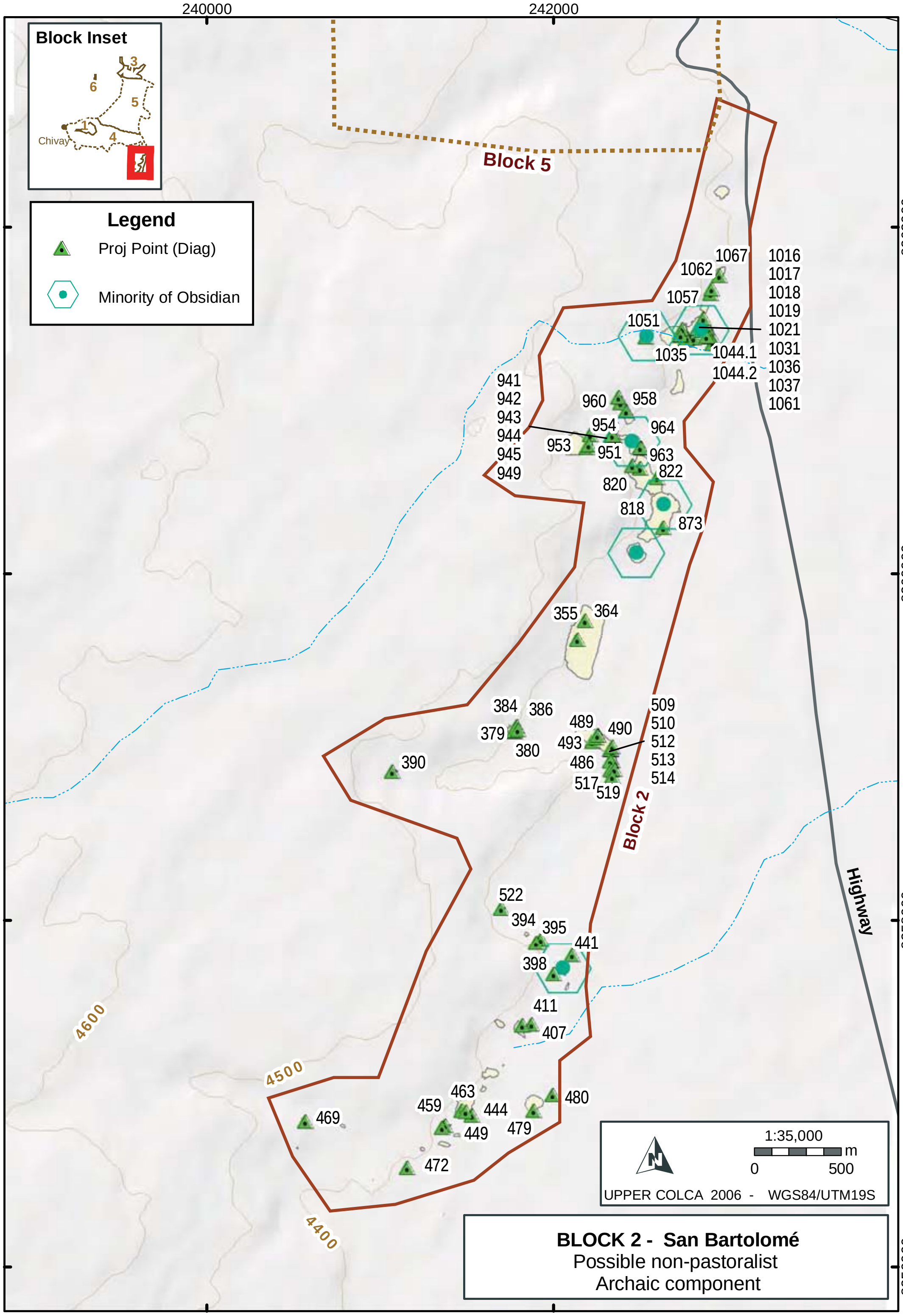


Figure 6-22. Block 2 Archaic Foragers component from lithic evidence.

Method

The criteria used here for sites isolating through the dominance of particular material types are as follows for both lab analysis Lithics_I and Lithics_II. First, the lab results by SiteID (or isolated ArchID), showing count and percent, were shown in a table against material type in Arcmap. This table was joined to the All_ArchID_Centroids point geometry [link to Processing in Ch 5] so that lab results for lithic material types were aggregated by site or isolate. These features were then filtered by constructing a query where the artifact count for a geographical feature had to be greater than 5 so that relative percentages were meaningful. Finally, the index symbolized in Figure 6-22 is the Lithics_I lab results (the most comprehensive table) where Percentage of Non-obsidian lithic artifacts is greater than or equal to 50%.

Results

The use of non-obsidian materials such as chert, chalcedony, and especially fine-grained volcanic materials, dropped precipitously during the Terminal Archaic at sites in Block 2. While all lithic material types persist in use during the pastoral period, the herd management tasks of butchery and shearing appear to have been largely conducted using obsidian. Reviewing the percentages of sites with strong evidence of a pastoralist occupation (only Series 5 projectile points, a corral, water, and grazing opportunies) these sites commonly have between 20% - 40% non-obsidian flaked stone. Thus, the distinction between pastoralist and forager components based on material type is not firm, but the distributional pattern is reinforced by non-series 5 projectile point distributions, and this evidence is shown together in Figure 6-22.

Six sites have been identified with a relatively robust Archaic Foragers component in Block 2 and the environmental characteristics of these six sites will be compared with all locational characteristics of B2 sites in order to look for patterning among the environmental criteria of Archaic Foragers sites. These six sites include the following A03- 396, 884, 894, 900, 1014, 1049 and while diagnostics from the Archaic Foragers period were widely encountered throughout the region, these sites are selected as representantive for the larger Archaic Foragers time period and life way based on inference. Clearly the boundaries of the "site" are probably not coterminous with the Archaic Foragers component of these sites, nevertheless these measures serve as a general indicator of changes in the environment context of settlement through time.

	Selected μ	Selected σ	All B2 Sites μ	All B2 Sites σ	All B2 Sites μ - Select μ
Altitude (masl)	4382.6	12.69	4393.2	25.7	-10.6
Slope (degrees)	7.86	8	8.33	6.34	-0.47
Aspect (degrees)	146.5	96.4	138.4	58.23	8.1
Visibility/Exposure	33.6	13.1	40.1	25.53	-6.5
Dist. to Bofedal (m)	497.3	212.2	307.5	261.5	189.8

Table 6-33. Environmental characteristics of selected Archaic Foragers sites in Block 2.

The high standard deviation values in the Table 6-33 "Selected sites" underscores the variability and inconsistency in these estimates. This comparison shows that the Archaic Foragers sites tend to be more sheltered/lower visibility than the pastoralist sites. As was previously noted, the Archaic Foragers sites are often adjacent to overlooks but the sites often do not occupy the high exposure area specifically. Archaic Foragers sites are considerably further than average from bofedales. This strong tendency in the data is probably accentuated by the intensification and maintenance of pastoral resources that has occurred in recent years. That is to say, as pastoralism is today the principal economy activity in the area, bofedales and attendant pastoral facilities have been well-maintained in the recent past, which is the criteria from which bofedales were selected from the ASTER satellite imagery for this measure. A further issue with respect to distance to water is the fact that many of the potential forager sites are adjacent to small streams that were probably seasonal and appear as dry in the modern dry-season ASTER imagery.

Discussion

Block 2 survey area represents a transition from the rugged lava flow topography on the west side of the block to the open pampa on the east side of the block. In addition, residents in the Block 2 area are able to exploit the higher density off resources in the puna while maintaining access and, perhaps, social relationships with residents in the adjacent lower altitude portions of the Colca valley.

A number of obsidian projectile points in this area were produced in the same general forms as chert points and, particularly, as fine-grained volcanic points. These forms are most akin to those documented at Sumbay, 30 km to the south. Given the greater local variability in point forms during the Late Archaic (Klink and Aldenderfer 2005: 53), the data from the Block 2 area provides an opportunity to study the local projectile point styles, best known from the Sumbay style points, in conjunction with the regional interaction documented through obsidian distribution data.

6.3.3. Block 3 – Archaic Callalli and adjacent valley bottom areas

The 2003 field season evidence shows that the Archaic Foragers period use of the river valley and adjacent puna appears to have been relatively light in comparison with the occupation in the B2 – San Bartolomé area. Diagnostic projectile points and aceramic sites represent the only strong evidence of Archaic Period occupation in Block 3 since only test excavations in B3, at the site of Taukamayo [A03-678], were dated to the early part of the Middle Horizon.

Projectile point distributions

The strongest evidence of human activity during the Archaic in the Upper Colca valley segment of the survey comes from projectile point distributions.

Period	Point Type	Obsidian	Volcanics	Chalcedony	Chert
Archaic	3d	599, 1080		25	10, 670, 810
E-M Arch	2a	1078			599.4
	3a	1001	34		
M Arch	2c			790.3	
	3b	1007			810.2
Latter part of M Arch	2b	1002			
L Arch	3f	1099			
	4d	86	85, 1008	94	38
L2 - T Arch	4f	93, 809			

Table 6-34. Diagnostic Projectile points Series 1-4 from Blocks 3, 6 and the valley portion of Block 5 identifed by ArchID number.

Projectile point counts shown in Table 6-34 include the Upper Valley areas of Block 3 and Block 6, and the counts also include projectile points from Kakapunku [a03-1000] that lay in the valley bottom segment of Block 5 on the perimeter of Block 3. The Upper Colca valley segment of the survey had relatively low numbers of Early, Middle, and Late Archaic Period occupation evidence as compared with other segments of the survey. As is evident from projectile point counts, only 26 of the 56 projectile points (46%) from this Upper Valley derive from the Archaic Foragers period, a 5700 year long time period.

Obsidian projectile points are well-represented throughout prehistory, although over half are Series 5 points from the Terminal Archaic and onwards. It is notable that obsidian is so well-represented in finished projectile point material types because evidence of production or maintenance in the form of obsidian flaking debris is far less common than chert in this area. Chert is found in the riverbeds in Block 3 and therefore it is the predominant local material. However, among projectile points in Block 3 obsidian predominates in all point styles except type 3D where obsidian is a close second. By count, obsidian is most frequent, but by weight obsidian points are smaller even if Series 5 point types are excluded.

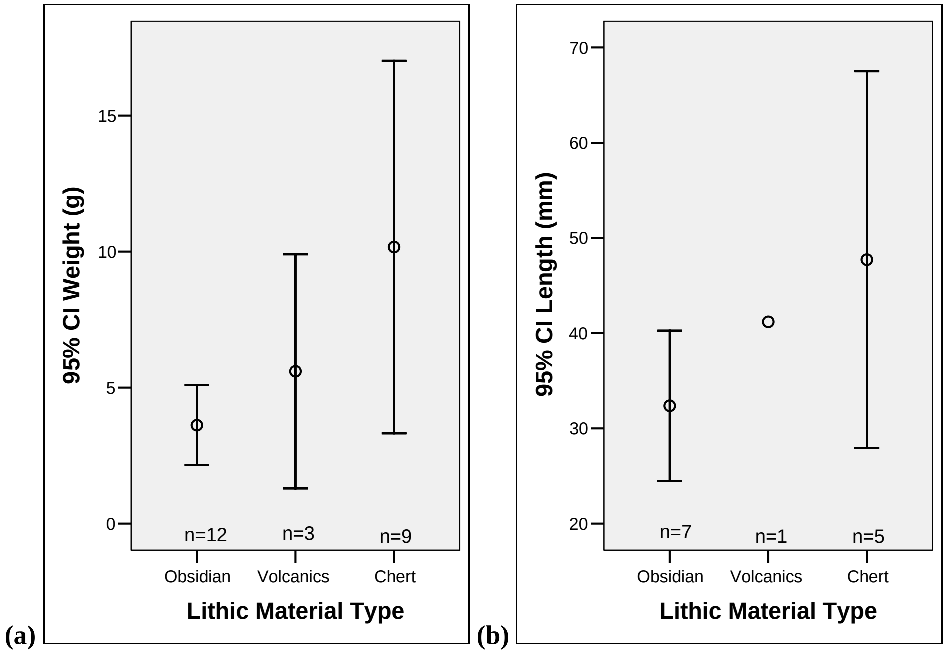


Figure 6-23. Projectile Point weights and lengths (when complete) by material type for Block 3, Block 6 and adjacent valley areas of Block 5. Series 5 points are excluded and chalcedony is included with chert.

The projectile points made from the immediately-available chert material type are larger than points of either obsidian or fine-grained volcanics (andesite). The difference in mean weights was assessed using the Kruskal-Wallis non-parametric test because the distributions were not normally distributed. The Kruskal-Wallis test showed that the observed difference in means between the three groups is significant (χ^2 = 8.235, .01 > p > .05).

Block 3 Archaic Foragers Archaic Settlement Pattern

Archaic Foragers sites in the B3 portion of the survey can be grouped into three categories of sites. For Archaic sites these categories generally correspond with socio-economic activity and lithic provisioning, as indicated by lithics observed during fieldwork and representative grab samples collected from the surface. The three categories of sites include: (1) large, sheltered base camps; (2) small logistical camps, and (3) chert provisioning and initial reduction locations along river banks. These three groups will be discussed, along with the specific characteristics of major sites in each group, and subsequently the isolated or uncategorized sites will be described.

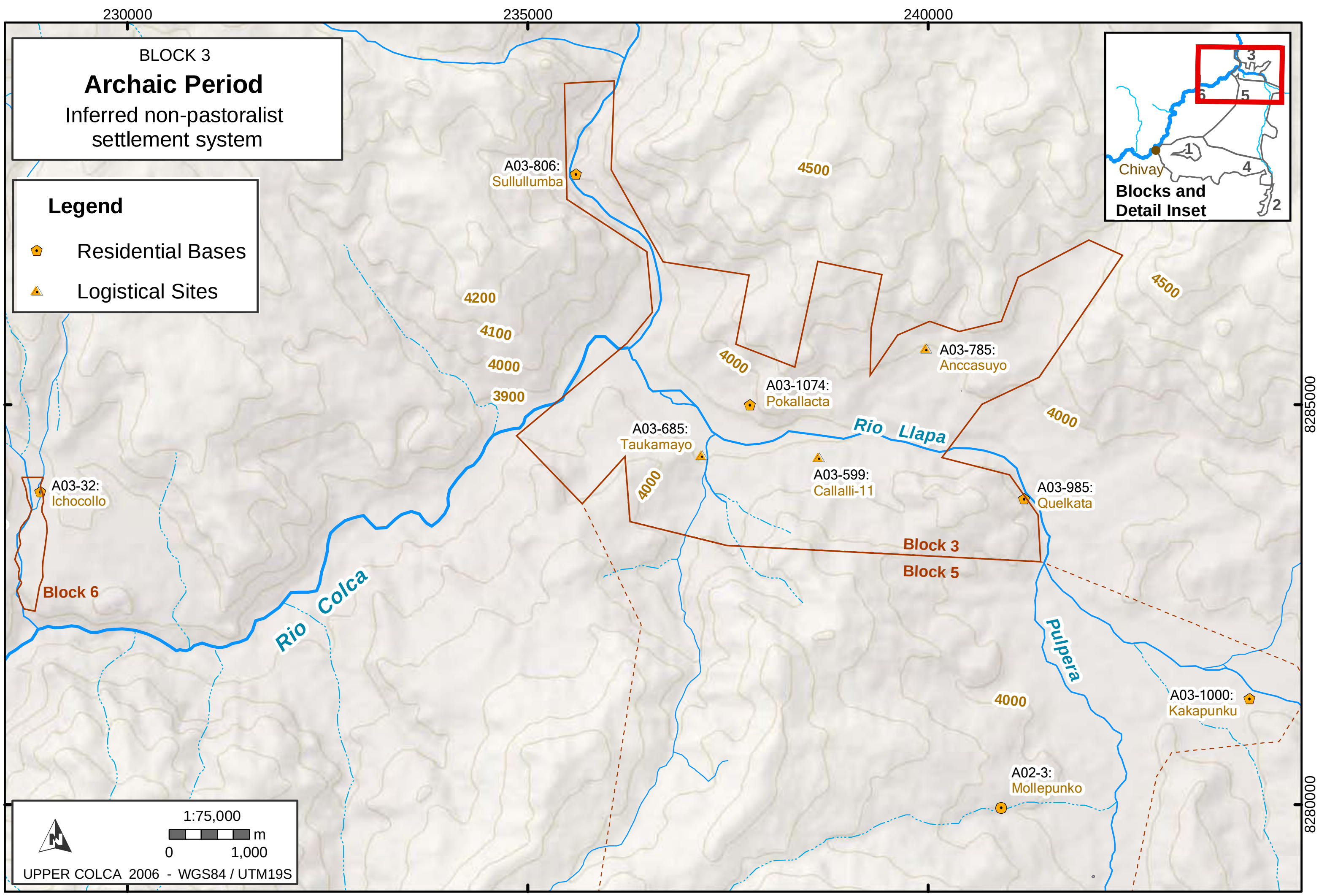


Figure 6-24. Archaic Period in Blocks 3, 6 and 5 (valley): Sites described in the text.

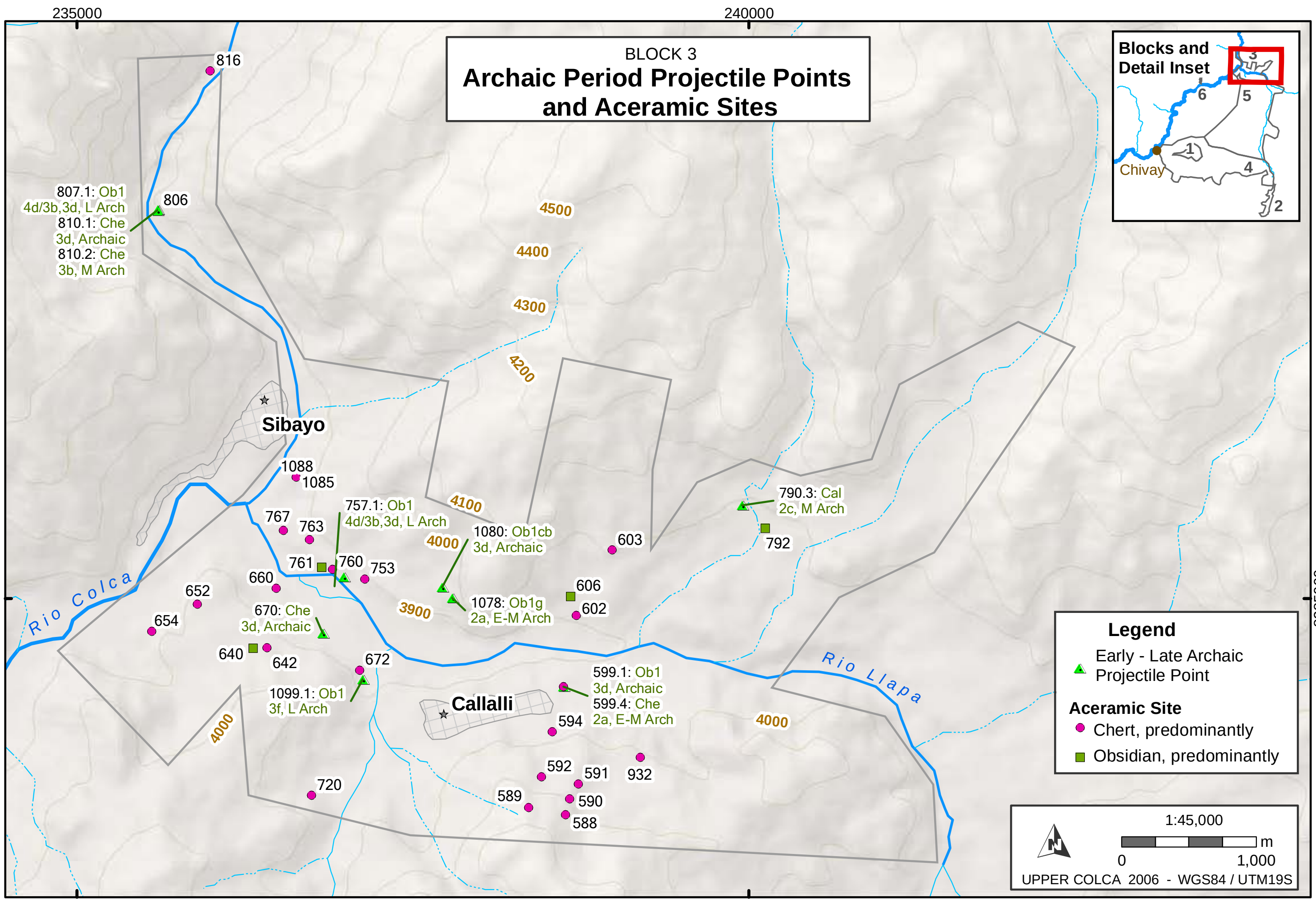


Figure 6-25. Block 3: Early, Middle, and Late Archaic projectile points and Aceramic sites.

A number of aceramic sites were difficult to differentiate from ceramic period sites and thus an comprehensive map, showing all of the potentially pre-pastoral sites, is depicted in Figure 6-25. Inclusively, this group includes most aceramic sites and locations with projectile points diagnostic to the Early, Middle, or Late Archaic Periods.

Site Type: Sheltered base camp

A03-1000 "Kakapunku" [A03-1000 – A03-1013]

The site of Kakapunku [A03-1000] (a.k.a. C'oponeta) is located on the south side of the Río Llapa on a north facing bluff just upstream of the confluence of the Río Llapa and the Río Pulpera. This site consists of three rock shelters spaced about 15m apart along the base of a 10m high irregular cliff band that lies approximately 30m up the hill and south of the high-water line on the Río Llapa. There is a colluvial ramp below the rock shelters and on a terrace below that ramp lie number of lithic loci and some ceramics. The rock shelters are generally north facing so that they are oriented to the mid-day sun and the shelters are warm and well-lit.

ArchID	SiteID	FileType	Description	Area (m²)
1000	1000	Site_a	"Kakapunku"	3400.0
1004	1000	Lithic_a	High Dens, ~70 Obs	1771.3
1010	1000	Lithic_a	High Dens, ~70 Obs	76.7
1013	1000	Lithic_a	Medium Dens, ~70 Obs	148.6

Table 6-35. Loci in Kakapunku [A03-1000].

ArchID	Description	Height	Depth	Width	Width Entrance
A03-1001	Mortuary, looted. MNI=7	1.6	3.2	5.2	1.9
A03-1002	Domestic, warm rock shelter	4	3.5	6	5.1
A03-1003	Mortuary, looted. MNI=14	1.6	~8	1.4	1

Table 6-36. Rock shelters at Kakapunku [A3-1000], dimensions in meters.

Figure 6-26. Site of Kakapunku [A03-1000].

A03-1001 –East rock shelter at Kakapunku

This is a looted mortuary context. The rock shelter is moderately difficult to access on a cliff face, and the entrance appears to have been formerly walled off. The original rock shelter height is difficult to determine because cist tombs in the floor of rock shelter have been excavated by looters. A number of complete crania and long-bones were present. The crania and long bones were examined in the field by Mirza del Castillo, a team member who is a physical anthropologist. From her in-field visual assessment she cautiously suggests that a number of the crania had female metric proportions, and that a number of the crania appeared to have hypoplasia of the bone marrow on the posterior edge of the parietal bones which is a possible indicator of anemia.

Figure 6-27. The entrance of A03-1001 with looted cist tomb visible inside the rock shelter.

A03-1002 - Center rock shelter at Kakapunku

This rock shelter is relatively shallow but other characteristics made it appear to be to be an inviting residential location for a small group of foragers or pastoralists. The shelter is dry inside the dripline, north facing, flat interior, defensible, a short distance from water, and immediately south of a terrace for open-air activities where loci a03-1004 through 1013 are located.

A03-1003 - West rock shelter at Kakapunku

This rock shelter is a lava tube sloping upwards into the cliff face. It appears to contain many disturbed interments. Undisturbed human remains perhaps exist here but they were not visible on the surface.

Discussion

Kakapunku is another case of a multicomponent site where discerning the Archaic component is difficult. Five projectile points were identified belonging to different Archaic Periods, and combined with the ceramics (described later), there is a some affiliation with virtually all time periods at this site.

ArchID	Index	Material Type	Form	Type	Temporal
1001	1	Obsidian	Proj Point	3a	Early-Middle Archaic
1002	1	Obsidian	Proj Point	2b	Latter part of Middle Archaic
1004	1	Obsidian	Biface	n/a	
1004	2	Obsidian	Biface	n/a	
1004	3	Obsidian	Proj Point Broken	5	Late
1005	1	Volcanics	Core	n/a	
1007	1	Obsidian	Proj Point	3b	Middle Archaic
1008	1	Volcanics	Proj Point	4d	Late Archaic
1009	1	Obsidian	Preform	5a	Late
1010	1	Obsidian	Proj Point Broken	5d	Late

Table 6-37. Selected Lithics from Kakapunku [A03-1000].

On the terrace below the rock shelter [A03-1002] the largest concentration of artifacts were noted. Samples collected from the medium and high density lithic loci on the terrace are approximately 50% obsidian materials with the non-obsidian primarily consisting of aphanitic volcanic stone. The northern high density locus, A03-1010, is eroding down the cutbank caused by erosion and it is possible that this terrace was significantly larger but has been truncated by fluvial erosion of the terrace. In sum, Kakapunku appears to have served as a regular residential area with three relatively small rock shelters.

A03-985 "Quelkata"

This rock shelter lies just below the confluence of the Río Llapa and Río Pulpera along a sweeping bend in the river channel where the Río Llapa first approaches the Castillo de Callalli formation. This rock shelter is well situated and probably served as a residential base through most of prehistory, however surface collections by Jose-Antonio Chávez Chávez (1978) for his Bachelor's thesis revealed primarily preceramic occupation levels with late, Series 5 projectile points. By the time Chavez was able to systematically investigate the materials in the rock shelter it had been largely destroyed in 1976 by the road construction crews associated with the Majes Project (J. A. Chávez 1978: 3). The rock shelter was dynamited because it is unfortunately located precisely at a point of the Río Llapa where the project planned to build a bridge on the road to the Condoroma reservoir. What remains today of the rock shelter is a concavity in the tuff with a shelter dry zone measuring approximately 150m wide inside the dripline. Chávez systematically collected and analyzed projectile points from this rock shelter but, curiously, the artifactual evidence available shows an occupation sequence going only as far back as the Terminal Archaic.

Figure 6-28. Cueva de Quelkata was dynamited by Majes Project road crews in 1976. Two people are visible for scale inside the shelter to the left of center.

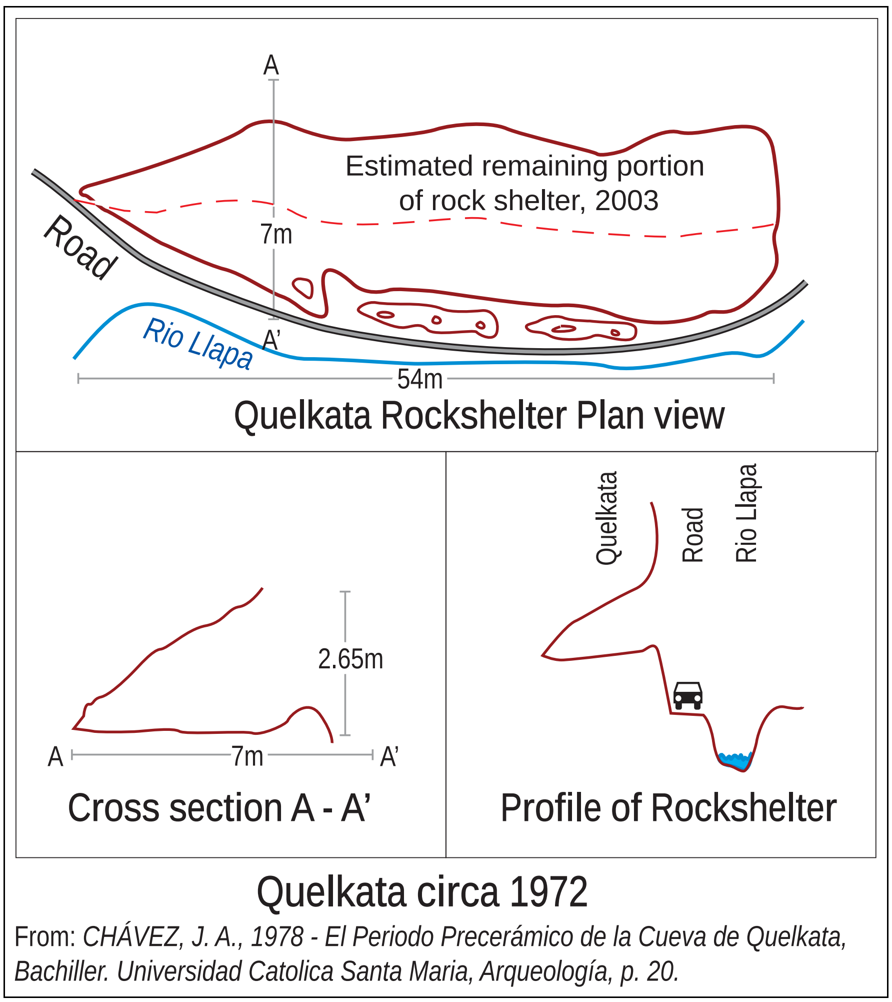


Figure 6-29. Quelkata in 1975 redrawn from Chavez (1978: 20). Red dotted line shows estimated border of the portion of the rock shelter that remains after the dynamiting for road widening.

Description

The rock shelter was significantly larger in the recent past. Chavez (1978: 20-21) estimates that the dry portion of the rock shelter was 7m deep, 50m wide, and 2.65m high at the mouth. The sheltered area amounted to a 365 m^2 area with the bulk of cultural debris concentrated in the south portion of the rock shelter. Chávez estimated that the stratigraphy included up to 3m of cultural material. During the 2003 season a great abundance of cultural material was not observed in the slopewash between the highway and the river, as one might expect if the highway were constructed on such quantities of cultural fill, but the area has been much disturbed in recent years.

Figure 6-30. Quickbird satellite image of Quelkata area in 2005. The shelter is under the tuff outcrops immediately to the left of the bridge. Data courtesy of Google / Digital Globe.

Quelkata is located at a major cross-roads in the local transportation network and it has probably been a significant landmark among people in the Upper Colca since the earliest human occupation of the region. The rock shelter mouth opens east-north-east and deposits still evident in the back of the rock shelter are approximately 5 vertical meters above the river and 2.5 meters above the modern highway. As the rock shelter is on a bend in the river the shelter appears to have been scoured out of the outcrop of welded tuff by the waters of the Río Llapa until the river channel was sufficiently incised that it not longer entered the rock shelter proper. Recently Noble (2003) collected a K-Ar sample from precisely this location and the resulting age of 20.7±0.6 million years indicates that the formation dates to the Early Miocene.

Geographical attributes of this location can be summarized as follows.

(1) Quelkata is a large, sheltered site close perennial to water source that probably provides year-round fishing opportunities.

(2) The east-north-east aspect results in warming by the morning sun.

(3) It is located at major intersection in local travel routes which suggests that many were familiar with the site, but also exposes the occupants to anyone traveling in this portion of the valley.

(4) Summits of the "Castillo de Callalli" tuff outcrops immediately above are defensible and appear to have been fortified during the LIP.

Figure 6-31. A 65cm column of cultural deposits still exists at the back of Quelkata at a height of approximately 1.8m above datum (at head height between the gravels and the tuff in photo).

Preservation of Quelkata

Road crews associated with the Majes Project dynamited the rock shelter in 1976 but this was not the first important disturbance in this high traffic area. Significant impacts on preservation at Quelkata are the following

(1) Although the rock shelter lies approximately 5 meters above the dry season water level of the Río Llapa, the rock shelter has probably been scoured repeatedly by high water in past millennia. Quelkata is located on the outer edge of river bend precisely at a channelized portion of the river where 1000 year or even 100 year floods potentially entered the rock shelter and disturbed the contents.

(2) As noted by Chávez (1978: 17) a road has long existed in this area due to the fact that it is a crossroads location and, as a channelized portion of the river, it

probably has had bridges prior to the modern bridge construction. With the mining history in the Cailloma area, a road was likely constructed to connect this ore-rich province with the Sumbay railroad sometime in the early 20th century. The dynamiting by the Majes crew was intended to widen the road at the bridge and the intersection, and it significantly impacted the rock shelter. However, the downslope colluvial outwash from the rock shelter, which are frequently deposits of great archaeological interest from a rock shelter, had long been disturbed by road construction and by fluvial erosion prior to the destruction by the Majes crew.

(3) The construction crews dynamited the site in 1976 and largely destroyed the southern portion of the rock shelter, the portion that Chávez (1978) describes as having the deepest deposits. There are still significant deposits at the back of the rock shelter, however. As part of the archaeological reconnaissance of the Llapa valley materials systematically surface collected from the rock shelter as will be described below.

(4) The intersection and bridge at Quelkata was a principal junction in the Arequipa highway network until 2002 when the highway connecting Arequipa with Juliaca was paved. Until the asphalting of the Arequipa-Juliaca highway virtually all of the highway traffic between Arequipa and Cusco passed directly in front of this rock shelter where one of the few restaurants and gas stations along the route was located. Thus, a relatively high number of travelers probably visited the rock shelter and its surroundings while waiting for transportation. Fortunately, the dynamiting of the shelter created a sheer 2 m wall so that a brief segment of 4th class rock climbing is required to enter the rock shelter, discouraging casual visitors.

There are still cultural deposits in a broad but thin and shallow section at the back of Quelkata. While much of the strata along the back of the rock shelter are disturbed sand and river gravels, a cultural level approximately 60cm deep is found across a swath approximately 40m wide at the back of the rock shelter.

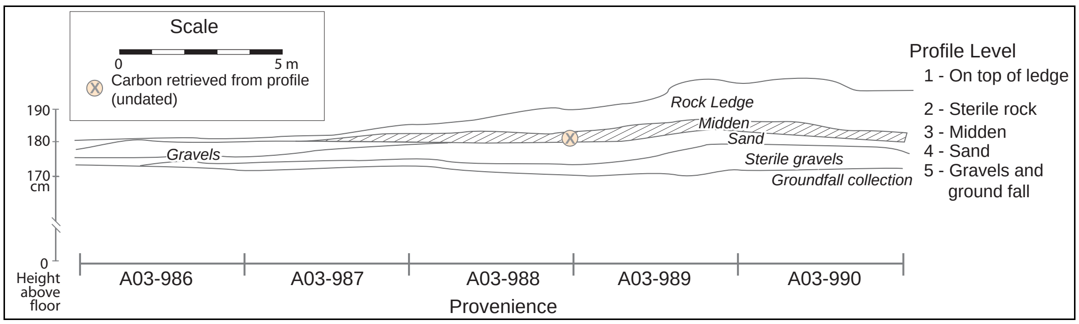


Figure 6-32. Profile of extant deposits at Quelkata shown in terms of relative collection units.

Proveniencing

As GPS cannot function in rock shelters, a collection strategy was devised using a datum inside the rock shelter. First, the shelter area was mapped expediently using tape and compass from a semi-permanent datum established on large rock on the north end of the occupation area near the road cut. Artifacts were surface collected from Quelkata in four horizontal collection units that were given ArchID# 986, 987, 988, and 989 to conform to the horizontal collection strategy throughout the survey. The deposits in the back of the rock shelter occurred on natural shelves and the vertical provenience was retained by collecting these shelves from the top (level 1) to bottom (level 5). The lowest level, the shelter floor, appeared to contain a mixture of materials that had cascaded down from above.

Site Collection

In the 2003 fieldwork season 22 flakes and retouched flakes from the rock shelter were collected. These consisted primarily of chert, chalcedony, and andesite. Of the 22 flakes 10 (45%) were made from obsidian, but these obsidian artifacts amount to only 7% of the flaked stone artifacts by weight. A number of bones and goat horns were among the faunal materials collected from the upper levels of the rock shelter, above the rock ledge. It is possible that the horns were placed in this location to dry out.

Chávez Collection

In his Bachelor's thesis José-Antonio Chávez (1978: 52-70) describes and analyzes surface collections that he conducted shortly after the dynamiting of the cave. Chávez includes photographs and drawings of projectile points that appear to be primarily of Type 5B and 5D forms. Chávez reports that he collected 36 projectile points and that the largest group was the concave base form (n = 17) that are probably Type 5B or Type 5D, diagnostic to the Terminal Archaic through the Late Horizon. Of these concave base forms 15 of them were made from obsidian (88%) and the remaining two were chert. Pressure flaking was noted on 16 of the points (Table 6-38).

	Obsidian	Non-obsidian	Totals
Unmodified	434	150	584
Modified	121	57	178
Total	555	207	762
Percent	72.8%	27.1%	100%

P.Pt Base: Convex	7	1	8
P.Pt Base: Flat	8	0	8
P.Pt Base: Concave	15	2	17
Probable Concave Base	12	0	12
Cores	2	3	5
Flakes – cortical	4	12	16
Flakes – noncortical	141	93	234
"Blades"	57	40	97
"Choppers"		5	5

Table 6-38. Counts of Material types by Artifact Form from 1977 Quelkata surface collections (Chávez 1978: 50-72).

A relatively large proportion of the points are non-diagnostic using Klink and Aldenderfer's typology. Three points described as "convex base" appear to be type 3D, a style which persists throughout the Archaic. Chávez notes that a large percentage of the artifacts were made of obsidian, although the identification of the Chivay source, 20 km to the south-west and 1000 meters in elevation above Quelkata, would not occur for another 15 years. Chávez attributes the relatively large percentage of obsidian to the many very small flakes of obsidian that were included in his sample. Had his analysis included weight of artifacts, the relative presence of obsidian by weight would have been considerably lower than that of other material types. It is apparent that obsidian was being transported to Quelkata and worked at the rock shelter from one of the Chivay obsidian source exposures in the study region.

Another notable pattern in these data is the lack of non-obsidian projectile points. This pattern is consistent with the predominantly base-notched (and Series 5) nature of this assemblage. However, results from the 2003 fieldwork show that this is anomalous in the region, even for the Terminal Archaic and onwards.

Discussion

Several of the projectile points that were noted on the top level of the rock shelter (in unit A03-988-level I) during a preliminary visit to the shelter in 2001 were gone from the rock shelter by the fall of 2003. The points required more careful study, but unfortunately this did not occur, and it was hoped that the points would have been retrieved during the course of the 2003 fieldwork.

It is notable that, despite the apparent importance of Quelkata in the regional settlement pattern, there were relatively few Archaic projectile points found in this rock shelter. Based on the evidence from Chávez and the 2003 examination of the rock shelter, the only definitive projectile point styles encountered at Quelkata are from the Terminal Archaic and onward. One parsimonious explanation for the lack of earlier projectile point styles is that the location of this rock shelter, only 5 m above the dry season water line, was insufficient to prevent particularly intense flooding during the Terminal Archaic which removed evidence from earlier time periods. Given data encountered at the site, this description of the Quelkata rock shelter perhaps belongs in the Early Agropastoralist discussion rather than the Archaic Foragers section of this dissertation. However, due to the centrality of this rock shelter in the settlement pattern, the shelter was likely a prominent settlement throughout the prehispanic period and thus it was included here.

A02-3 "Mollepunco"

The rock shelter of Mollepunco (aka Mollepunku, Cueva de Pirita) is one of the principal tourist destinations in the Upper Colca area (Cardona Rosas 2002: 143-147; Linares Málaga 1992: 287, 290, 291, 298; Hostnig 2003: 52) and it probably receives visitation by about ten groups of tourists per week during the high season. Formerly known as "Pirita" the shelter was renamed "Mollepunco" by Eloy Linàres Malaga in 1984 (1990; 1992). This dry rock shelter at the base of a partly welded tuff outcrop consists of two principal cavities and with flat floors and sloping ceilings, and a dry outdoor activity area. The principal cavity is 7m deep, 4m wide, and 5m tall. The shelter is approximately 100 vertical meters above the Pulpera valley floor and it is adjacent to a small perennial stream. The shelter features pictographs and petroglyphs of camelid, bird, and humanoid figures that Augusto Cardona (2002: 143-147) argues are significant because they show the transition from pictographs to petroglyph techniques, and the art is believed to have been executed by herders and is therefore no older than 3000 BCE. The art has been interpreted as dating to relatively late periods because plump camelid figures are often shown in herds, and one solitary camelid has what appears to be a rope around its neck. The shelter was excavated by Linares (1992) and despite the gate blocking the entrance of one sector, it appears that the shelter was significantly looted. An open burial chamber probably dating to the LIP is evident high in the southern end of the rock shelter.

Figure 6-33. Cueva de Mollepunco (A02-3).

Figure 6-34. Petroglyph of camelid on wall of Mollepunco.

Lithic debris is predominantly chert but a significant portion of the flaked material is obsidian. Bone and LIP ceramics are also evident at the site, perhaps resulting, in part, from the looted burial. Given the heavily visited and previously collected nature of this site surface the 2003 Upper Colca project field crew did not attempt a systematic recording of surface artifacts.

A03-1074 “Pokallacta”

This is a small, sheltered site that has evidence of occupations in both the Archaic Foragers period and subsequent times. The site is immediately to the west of a steep tuff outcrop approximately 100m high. The site is in the shadow much of the day, but it is a sheltered location that is protected and yet offers large views of the river valley.

The rock shelters are fronted by a flat area that today is a corral. This flat activity area is mapped as two Structure Loci though they are essentially one terrace. The two loci delimit the artifact spill zone for each respective rock shelter and each structure locus was assigned the same ArchID number as the rock shelter above it.

ArchID	SiteID	FileType	Description	Area (m^2)
1074	1074	Site_a	“Pokallacta”	4,342.7
1075	1074	Struct_a	Southwest shelter	63
1076	1074	Struct_a	Northeast shelter	45

Table 6-39. Loci in Pokallacta [A03-1074].

ArchID	Description	Height	Depth	Width	Height At Back
1075	Residential, pastoral	2.5	9	10	1.2
1076	Residential	2.2	6	5.3	0.9

Table 6-40. Rock shelters at Pokallacta [A3-1074], dimensions in meters.

ArchID	Index	Material Type	Form	Type	Temporal
1074	1	Obsidian	Proj Point Broken	5d	TA – LH
1074	2	Obsidian	Biface Broken	n/a	
1074	3	Obsidian	Proj Point Broken	5a	Term Archaic
1074	4	Volcanics	Biface Broken	n/a	
1075	1	Chalcedony	Proj Point	5	TA - LH
1076	1	Obsidian	Proj Point	5b	TA - MH
1078	1	Obsidian	Proj Point	2a	Early - Middle Archaic
1080	1	Obsidian	Proj Point	3d	Archaic

Table 6-41. Selected Lithics from Pokallacta [A03-1074].

The bifacially flaked items are largely obsidian but notably the bulk of the grab sample of unmodified flakes was of chert and chalcedony. This reflects the location of the site on the north side of the Río Llapa, and is consistent with a raw material use pattern observed elsewhere on the survey.

A03-1075

This rock shelter has a very thick dung cap and it is difficult to see the ground. The slanting roof and open west side provides a large but only partly sheltered area. It appears that a protective wall was constructed on the west side in the past.

A03-1076

This rock shelter is the more protective residential shelter of the two, offering a view of the river valley and the surrounding terraces.

Site Type: Small logistical site / hunting blind

Given the weak evidence of Archaic occupation in the Block 3 area, traces of early logistical sites and hunting blinds were difficult to discern from the well-distributed pastoral period evidence. As described above, archaeological sites were judged to contain pre-pastoral components belonging to logistical sites and hunting blinds when assemblages were of low diversity and long term site occupation evidence was slight. Often such sites are hard to definitely characterize as "archaic logistical sites" because the sites were found in places that appeared to be either predominantly later occupation period, or they were situated in were from ridgelines and other relatively exposed, steep, and waterless locations that were judged to be relatively unsuitable for long-term residential occupation.

A number of sites fall into the category of logistical sites and hunting blinds because it is essentially a catch-all category of potential pre-pastoral behaviors that do not contain definitive evidence for later occupation, such as ceramics. However, during the wet-season herders in the Upper Colca area return to the valleys (Markowitz 1992) and the slopes above the city of Callalli become suitable grazing land. A herder tending the flock high on the slopes might knap stone and create an aceramic site far from pastoral facilities or bofedales. Thus, it is difficult to conclusively say that the Block 3 aceramic sites (shown in Figure 6-25) predate the Terminal Archaic; the aceramic distribution is presented here conditionally.

	Site μ	Site σ	Block 3 μ	Block 3 σ	Block 3 μ – Site μ
Altitude (masl)	3947.2	83.7	3984.5	87.45	+37.3
Slope (degrees)	9.8	5.5	12.3	8.5	-2.5
Aspect (degrees)	SE	SE	SW	SE	NE
Visibility/Exposure	38.3	24.2	39.1	23.4	+.8
Dist. to Bofedal (m)	1420	600	1024.8	567.9	-395.2

Table 6-42. Environmental characteristics of aceramic sites.

An exploration of the environmental circumstances of these aceramic sites shows that the sites are found in higher altitude areas, relative to the terrain in Block 3, and the distribution are on relatively steep slopes for site locations. The highly variable aspect measure is not particularly informative, though it shows a slight tendency towards south-east exposures in a block that trends to the south-west. These sites are found in relatively exposed, high visibility areas, and they tend to be farther than average from bofedales, though on the whole bofedales are not widespread in Block 3. Examples of such sites would include a few that contain diagnostic pre-pastoral Archaic projectile points, but also appear to contain evidence of later occupations.

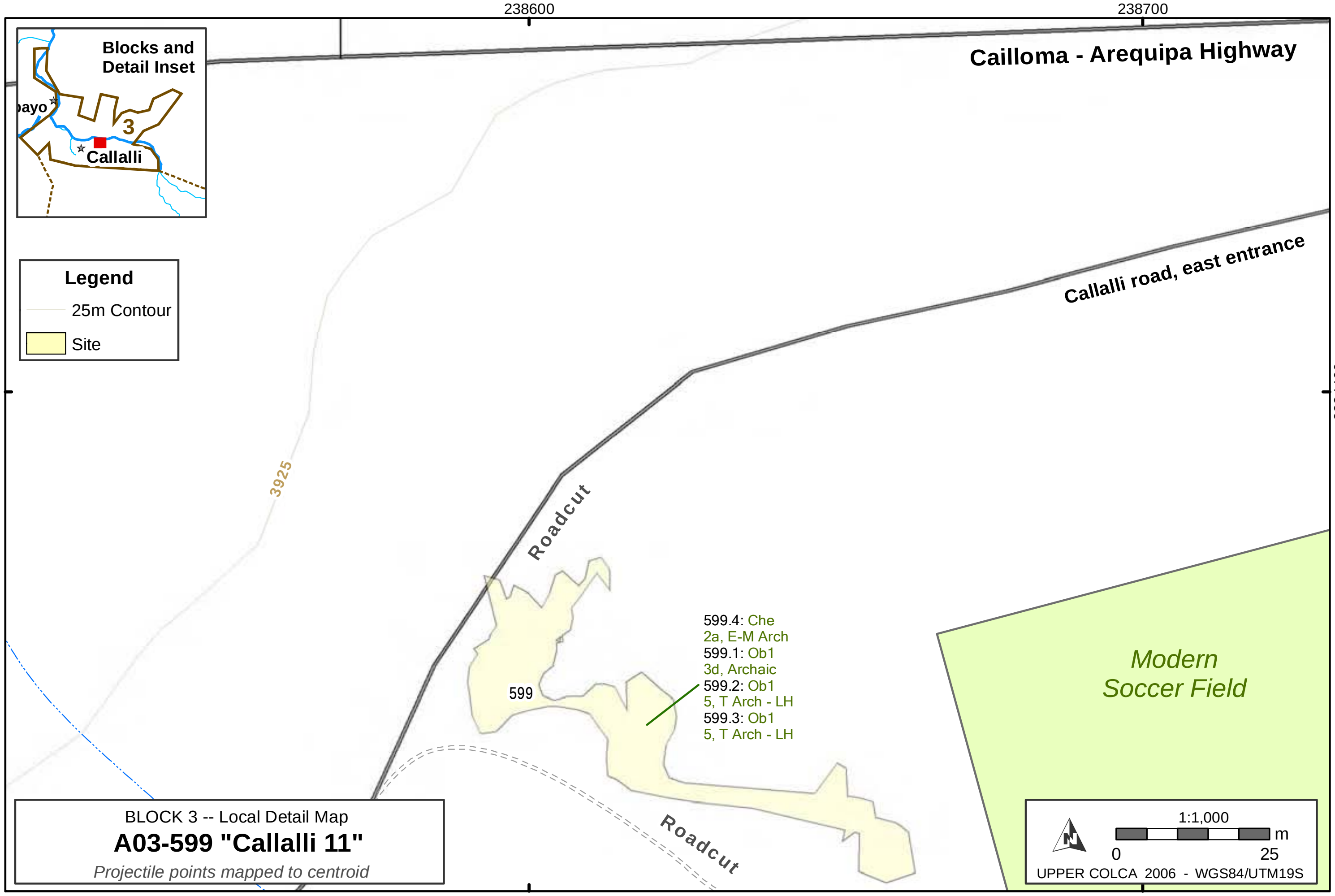
A03-599 "Callalli 11"

This site is on the east edge of Callalli just beyond a quebrada. A relatively dense scatter of flaked stone and projectile points from two Archaic styles and two later (Type 5) styles were found here, but the artifacts were not sufficiently dense to merit mapping as a low density lithic locus. The site is heavily disturbed by the construction of two roads on either side of it: the modern Callalli access road to the north and a narrow, steep road accessing the soccer field to the west and south of the site.

Figure 6-35. View westward from "Callalli 11" across quebrada shows the eastern edge of Callalli.

This deflated terrace edge area contained flakes approximately one half chert and one half obsidian by count, and 1/4 of the obsidian was cortical. A ground andesite hammerstone weighing 294 g and stained with ochre was also found here. This open air site area offers partial shelter in the form of the quebrada and associated lower terraces that are now destroyed by road construction. The quebrada probably contained water for part of the year.

Figure 6-36. Callalli 11 [A03-599] on terrace on the east edge of the town of Callalli.



A03-785 "Anccasuyo"

Another possible logistical site was found away from the principal river channel in the area of the colonial site of Anccasuyo. A single type 1A (Early Archaic) or 2C (Middle Archaic) projectile point of chalcedony, broken at both ends, was found here. The temporal assignment is ambiguous because of the broken base. This location is adjacent to a small tributary to the Río Llapa and where an outcrop of tuff creates a small pool that has been developed into a stock pond.

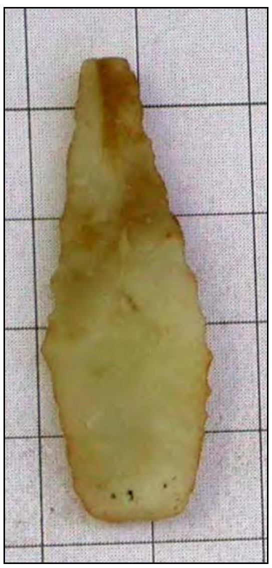


Figure 6-37. Chalcedony projectile point [A03-790] from Anccasuyo [A03-785].

There were two obsidian flakes here, and five non-obsidian flakes. While the Archaic evidence from this site is small, a single point (that could have been scavenged from elsewhere by the colonial occupants), if the context is intact it represents a kind of peripheral, hidden habitation that one might expect to complement the larger residential bases elsewhere in the valley.

A03-675 "Taukamayo" (A02-26)

This area meets the criteria for a possible short term camp or logistical camp during the Archaic Foragers period. A red chert foliate projectile point was found just outside of the principal site of Taukamayo, a site that will be discussed in detail below. The chert point is probably type 3D (incomplete scar coverage) and it is of a style that is only diagnostic to the preceramic period. This location is a bench terrace that is relatively exposed topographically but, as with site A03-599 Callalli-11 there are opportunities for shelter nearby. This site is classified here this as a possible logistical camp during the Archaic because the immediate occupation appears relatively small and exposed for a residential base, but the evidence is conflated with quantities of flaked stone and pottery from later occupations. The site is positioned at the base of a principal access trail to the high country to the south, and close to the biggest river confluence in the region. In other words, there is not a lot of evidence of long term occupation or diversity of activities during the pre-pastoralist period at this site, but the location appears to be positioned strategically with respect to local travel corridors and the monitoring of the river confluence, and the site thus appears to have more than merely a chert procurement location.

Site Type: Chert provisioning site

A final site type category to be considered in this section is that of Archaic Period Block 3 provisioning and initial reduction sites. A relatively large number of sites are found on the lower terraces of major watercourses. The sites can be characterized as exposed, open air sites featuring cortical reduction debris where the majority of material is chert or chalcedony, and the tools are discarded bifacial tools and points. The process appears to have consisted of obtaining chert cobbles from the river bed during low water seasons and opening the cobbles in the riverbed to evaluate the knapping quality of the material. Some percentage of cobbles deemed suitable for further reduction were then transported to the terrace above, where knapping occurred. Sites rich in chert were not exclusively encountered on these river bank areas, but these production sites were abundant in cortical material and the mean flake sizes were relatively large.

These kinds of sites were encountered most frequently on the very edges of terraces but this was perhaps due in part to the greater visibility from erosion along the terrace margins. The sites are otherwise exposed and appear to have been an unlikely place for residential occupation. The profiles of cut banks were investigated at some of these sites and stratified deposits were rarely observed eroding from the cutbanks. The 2003 season survey did not encounter chert raw material in its original geological context, it was only found in the bed of streams in the Block 3 area. As a consequence, it appears that most of the chert artifacts recovered during the 2003 season were probably knapped along these river terrace margins, and it is difficult to assign a time period to these early production sites. There was no strong patterning with the temporally diagnostic point styles and the material types used in Block 3 during the Archaic Foragers period. Points were made from chert and obsidian in Block 3 throughout the Archaic and obsidian points were frequently found on river terrace margins surrounded by chert knapping debris.

A03-806: Sullullumba

A good example of a river terrace provisioning site with evidence of multiple Archaic Period occupations is “Sullullumba” [A03-806]. This site was the only site with purely Archaic occupations in Block 3. It is located up the Colca river from the confluence at Sibayo, and is therefore one of the areas furthest in the study area from the Chivay obsidian source. The site is located on a pronounced terrace edge on the inside bank of a broad bend in the Colca river. Under modern conditions, the area is exposed both to valley winds and by the fact that it lies on the edge of a 40 m steep downslope to the annual high water mark in the river channel.

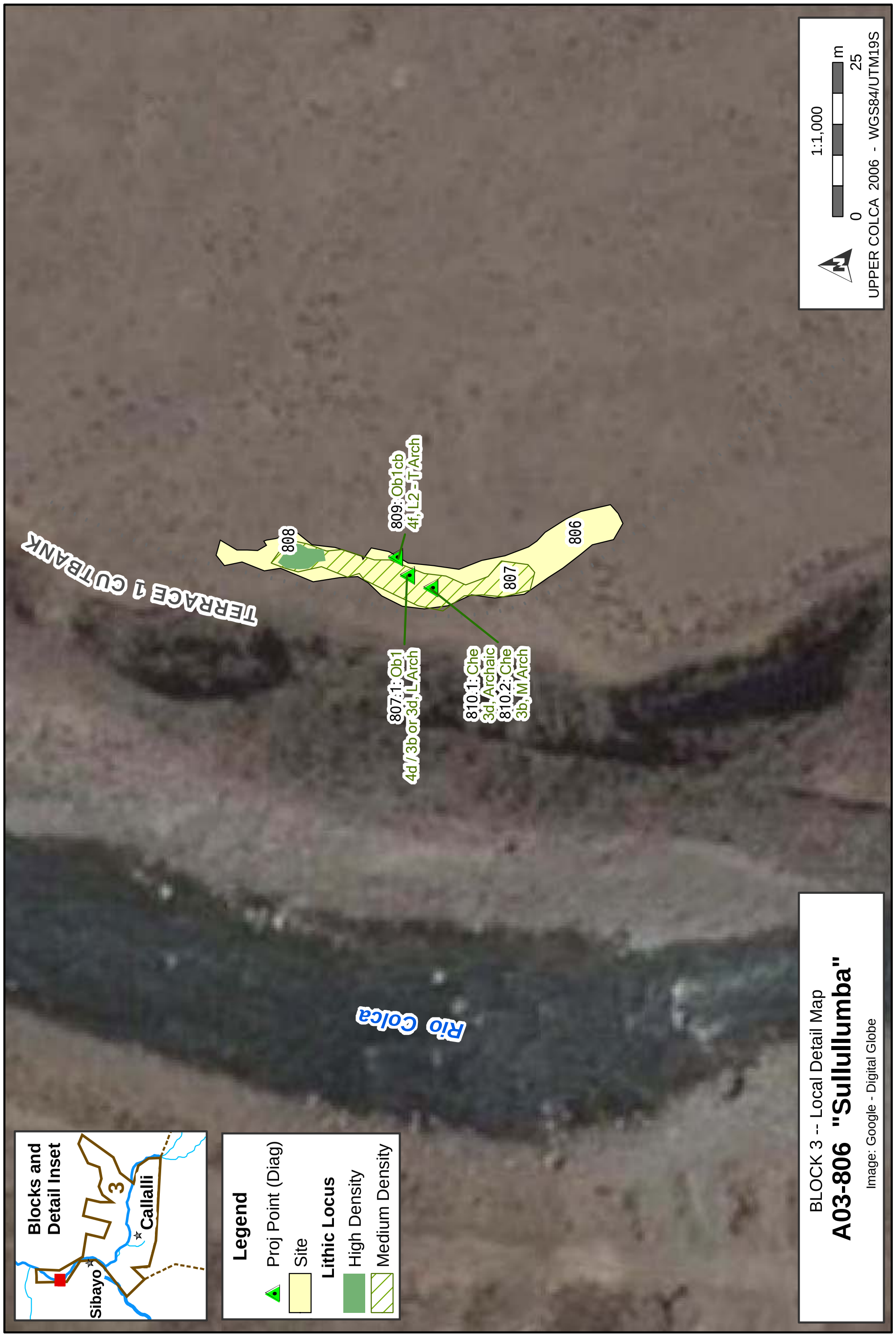


Figure 6-38. Map of the Sullullumba [A03-806], an Archaic Foragers site showing lithic loci on terrace edge 40m above the annual flood line. Image courtsey of Quickbird DG / Google.

Figure 6-39. Sullullumba [A03-806] along terrace edge above the upper Río Colca. Yellow notebook and scale bar are visible in the center-rear of photo.

ArchID	SiteID	FileType	Description	Area (m^2)
806	806	Site_a	Sullullumba	366.6
807	806	Lithic_a	Medium Dens, 10 Obs	169.6
808	806	Lithic_a	High Dens, 10 Obs	21.3

Table 6-43. Loci at Sullullumba [A03-806].

Artifact analysis from Sullullumba

As one of the only single component Archaic Forager sites, seventy-four artifacts collections from this site were given thorough attention in lab analysis. The items below indicate the kind of lithic reduction that occurred on river terraces some distance from the Chivay source.

Obsidian

Obsidian material consisted of two types: clear and clear-banded flakes with no heterogeneities, and grey and black shaded obsidian with heterogeneities. Two broken projectile points and one broken biface were made from obsidian that is presumably of Chivay type material. A single flake of clear obsidian was found highly rotated and with 20% dorsal cortex, placing it at a mid-stage reduction. This obsidian flake was perhaps struck from the biface or the projectile point collected from this site.

Chert and Chalcedony

No pattern was discerned in the color of chert used at Sullullumba, but there was a relatively high percentage of chert and chalcedony in the surface assemblage. From the collection of 74 artifacts from the site, 50% were made of chert or chalcedony. Sixty-five percent of the chert showed signs of heat treating. Interestingly, about half of the chert flakes showed signs of rotation indicating that the potential of chert cores was maximized despite the probable availability of chert in the Colca river. None of the flakes, however, were bifacial thinning flakes and only six flakes had more than 20% cortex. No correlation was noted between (1) the flakes with high rotation index and (2) heat treatment or chert color. Thus, it appears that chert was being procured and preforms were being produced but the final, thinning stages of point production were not occurring at this site or these smaller flakes were not recovered from the surface context.

A number of interesting projectile points were collected here that include a type 4f (Terminal Archaic) point made from clear banded Ob1 obsidian that includes pressure flaking around the haft Figure 6-40. Another point is a likely type 3b (Middle Archaic) point made from red chert with several spines on the haft margin.

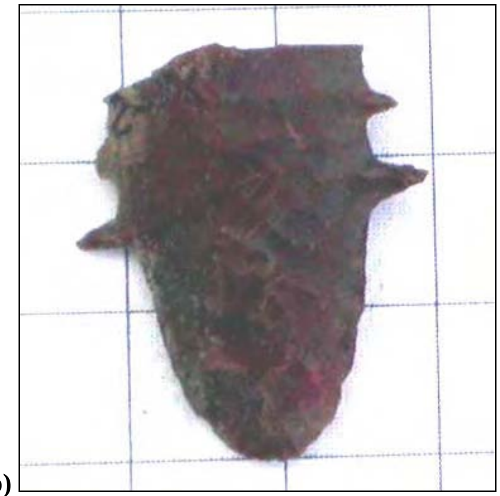
(a)  (b) 

Figure 6-40. Projectile points from Sullullumba [A03-806]. These include (a) an obsidian Ob1 4F (Terminal Archaic) point [A03-809.1] and (b) and the base of a probable 3b (Middle Archaic) chert point with shoulder spines [A03-810.2].

Figure 6-41. The high density lithic locus A03-808 consisted of aphanytic volcanics and chert.

Complete flakes from this site show highly variable attributes that result from a complete reduction sequence having occurred in the area. A high density locus of flakes made of fine-grained volcanics, chert flakes, and chert heat-shatter [A03-808] perhaps result from a single knapping event. In sum, this site presents evidence of Archaic Period open-air activities a greater distance away from the influence of the Chivay source.

A03-32 "Ichocollo" site cluster in Block 6

Approximately 10 km down stream from Block 3 a cluster of open-air sites along a tributary to the Colca was encountered in a smaller survey area called block 6. This block contains a large fraction of diagnostic Archaic projectile points along with ceramics and projectile points dating to the later Prehispanic period. In the modern geography of the region Block 6 lies immediately above the portion of the Colca valley with intensive agriculture. The Río Challacone descends from the north-east flanks of the glaciated Nevado Mismi (5556 masl) on the north side of the Colca valley, while the Ichocollo drains the south side of Cerro Chungara (5286 masl), a peak that was probably glaciated on its southern flank approximately in the same period of time as the Chivay obsidian source area contained glaciers.

SiteID	FileType	Description	Area (m^2)
22	Site_a	"Ichocollo 3"	400.1
29	Site_a	"Ichocollo 4"	36.4
32	Site_a	"Ichocollo 5"	527.5
44	Site_a	"Ichocollo 6"	729.9
61	Site_a	"Ichocollo 7"	1375.5

Table 6-44. Site sizes in Ichocollo [A03-32].

This glaciation may have provided steady water to residents along the eastern tributary stream named Ichocollo. Today, the western of the two, the Challacone drainage, appears to be the larger stream channel and is more scoured out (see geology map in Figure 4-15), a feature perhaps related to the geologically recent large mudslide visible in the geology map as “Ladera Tinday” with the *Qr-de* symbology.

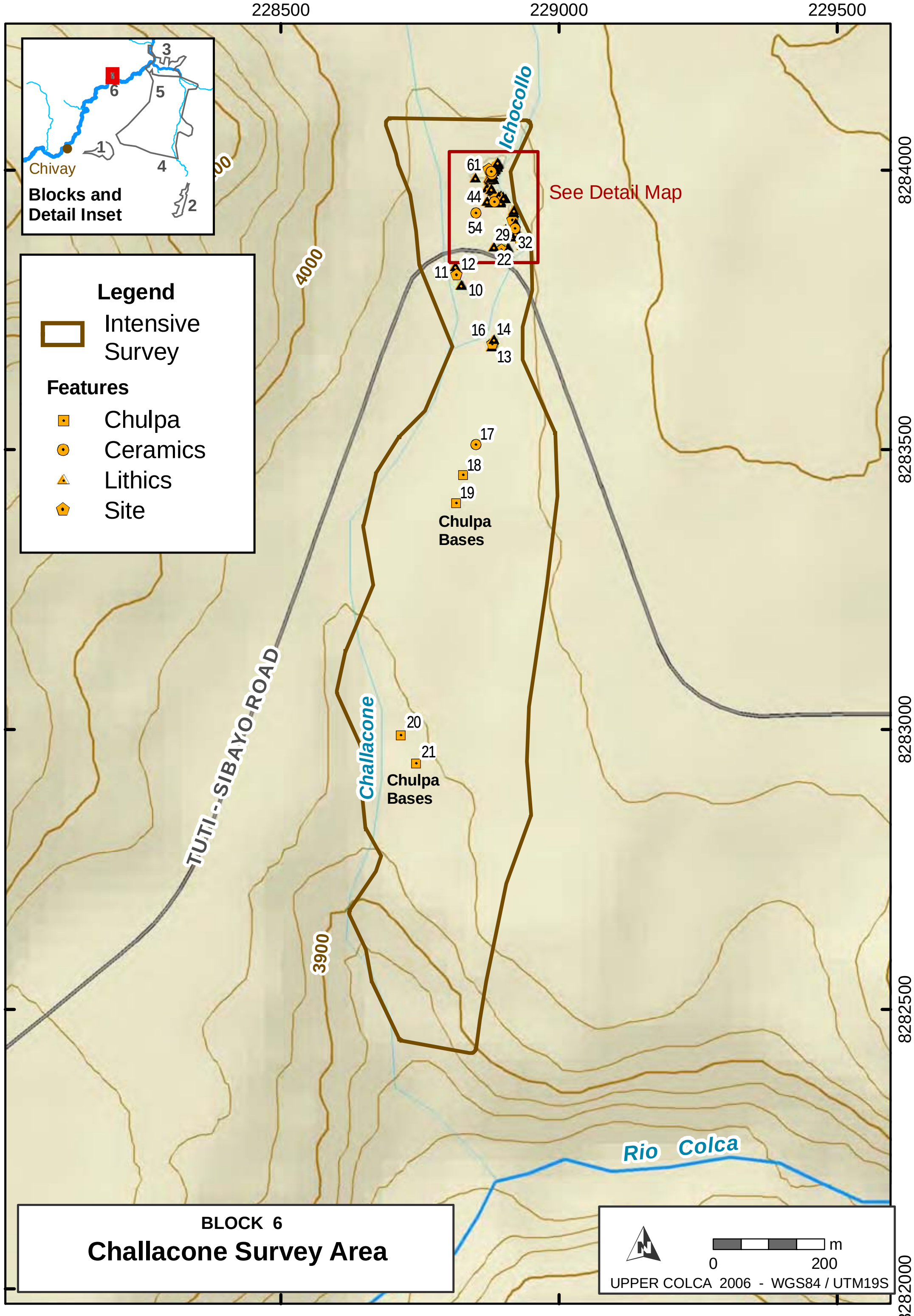


Figure 6-42. Block 6 Challacone - Ichocollo overview map

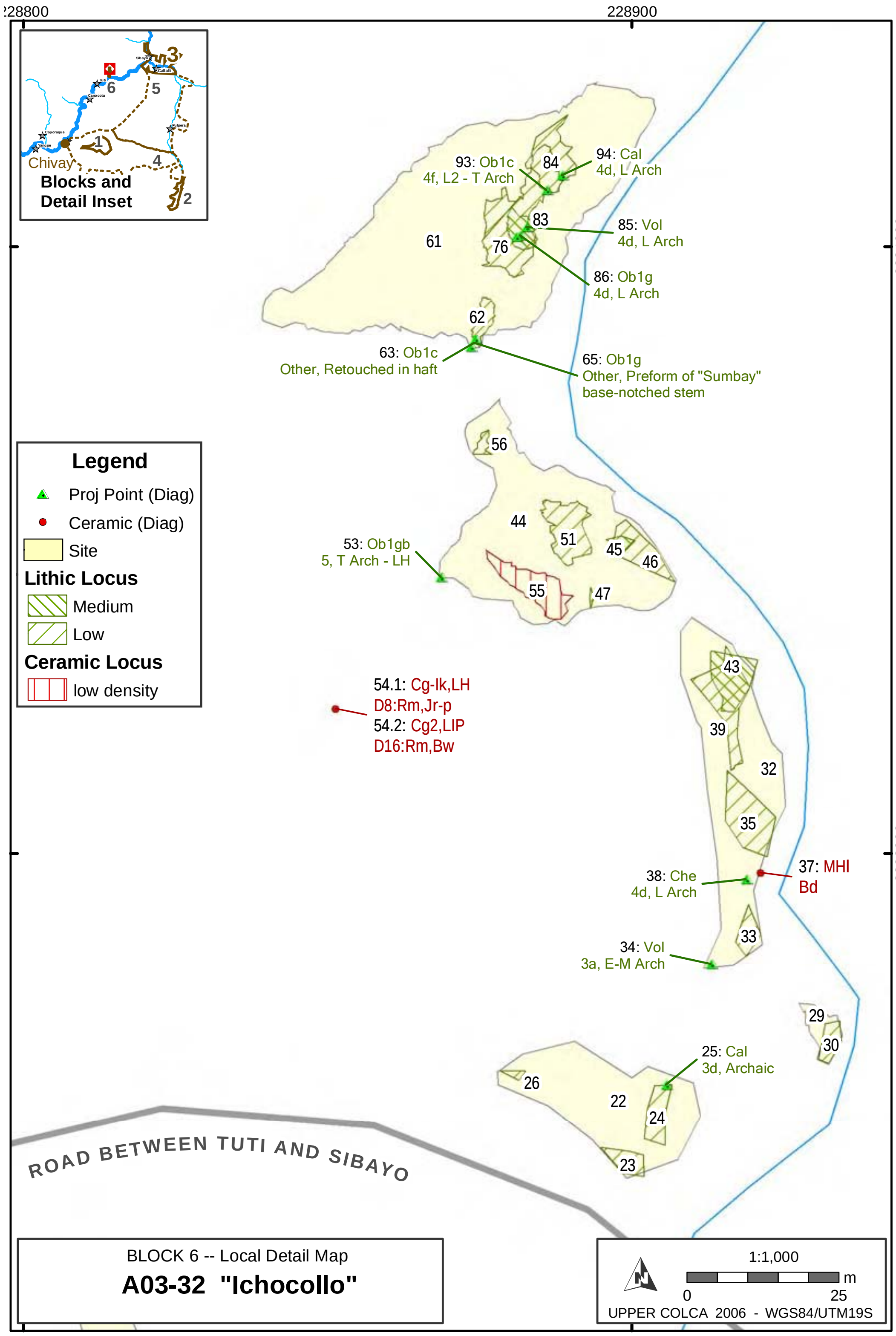


Figure 6-43. Ichocollo complex along Quebrada Ichocollo.

Artifacts from Ichocollo complex

Several clusters of lithics and ceramics were identified and divided into sites in this confluence area between the two drainages. The greatest density of artifacts were found on the west bank of Quebrada Ichocollo between the two streams, in an area that is relatively low lying compared to other creek banks in the zone. The area was occupied in numerous episodes in prehistory, as is evident in the diagnostic artifacts that belong to styles spanning all time periods from the Early Archaic to the Inka period. There are a number of environmental characteristics that would suggest that this area would be reused frequently in prehistory. On a local scale, the position of these sites between the two creeks perhaps provided the residents with greater opportunities in both water sources and in lithic raw materials, as cobbles occur in the creek beds. In terms of the position of this survey block in the valley, as was noted previously, the Challacone drainage is at nearly 4000 masl but it is geographically only 3 km to the east of Tuti zone that includes the warmer reaches of the Colca valley below 3900 masl and the beginning of intensive agriculture in modern landuse patterns.

A number of chert and chalcedony nodules were observed in the Ichocollo streambed and the chert was predominantly red in color and was a consistent, homogeneous material with moderately good fracture characteristics. The predominantly red-orange chert nodules in the river are evident in material used for the bifacially flaked lithics found in this site cluster, and 30 of these bifacial tools showed signs of heat treating. Relatively few of the artifacts of any material type, including chert, contained exposed cortex. One chert core had 3 rotations, and chert flakes were predominantly in advanced stages of reduction. Obsidian was of both grey and clear varieties and 27% of the obsidian in the collections had heterogeneities.

Figure 6-44. Photo looking northwest across Ichocollo creek in the foreground, the site cluster that includes "Ichocollo" [A03-32], and Challacone creek below the structure in the background.

	Biface	Retouched Flake	Proj Pt	Core	Total
Obsidian	14	2	5		21
Volcanics	3	1	2		6
Chalcedony	1	1	3		5
Chert	10	5	1	1	17
Quartzite	3				3
Total	31	9	11	1	53

Table 6-45. Bifacially Flaked Lithics from Ichocollo by Material Type

	Length (mm)								Total
	15-20	20-25	25-30	30-35	35-40	40-45	45-50	>50	
Obsidian	4	8	3	3	1		1		20
Volcanics		1		1		1			3
Chalcedony			1	2		1		1	5
Chert		1	1		3	3	2	5	15
Quartzite						2	1		3
Total	4	10	5	6	4	7	4	6	46

Table 6-46. Bifacial Lithics at Ichocollo showing Counts of Material Types by Length

An examination of lengths of bifacially-flaked artifacts from the Ichocollo area by material type shows that the immediately-available chert and chalcedony materials are found in bifaces in a range of sizes. Together with the lack of high rates of cortex, these data suggest that the Ichocollo site cluster is associated predominantly with middle-stage reduction. Potentially, decortication occurred in or near the stream bed, while middle and more advanced reduction occurred closer to the residential sites.

Block 3 Archaic Period discussion

The evidence reviewed here has shown that the pre-pastoral Archaic occupation of the Block 3 survey area was light and appears to have consisted of many relatively shortterm occupations. The Archaic Forager period in this region perhaps involved passing through through the river valley while traveling between the puna and the lower elevation Colca valley.

Based on this appraisal of modern resource distributions, the Block 3 section of the landscape presents relatively few opportunities for foragers that are not available in greater abundance elsewhere in the region. Hunting opportunities were likely to have been good in the smaller stream channels and atop the transversal lava flows and the tuff outcrops, but the Block 3 area falls between two rich areas that probably had greater natural abundance: the rich, rain-fed grasses of the puna above, and the lower elevation vegetative productivity of the main Colca valley where berries and herbs probably became available. Gathering opportunities may have been more abundant in the lower elevation parts of the Colca valley downstream, while the economic focus in the puna would have been on hunting.

6.4. Survey Results: Early Agropastoralists Period (3300BCE – AD400)

This temporal period covers the calendar years 3300 BCE through AD400, incorporating a time that includes dramatic changes in the region from the Terminal Archaic through the Late Formative following the Titicaca Basin chronology. As was described in Chapter 3, during this time period the sweeping changes that occurred in the larger region are linked at the Chivay obsidian source through evidence of intensification of obsidian production, the establishment of regular llama caravan traffic linking far-flung parts of the south-central Andean highlands, and a dynamic political environment in the Titicaca Basin consumption zone that appears to have influenced behavior at the source.

In the Terminal Archaic, distinctive economic changes that were accompanied by social and political developments were brought about in a broad suite of transformations that appear to have been co-evolutionary. Briefly, these changes began with transitional or low-level food production (B. D. Smith 2001) in the form of animal husbandry and a greater reliance on seed-plants. These changes were also associated with greater evidence of sedentism (Aldenderfer 1998b; Craig 2005) and these settlements were linked through expanding interregional networks that appear to have interfaced through regular llama caravan transport (Browman 1981a; Dillehay and Nuñez 1988). By the end of the phase described here as "Early Agro-Pastoralists" a number of regional centers in the Lake Titicaca region emerged during the Late Formative (Stanish 2003: 137-164) that were controlled by a socio-political elite in a socially complex, ranked society. The influence of these powerful political and religious elite were most evident at the primate centers of Late Formative Tiwanaku and Pukara, centers that grew in influence through, some have argued, the harnessing of labor to produce food, build monuments, and control interregional exchange.

In this research, features used to differentiate the Early Agropastoralists period occupations from the preceding Archaic Foragers and from the later Late Prehispanic periods are comprised by evidence from artifactual data and settlement pattern data. With the beginning of the Early Agropastoralists period one can expect the reliance on herding in the Upper Colca to have changed the settlement pattern in the direction of areas that are suitable for herding, in particular reliable water sources and bofedales for alpacas. The Series 1-4 projectile points (except 4c and 4e) are diagnostic to the Archaic Foragers period and so components associated these projectile points are therefore pre-pastoralist by the definition used here. A ceramics style termed "Chiquero" is thought to be diagnostic to the Formative Period based on surface distributions in the main Colca valley (Wernke 2003), but in the course of the 2003 Upper Colca fieldwork, ceramics in the style similar to Chiquero persisted into Middle Horizon period strata in one test unit in Block 3, suggesting that this ceramic style persisted in use in the higher altitude regions of the Colca. Thus, the presence of sand-tempered, unburnished ceramics can be used to differentiate the Early Agropastoralists period from the preceding preceramic time period, but not the Middle Horizon end of the Early Agropastoralists period in the Upper Colca. The end of the Early Agropastoralists period with the onset of the Titicaca Basin Tiwanaku period (AD 400) is more difficult to differentiate because the pastoral economic basis of the periods in the Upper Colca are not significantly transformed, and therefore the settlement pattern may be largely unchanged.

Diagnostic ceramics of the Middle Horizon, Late Intermediate Period, and Late Horizon have been described comprehensively by Wernke (2003) and therefore the presence of these ceramics is one way to differentiate certain components as "Late Prehispanic".

Based on the site classifications used for the pre-pastoralist Archaic, the Early Agropastoralist sites in the Upper Colca are considered here in terms of (1) residential bases, (2) logistical camps, and (3) isolates. These site groupings have analogs in the settlement pattern of modern pastoralists, where residential bases consist in distributed *estancias* of varying sizes with adjacent grazing areas where permanent or seasonal residence is established, and logistical camps or "herding posts" that consist of regular travel stops during travel between estancias and other settlements (Nielsen 2001: 193-196; Tomka 2001). These types correspond with "main residences" and "herding posts" described with archaeological correlates by Nielsen (2000: 478-482).

Type	Description	Expectations
Residential Base	Long term occupation or regular reoccupation by several adults and sometimes children. Corrals with soil of compacted dung. Formalized use of space apparent in task areas and artifact distributions. Regularly distributed across land with available grazing areas and a reliable water source.	Variety early vessel forms, including large cooking vessels. Possible correlation between low diversity in lithic raw material types and long term occupation due to relatively low mobility. Site maintenance activities (cleaning, dumping) and designated activity areas expected.
Logistical Camp	Short term but regular reoccupation by special task groups. Smaller and more uniform site characteristics.	Few large vessels, possible caching of implements for reuse. Relatively high assemblage diversity in both lithic types and ceramic pastes. Less evidence of site maintenance due to multiple short-term occupations.
Herding shelter	Small occupation for night or day use with windbreak and view of grazing areas.	Windbreak with view, possible animal bone and some lithic debris, possible hearth. No corral necessary for short occupations.

Table 6-47. Classifications for Early Agropastoralist components of sites

Criteria used for identifying pastoral camps were available in the course of this study (Table 6-47). Unlike the Upper Colca area, some of the ethnoarchaeological data used for constructing these categories come from regions, like eastern slopes of the Andes in Bolivia (Nielsen 2000: 480-483), that had low site reoccupation and spatial redundancy due to an abundance of suitable pastoral camp areas. Ethnoarchaeological evidence suggests that short-term herding posts with little site structure but many reoccupation episodes will often contain many hearths with associated overlapping middens that result from groups moving the hearth facilities to avoid debris from earlier occupants (Nielsen 2000: 480-483).

Pastoral bases and herding posts are characterized by extensive but shallow refuse discard. Bases may contain greater density contrasts in refuse discard because of longer term occupation and site maintenance activity, and areas around rich resource patches are likely to contain "large and dense archaeological sites resulting from multiple, non-contemporaneous, partially overlapping, and perhaps functionally diverse occupations" (Nielsen 2000: 482-483). Short term caravan stops do not necessarily contain corrals, as camelids do not require corralling every night.

Nielsen (2000) observes that short term herding posts (logistical camps in the typology used here) and shelters appear to prioritize the following features, beginning with the well-being of the caravan animals:

(1) Grazing opportunities.

(2) Water for the herd.

(3) Shelter from the wind.

(4) Other human concerns such as hunting opportunities and proximity to the residences of exchange partners.

Herders will take advantage of existing structures, such as wind breaks and sometimes existing hearths, but they virtually never construct new features in their short term occupation of overnight camps (Nielsen 2000: 452).

Problems in isolating Early Agropastoralist sites

As was mentioned in the discussion of the pre-pastoralist Archaic occupation of Block 1, nearly all sites of significant size were multicomponent sites, and the difficult in differentiating components by time period is severe. The strongly pastoralist occupation will be described here, as well as the intensification on obsidian procurement in the Maymeja area that appears to have occurred with the onset of pastoral lifeway in the Terminal Archaic. Some of these sites discussed here may, in fact, date to later pastoralist periods but if the site does not have ceramics diagnostic to later periods, then it was not possible to differentiate the later occupation from mere surface artifacts. Architectural remains, such as *chulpas*, also serve to differentiate some Early Agropastoral from Late Prehispanic (particularly LIP and LH) occupations.

The problems associated with differentiating the Early Agropastoralist component in the study area can be characterized as follows.

(1) Persistence of pastoral economy. Areas with rich pasture have been consistently occupied since the early pastoral period until modern times, and in many cases the pasture has been enlarged through landscape modification such as expanded irrigation to the margins of bofedales.

(2) Projectile points. The projectile point typology proved to be very useful during the earlier Archaic Foragers period, but the typology is largely non-diagnostic to time period from the Terminal Archaic onward (Series 5 types).

(3) Ceramics. Formative Period ceramics are poorly defined in the Arequipa highlands and this limits the ability of archaeologists to differentiate Formative wares from utilitarian wares from later periods. Furthermore, utilitarian wares may be encountered more frequently at remote pastoral bases.

(4) Architecture. The defining features of pastoral settlement in the region, estancias and corrals, are generally not diagnostic to time period. Architectural features specific to the Collagua during the LIP, such as square structures with round corners and tall narrow doorways did become established in the main Colca valley, but the pastoral structures encountered in the course of this research showed no evidence of this kind of architecture.

6.4.1. Block 1 – Source

The Early Agropastoralist period in the Maymeja area of the Chivay source appears to reflect to major foci of economic interest in the area: (1) obsidian intensification, and (2) the exploitation of the rich pasture from the bofedal that lies in the western half of Maymeja. The strongest manifestation of settlement redundancy in the Maymeja area was at a handful of residential bases that were utilized by pastoralists over the millennia.

The most telling patterns in lithic production evidence come from contexts that differ from the expectations derived from purely pastoralist settlement patterns. For example, there is evidence of substantial settlement in an area with an obsidian workshop that is relatively unused today by the herder that dwells in Maymeja with over 200 head of alpaca. One explanation for this pattern is that the earlier settlement pattern was the result of obsidian procurement and production occurring at the quarry pit on the south side of Maymeja. That is, pastoral land use patterns are largely redundant in the region since approximately 3300 BC, but despite this redundancy there was variation from the purely pastoral pattern that suggests a Formative Period economic focus on obsidian production.

Block 1 Obsidian procurement features

One of the biggest challenges of working at the Chivay source during the 2003 season was evaluating the evidence for the incentives that drove ancient people to excavate a quarry pit to acquire larger nodules of obsidian, and the evidence for who was responsible for the quarrying work. Presumably, the earliest visitors to the Chivay source had the first pick of the largest and most homogeneous nodules, but over the millennia the source would be relatively depleted as compared with the initial abundance during early human visitation sometime in the Early Holocene. A quarry pit [Q02-2] that was encountered in the south-east quarter of Maymeja is evidence that investing labor in excavating for obsidian was indeed worthwhile.

At some sources, for example in the upper reaches of the Alca source as described by Rademaker (2005, pers. comm.) large blocks of obsidian of variable quality are found littering the surface. At lower elevations at the Alca source, and closer to large settlements, small cavities and tunnels were excavated to retrieve obsidian (Jennings and Glascock 2002).

Q02-2 "Quarry Pit"

The upper area of Maymeja, as well as the eastern flanks of Cerro Hornillo, are blanketed with small fragments of obsidian that appear as lag gravels among the tephra soils of the area (Section 4.5.1). In particular, flows and large nodules of obsidian are exposed through erosion in some areas, which suggests that underneath the tephra are larger nodules, but one has to excavate for them. On the north side of Maymeja, in an area heavily eroded by glaciers, a flow of obsidian [Q02-1] was observed but it contained vertical, subparallel fractures and was generally not suitable for tool production.

At the same altitude as this natural flow, but 700m to the south and across several moraines is a quarry pit [Q02-2] located in an area where the ashy soil was particularly light-colored. Similar open-air obsidian quarries have been described in central Mexico as “doughnut quarries” (Healan 1997) and “extracción a cielo abierto” (Darras 1999: 80-84). See Section 7.4.1 for further details on this quarry pit.

The coordinates of the Q2-2 pit are 71.5355° S, 15.6423° W (WGS84 datum), and it lies at 4972 masl. Around this quarry pit many small obsidian nodules in a depression were encountered that were typically < 5cm in size, but a few were closer to 15cm on a side. There is a smaller mound of sandy soil and small fragments of obsidian inside the larger quarry pit, suggesting that someone has attempted to further excavate the quarry pit in the more recent past.

Figure 6-45. Testing at Quarry Pit Q02-2 with 1x1 test unit Q02-2u3. Snow remains in the pit.

During the 2003 field season a test unit was placed in the debris pile immediately downslope of this quarry pit. The quarry pit and the test unit results are described in more detail in Section 7.4.1 and a brief discussion of ancient quarrying methods can be found in Section 8.3.2.

A03-268 "Camino Hornillo"

Departing from the quarry, a prehispanic road was identified that is 3-4m wide and is cleared of all but the largest rocks. This road [A03-268] departs the Maymeja area towards the south, following the route with the lowest gradient out of the volcanic depression, and avoiding difficult talus areas. As the road is defined by being swept free of rocks, the road is difficult to follow where it enters areas consisting only of sandy soil with no rocks to define its edges. In 2003 two sections of this road were mapped for a total of 3 km, and based on observations it can be described as of the "*Cleared Road type*: … systematically cleared of all stones or other debris" (Beck 1991: 75-76). While the soft pads of camelid feet negotiate rocky terrain with relative agility, loaded caravan animals generally travel on cleared roads and trails. Nielsen describes caravan routes in the open altiplano as "wide (4-10 m), straight, and free of vegetation, but lack[ing in] any improvement" (Nielsen 2000: 447). By these criteria, the route encountered at the Chivay source is relatively narrow, but it is roughly twice the width of a single-file path.

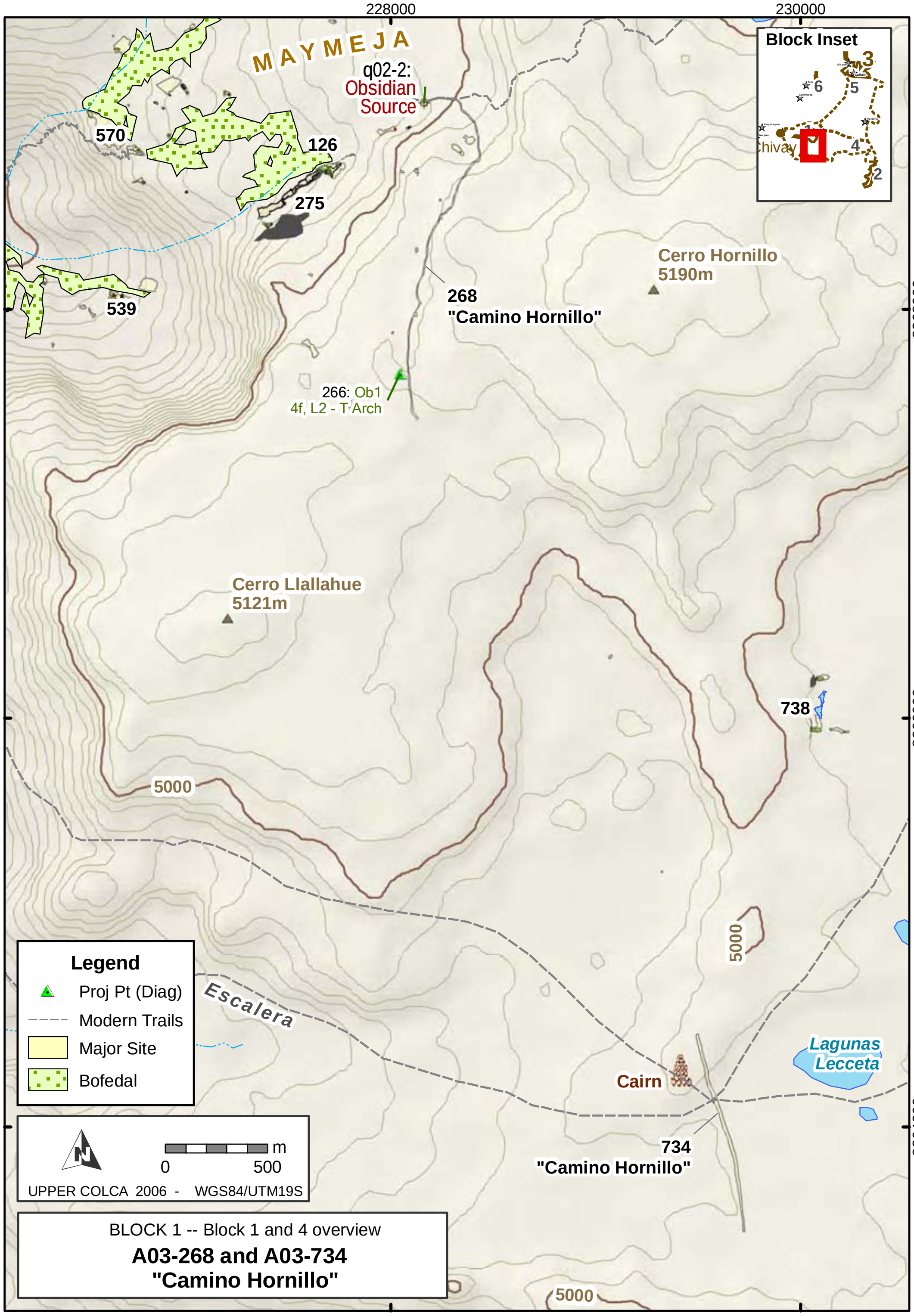


Figure 6-46. A03-269 and A03-734 "Camino Hornillo" and modern trail system.

No ceramics or architectural features were found in association with this road, and the only temporally diagnostic artifact identified was an obsidian type 4f projectile point diagnostic to the latter part of the Late Archaic and the Terminal Archaic. The construction of the swept road is being interpreted here as Terminal Archaic – Early Formative in age because it is associated with a workshop that contained radiocarbon dating to that time, and this date is further supported by the presence of the Terminal Archaic projectile point along the route.

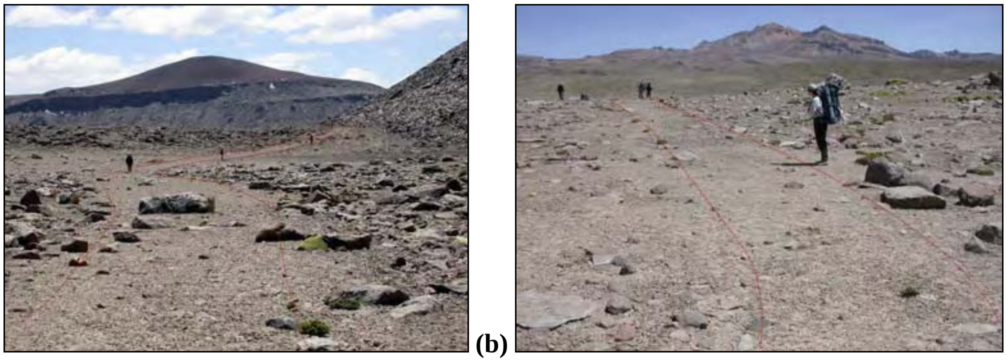
At 4 km from the quarry pit, the southern segment [A03-768] of Camino Hornillo meets the Escalera route, a large trail that appears to have been a major thoroughfare for pack trains climbing steeply out of the Colca Valley to the puna and off towards the East-South-East (the direction of Lake Titicaca). A relatively large cairn or *apacheta* stands on top of a boulder just northwest of this significant intersection, probably a guidepost marker in an otherwise open and featureless expanse.

Figure 6-47. Apacheta (cairn) close to junction of the Escalera route with Cerro Hornillo.

While there were no artifacts associated with this cairn to facilitate dating its construction, the practice of contributing stones to cairns by passersby suggests that large cairn have some antiquity (Nielsen 2000: 447-448, 489). These features are associated with ritual activity in a variety of cultures worldwide including the North African Twareg (Rennell 1966 [1926]: 293), Tibetans (Trinkler 1931: 72), and other Himalayan highland groups (Valli and Summers 1994: 11). While cairns are abundant on an adjacent pass at Patapampa along the principal Arequipa highway to the Colca, those cairns have become a focus for tourist activity and many are the result of modern construction by passing tourists.

Today, the route of the modern Chivay – Arequipa highway has shifted traffic to Patapampa and around south side of Cerro Huarancante, and as a consequence these more ancient travel routes long used by pack animals, see little modern use except by local herders.

Interestingly, Camino Hornillo crosses the Escalera route and continues with the same width and definition in the direction of Nevado Huarancante to the south, as if the role of Camino Hornillo was more than simply a spur on the larger trail network in the direction of the Chivay obsidian source. Beyond the Lecceta-Escalera pass area, the Camino Hornillo [A03-734] begins climbing a hill and disappears again into sandy soil. Due to time constraints the 2003 field season team was not able continue following this road, but the route suggests that there was an objective in the southerly direction beyond the Escalera thoroughfare.



(a) (b)

Figure 6-48. Camino Hornillo showing (a) A03-268 and (b) A03-734 segments. Photos were digitally modified to highlight the route in red.

The Quebrada Escalera route (in the southwest portion of Figure 6-46), which is now primarily a narrow footpath, seems to have had varying degrees of historical importance as access route in and out of the Colca. As reviewed in Section 3.2, the ethnographic accounts of caravans arriving into the Colca from the eastern puna are numerous (Browman 1990: 404,416-414; Casaverde Rojas 1977; Flores Ochoa 1968: 107-137). These caravans, by necessity, would have had to take one of the relatively steep routes that go to the north or the south of Nevado Huarancante. The route to the south of the mountain, which is the route taken by the modern highway to Arequipa (constructed in 1947 by Conscripcíon Vial), has steep pitches that would have presented obstacles to caravan transport as does the Quebrada Escalera route. Guillet (1992: 27-28) describes the historical importance of the construction of railroad station at Sumbay in Pampa de Cañagua, because with the railroad travel to the city of Arequipa by mule was reduced from being a one week journey to being a 2.5 day trip. One well-established route between Sumbay and Chivay passed through the Lecceta-Escalera area as it skirted north of Nevado Huarancante and descended Quebrada Escalera into the Colca. In sum, two faint segments are apparent of a road referred to here as “Camino Hornillo” that depart the quarry pit [q02-2] towards the south and arrive at the major travel route represented by the Escalera, but then the route continues southward in the direction of Huarancante. Further study of this road is needed.

Block 1 Reduction and projectile points in the Early Agropastoral period

Consumption patterns in the south central Andes indicate that projectile points are the most frequent artifact type for obsidian, a pattern that becomes particularly strong with Series 5 projectile point production sometime after the onset of the Terminal Archaic circa 3300 BCE An important question in this research is, therefore, “in what form was obsidian leaving the Maymeja zone during a particular time period?”

Part of this question is answered simply by looking at the 2003 projectile point inventory: obsidian Series 5 points are actually relatively scarce in the Maymeja area, and flakes that approach Series 5 projectiles in shape, are not especially common in the collections either (see Table 6-15, above). As will be suggested by the Maymeja excavation data in Section 7.4, distinct groupings of cores and flakes discarded at the workshop suggest that reduction was following a few discrete pathways that might indicate that two trajectories, both the flake-as-core and the flake directly to implement, reduction strategies were occurring at the Chivay source.

Block 1 Early Agropastoralist Settlement pattern

A primary goal of modern pastoralists residing in Maymeja is to guard their flock both during daytime grazing and during the night when rustlers, foxes, and, formerly, mountain lions, are liable to attack the herd (T. Valdivia 2003, pers. comm.). It is evident from regional distributions in the Chivay Source area that during the Terminal Archaic and Formative Period there was a combined interest in herd maintenance with obsidian production. A key feature of the Maymeja area is that procuring obsidian from this zone did not require compromising grazing potential for access to obsidian: both appear to have been available on the southern margins of Maymeja.

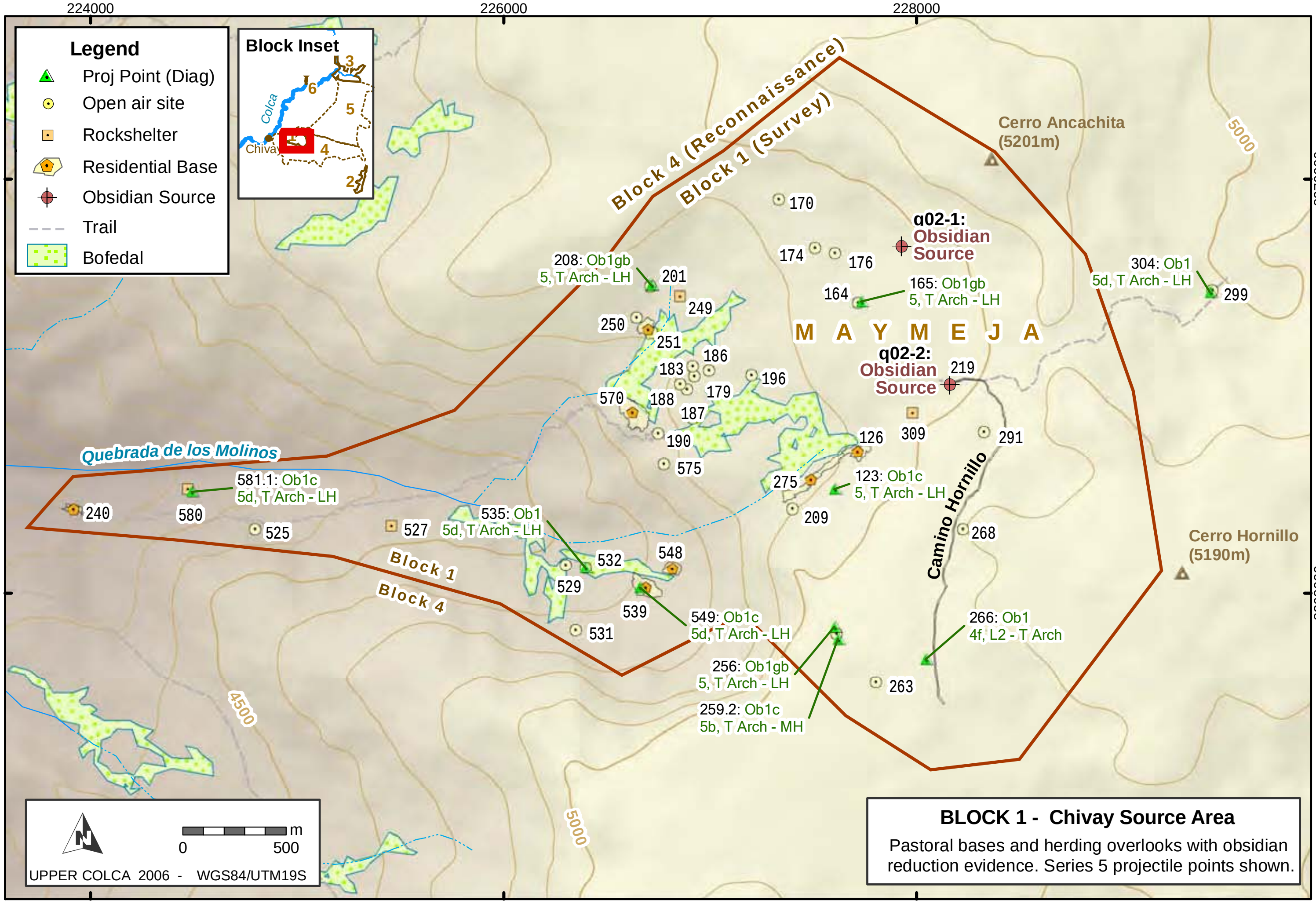


Figure 6-49. Block 1 possible Early Agropastoral settlement pattern with Series 5 projectile points.

Residential bases: Several large sites were identified that have been interpreted as residential bases for herders. These residential bases include corrals, possible remnants of residential structures, and site maintenance activity such as the discard of lithics in discrete areas. These bases represent probable overnight camps.

Open air sites: Small sites, consisting typically of a windbreak and a small obsidian scatter overlooking a bofedal, are distributed throughout the Maymeja zone. These small camps, described here as “open air sites” are probable day-use overlooks for herders.

Rock shelters: A number of small rock shelter sites were also encountered in this area. These are typically very small rock shelters, often no more than a small overhang of a boulder or the edge of a lava flow. The shelters commonly contain a small scatter of obsidian flakes, and sometimes cores, at the dripline of the rock shelter.

Miscellaneous other site types: Other kinds of sites include an obsidian quarry pit [q02-2], and Camino Hornillo [a03-268] which is a route leading to the quarry pit from the south.

A03-126 “Maymeja 1”

On the southern edge of Maymeja a site was located that contained a dense mound of flaked obsidian, an extensive scatter of obsidian, traces of terracing and wall building, but virtually no ceramics. Dates from a 1x1m test unit [Q02-2u3] placed in the obsidian mound (Section 7.4.2) showed that this site was occupied from at least the Terminal Archaic until the end of the Early Formative.

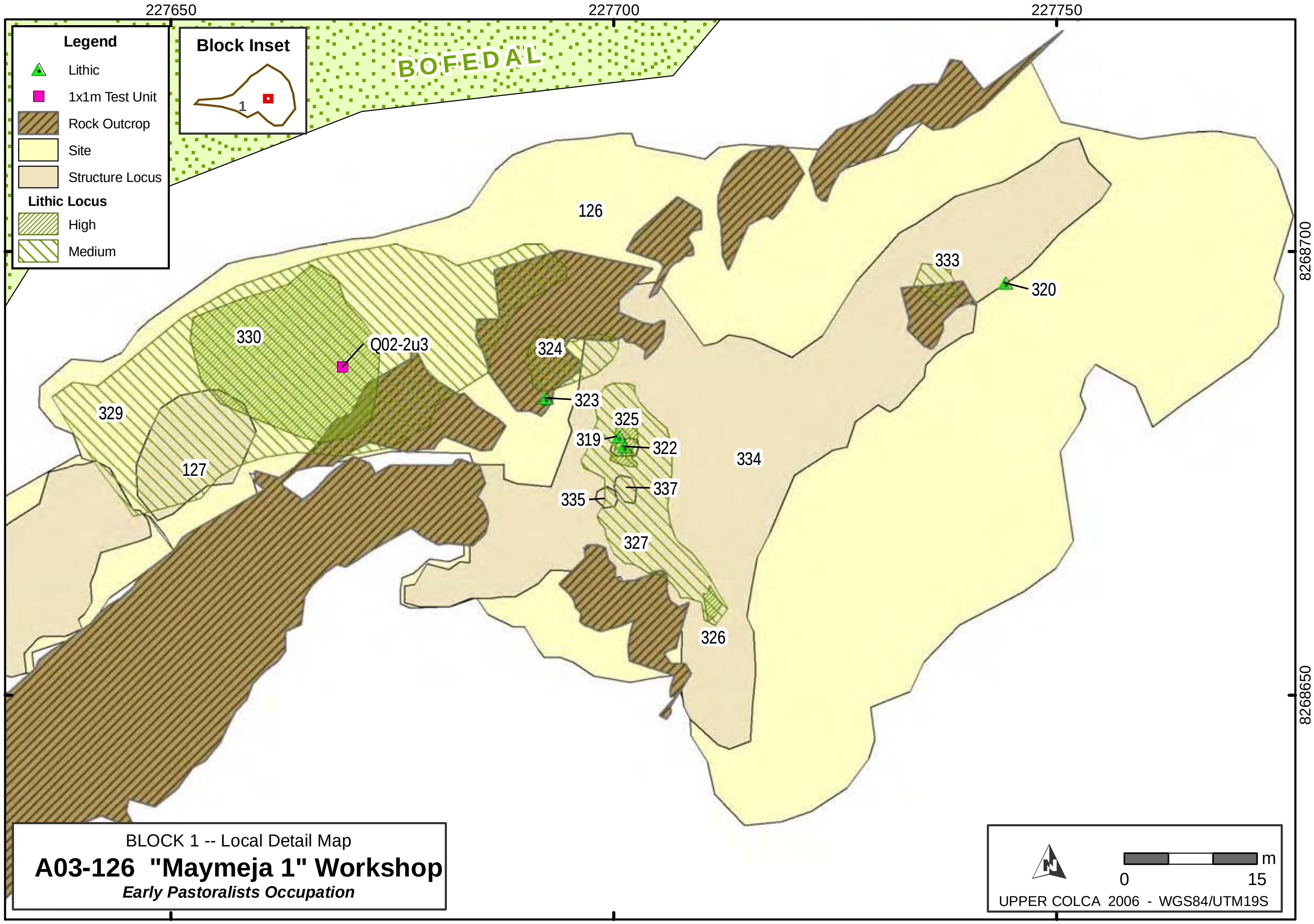


Figure 6-50. A03-126 "Maymeja 1" workshop and vicinity.

Maymeja 1 [A03-126] belongs to a complex of features that have been divided into an upper site A03-126, and a lower site A03-275 that has some LIP and LH component. This complex is located on the dry southern margins of the Maymeja area where viscous lavas emanating from the Cerro Hornillo vent slope downwards to the northwest into the depression referred to as Maymeja. Subsequent glaciation polished these lavas into smooth banks with excavated depressions that offer adequate shelter in this exposed region. The shelter and abundant sun in this north-facing zone is compensated for by the mountain winds that blow with regularity in the area.

Figure 6-51. View of A03-126 "Maymeja" from north. Terraced area A03-334 on upper level. Test Unit Q02-02 is just right of the orange bucket. Project tents are visible in corral A03-127.

(a)  (b) 

Figure 6-52. (a) Workshop area of "Maymeja 1" showing proximity of bofedal, (b) Testing Q02-2U3, with the quarry pit [Q02-2] visible among light ash 600m uphill in the background.

The residential base of A03-126 consists of two principal zones that show human modification: (1) the upper area above the polished lava bluffs visible in Figure 6-51, and (2) a lower zone that abuts the bofedal to the north. As the area is almost devoid of ceramics the primary indicators of occupation are lithic scatters of varying density and with highly eroded walls and terraces. The central greatest concentration of flaked stone is the workshop area labeled as a high density lithic locus [A03-330], shown on Figure 6-50.

Arch_ID	Site_ID	Feature Type	Description1	Description2	Area_m²
126	126	Site	"Mayemeja 1"	Workshop and upper sector	6,007.0
127	126	Structure Locus	Walls	Corral area	130.6
275	275	Site	"Mayemeja 5"	Lower slopes parallel to bofedal	10,401.4
276	275	Structure Locus	Wall bases only	Eroded terraces along lower slope	1,414.2
277	275	Structure Locus	Wall bases only	Eroded terraces along lower slope	978.2
278	275	Structure Locus	Wall bases only	Eroded terraces along lower slope	524.6
279	275	Structure Locus	Wall bases only	Eroded terraces along lower slope	1,234.2
280	275	Structure Locus	Wall bases only	Eroded terraces along lower slope	4,306.6
324	126	Lithic Locus	Medium Density	Concentration in on top of lava outcrop	49.6
325	126	Lithic Locus	High Density	Flakes washing down from structures	12.4
326	126	Lithic Locus	High Density	Concentration in sheltered area	4.5
327	126	Lithic Locus	Medium Density	Expanse of flaked stone	182.4
328	126	Lithic Locus	Low Density	Light scatter coterminous with site bndy	2,942.7
329	126	Lithic Locus	Medium Density	Expanse of flaked stone	940.5
330	126	Lithic Locus	High Density	Workshop mound	292.1
333	126	Lithic Locus	Medium Density	Concentration in sheltered area	15.6
334	126	Structure Locus	Wall bases only	Eroded terraces along lower slope	1,504.4
335	126	Structure Locus	Wall bases only	Base of circular structure	4.3
336	126	Structure Locus	Wall bases only	Base of circular structure	5.2
337	126	Structure Locus	Wall bases only	Base of circular structure	5.5

Table 6-48. Areal features belonging to A03-126 and A03-275 workshop complex.

Spatial features in this area were initially delimited with dGPS and then, during a visit in 2004, the boundaries of the smaller structural features were remapped with a total station.

Terraces and structure bases

At an altitude of nearly 5000 masl in sandy soil, this area is far above the growing zone even for tubers. If these were residential terraces, where were the ceramics? One possible explanation was provided from three ^{14}C samples from the workshop test unit [Q02-2u3] that revealed that the workshop occupation belonged to the preceramic and very early ceramic period. It appears that that the dominant component of this site is from prior to the use of ceramics in the area.

The terrace margins are generally highly eroded and ill-defined in places, and the focus in 2003 was therefore on mapping terraced zones as several large polygon areas rather than attempting to map each terrace as a linear feature. The upper terraced area [A03-334] was particularly eroded, but faint traces of intermittent terraces were apparent. The terraces walls, and wall bases that appear to have been small circular structures, are single walled with no mortar. The sole exception was a corner of doubled-walled construction made of ground fieldstone in the lower terraced area [A03-276] where the corner of a structure of cut-stone masonry of possible Late Horizon date was located, a feature that is described later in the Late Prehispanic Block 1 section.

The eroded terraces of A03-275 are generally 20-50cm in height and are constructed with fieldstones of a variety of sizes. Typically, a few large boulders will form the general structure of the terraces, and then small level surfaces would be constructed by building terrace walls of the flat local lava rock. It is difficult to date these constructions but due to the presence of sherds from several Inka plates, and a possible LH feature, these terraces are further discussed in the Late Prehispanic section titled A03-275 “Maymeja 5”, along with several photos of these constructions.

In the sector of A03-126, above the bofedal margin, several small circular structures [A03-335] of possible Early Agropastoralist age were identified. These structures consist of circular wall-bases with concentrations of obsidian eroding downslope from the interior area. Two adjacent circular constructions were in the middle of an eroded terrace, but the predominant pattern was for small circular constructions measuring 2-3m in diameter to be built adjacent to rock outcrops that appear to offer protection from the western winds. These small wall-bases were observed along the expansive rock outcrop that extends just south of the bofedal. No hearths or bones were observed in this area, although bone preservation would probably be very poor in this exposed area.

Figure 6-53. Base of structure [A03-335] is formed by fifteen large, partially buried stones and measures 2.5m in diameter.

These structures are being interpreted as residential constructions or windbreaks occupied on short term basis by obsidian procurers who were allowing their animals to graze while they quarried and reduced obsidian from the Maymeja area, and perhaps dug the quarry pit Q02-2. Herders would presumably have had sufficient animal hides and woolen textiles to insulate stone walled structures from the penetrating winds.

It is also conceivable that these are bases for large circular LIP *chulpas*, as the wall bases are sufficiently large. This is unlikely, however, as there were no LIP ceramics in the area, and the obsidian flaking debris eroding downhill strongly suggests that obsidian reduction was occurring inside these circular structures.

Workshop mound

The workshop mound [A03-330] forms the largest and highest density of flaked obsidian observed in the Upper Colca project region. The 1x1m test excavation in this mound (Section 7.4.2) revealed episodes of reduction activity that generated cultural levels with distinctive concentrations of knapping debris associated with early stage reduction. The flake densities attenuate away from the mound center where the test unit was placed, and immediately south-west of the mound a corral is evident that is probably relatively ancient. One possibility is that animals were loaded with obsidian inside the corral subsequent to knapping at the workshop.

A03-209 "Maymeja 7"

Approximately 700m to the south-west of the workshop area another concentration of culturally derived obsidian flakes was encountered, and this concentration was distinct in that it was well-removed from the area with naturally abundant obsidian. A small cavity in a rock face was located with what appeared to be a wall in back and a large obsidian scatter extended down the hill below the wall cavity. The rock cavity may have contained a burial at some point, but the space was empty save for a few LIP sherds. This reduction zone was notably distant from the obsidian source, away from the bofedal, and was uphill and on a relatively steep slope (25º) high above any of the eroded terracing. Given the density of this reduction area, including two high density loci measuring $17m^2$ and $39m^2$, the best explanation appears to be that this site conforms to the previously observed pattern of obsidian reduction occurring on the western lip of the Maymeja area where the views westward are excellent (see interpretation in Section 8.3.3). The mean visibility value for features in Block 1 overall is 18.5, while the visibility value for A03-209 is 31, or 40% higher than the average visibility in Block 1.

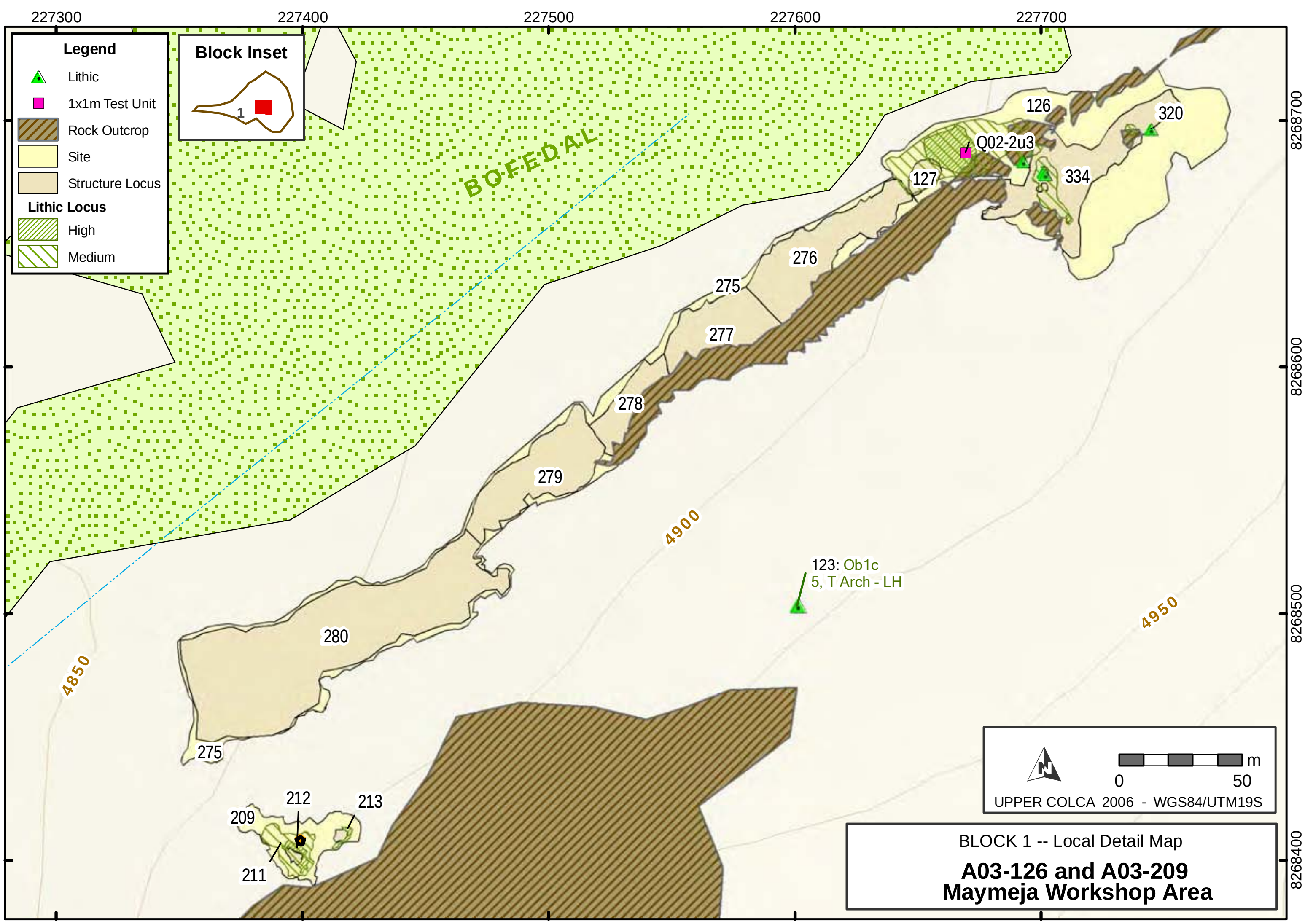


Figure 6-54. A03-126, 209, 275 Maymeja workshop and vicinity.

A03-201 “Saylluta 2”

This site consists primarily of a medium sized corral built among large colluvial boulders that have descended from the north margins of the Maymeja area. The area is littered with obsidian flakes, and natural and culturally fractured obsidian flakes cover the ground. It is perhaps due to the extensive glaciation in the area that the sandy soils of this corral contain a low density of geologically fractured obsidian flakes.

Figure 6-55. View looking south from above at A03-201 "Saylluta" with excavation of test unit Q02-2u1 under way in top center of corral by the orange bucket. Site datum is on top of the large boulder to the south of Q02-2u1 (just above test unit in the photo).

The corral offers excellent protection from the mountain winds that prevail on the southern edge of the Maymeja area, but at the cost of warmth from direct sunlight. In early August the sun would disappear from this area around 4pm. As is visible in Figure 6-55, a wall between 1.5m and 2m in height encircles this corral, and constructed stairs access the corral from the south. A fan of flaked obsidian, bone fragments, and a few unslipped, unpainted pottery fragments extends 20m downslope from the access stairs to the edge of a grassy area that has probably been a bofedal during wetter times.

A test unit [Q02-2u1] was placed on the southern half of this corral, and it revealed a fill of sandy local soil, and perhaps camelid dung, that was used to level out this corral in an otherwise sloping area. A discouraging colonial-style nail was encountered in level 4 of this test unit, suggesting a post-conquest occupation, nevertheless the test unit was excavated to sterile where large, irregular rocks cover the base of the 1x1. No distinctive prehispanic features were identified, and as yet the small pieces of carbon recovered from this test unit have not been analyzed with ^{14}C dating.

This corral is a suitable shelter from wind and it is also relatively well hidden and could serve as a refuge as it goes unnoticed among the talus boulders of northern Maymeja. Due to the lack of sunlight during the winter months, and the relative scarcity of water adjacent to A03-201 under current conditions, this location is thermally a less comfortable camp as compared with the sites on the southern edge of Maymeja.

A03-570 "Valdivia 1"

At the lower end of Maymeja, close to where the principal trail arrives in the zone from Chivay, a large obsidian scatter was encountered adjacent to an active estancia owned by Eliseo Vilcahuaman Panibra but occupied by Timoteo Valdivia who was hired to guard the herd. The site of A03-570, defined by a low density scatter of obsidian flakes, occupied the entire east slope of a large breccia promontory that forms one of the distinctive landmarks on the western edge of Maymeja. A relatively large (419m^2), medium density scatter [A03-572] is located on the northern end of this area, where the water from the northern half of Maymeja cascades over the breccia layer and descends steeply into Quebrada de los Molinos.

The site of “Valdivia 1” [A03-570] appears to be a prime site for occupation by pastoralists. The excellent views of two of the largest bofedales in the Maymeja area, extensive sun throughout the day, and a position on the lee side of a promontory protecting it from the westerly winds make this place a desirable location for pastoralists in the area. This site, and the adjacent site of A03-190 at the head of the trail from Chivay, belong to a cluster of sites that occupy the steep western margin of the Maymeja area and that provide sweeping views of the Quebrada de los Molinos. This site has a high visibility index, particularly from the lithic locus A03-571, where a visibility index value of 40.6 was calculated that can be compared with a mean visibility index of 18.5 for sites in Block 1. An interpretation of these viewshed values is discussed in Section 8.3.3.

A03-539 “Mamacocha 5” and A03-548 – “Mamacocha 6”

These pastoral bases in the upper end of Quebrada de los Molinos have been considered bases because of the remnants of large corrals found in therein. However, these sites lack temporally diagnostic materials. This area consists of moraines with large lava boulders that have descended from the steep slopes above and offer wind protection as well as a few small rock shelter features.

Blocks 4 and 5 Reconnaissance Areas

The diffused nature of pastoral settlement was evident from the distribution of land use observed in the extensive Blocks 4 and 5 zones. These areas primarily consist of rugged lava terrain that appear desolate in the dry season. In the wet season, however, there are probably adequate grazing opportunities through these areas. By distributing pastoral impacts over the larger landscape during the wet season, the bofedales would be allowed to recover.

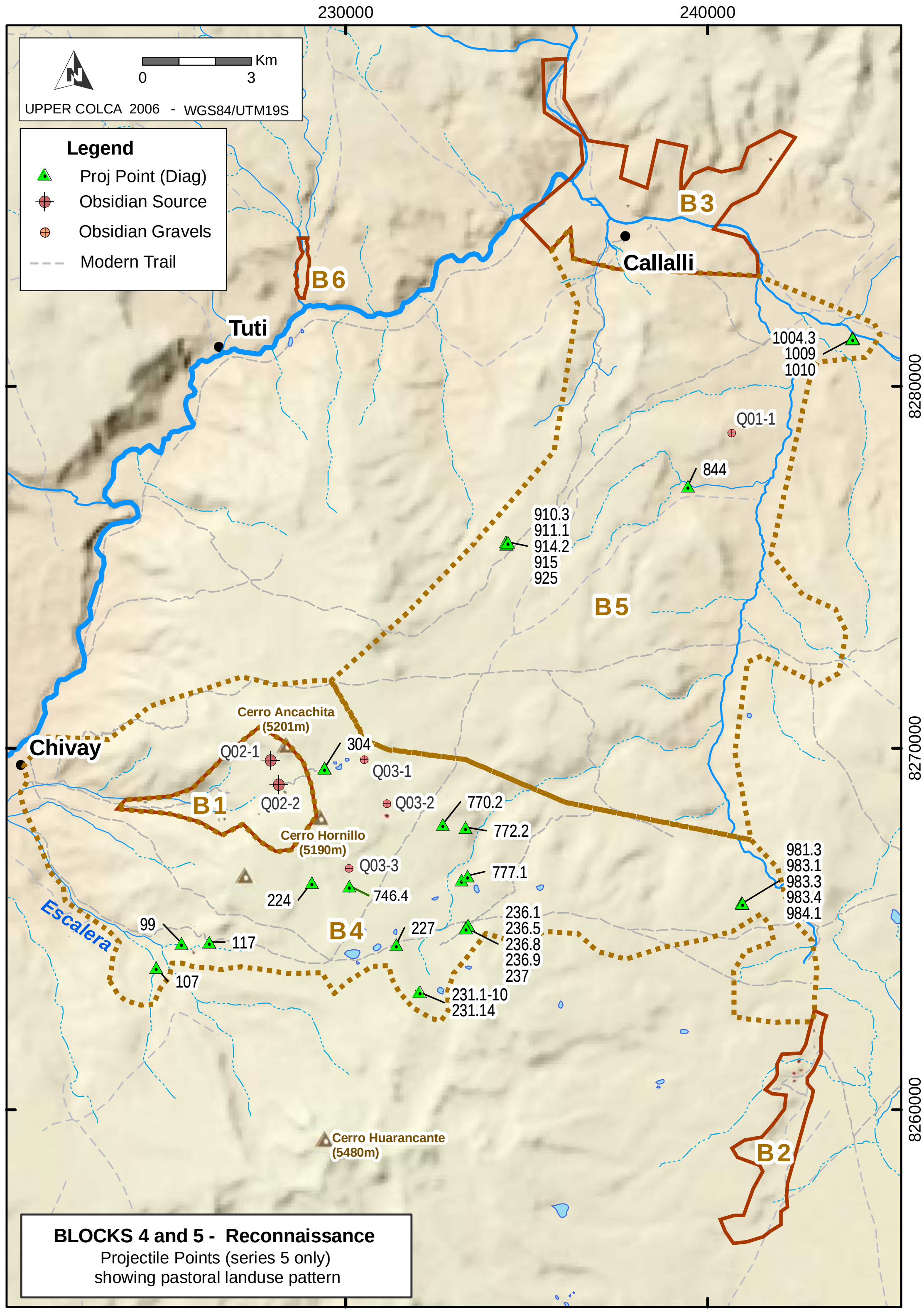


Figure 6-56. Blocks 4 and 5 showing Series 5 projectile point distribution.

Series 5 projectile points are not exclusive to the Early Agropastoral period, but given the increase in obsidian production during that period, this dataset provides a perspective on this period that is not available for this transitional stage between diagnostic lithic and ceramic technologies. One informative aspect of the Blocks 4 and 5 projectile point distributions is from the types of obsidian in use for projectile point manufacture. Recall that much of the obsidian surface gravels available at around 4975 masl on the eastern flakes of Cerro Hornillo contain deficiencies either because they contain heterogeneities or because they derive from smaller nodules. Projectile points from Blocks 4 and 5 are almost never made from material with heterogeneities.

Proj Points	Ob1	Ob2	Volcanics	Total
5	25	1	1	27
5a	2			2
5b	2			2
5d	9			9
Total	38	1	1	40

Table 6-49. Material types for Series 5 points in Blocks 4 and 5.

This table demonstrates that despite the proximity of many of these sites to Ob2 surface obsidian gravels with heterogeneities, the Ob2 material was almost never used for point production. The obsidian observed on the eastern flanks of Hornillo did not entirely consist of Ob2 material with heterogeneities. In fact, the Q03-3 source south of Hornillo contained nodules measuring 15 cm across free visible heterogeneities. The Q03-3 material, however, did not appear as transparent as the Q02-2 glass from Maymeja.

Discussion

During the Early Agropastoralist period in the obsidian source area observed what appears to be intensive obsidian production in the initial stages of reduction at a workshop 600m downslope from the quarry pit, as well as evidence that suggests that obsidian was being transported away from the Maymeja area as whole nodules.

6.4.2. Block 2 – San Bartolomé

As with the obsidian source area, the economic pattern from the San Bartolomé area is predominantly pastoralist, making it difficult to isolate sites belonging to the Early Agropastoral period from Late Prehispanic and colonial period camelid pastoralist sites. The unslipped, unpainted pottery with a brushed interior resembling the Chiquero type is found in this area, but the pastoral camps are mostly multicomponent such that sherd concentrations on the surface are largely mixed with painted styles, colonial styles and utilitarian modern pottery. The majority of these pastoral sites contain obsidian flakes and virtually all the obsidian is the Ob1 obsidian that derives from the Maymeja area of the source.

It should be noted that hunting opportunities abound in this area, and textured landscape atop the lava flow area of Block 2 is popular with hunters to this day. Herders during the Early Agropastoral period probably supplemented the returns from the herds by hunting *viscacha*, *taruca* deer, and perhaps wild camelids.

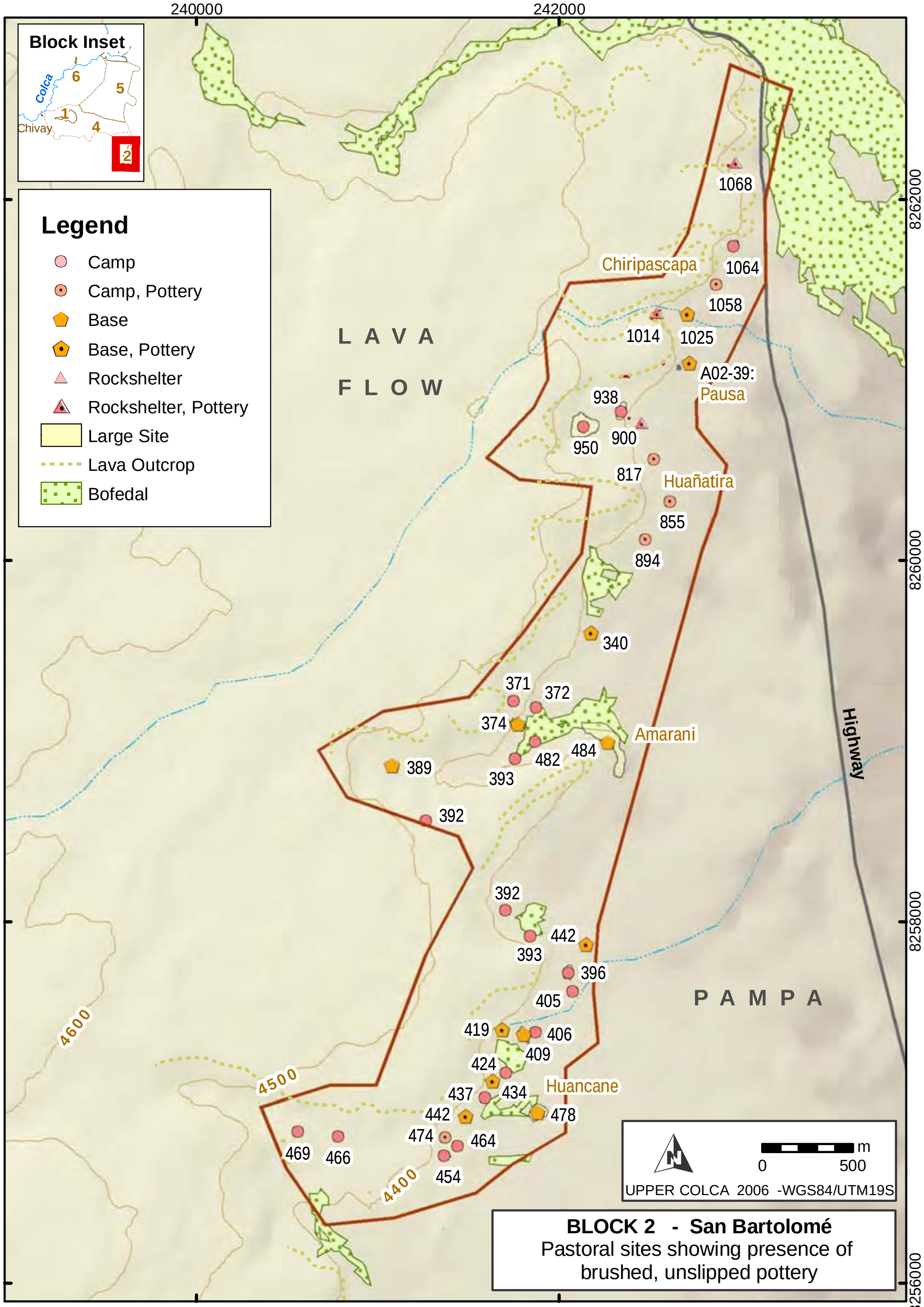


Figure 6-57. Block 2 - Early Agropastoral occupation.

Evidence from ceramics

While single-component sites are rare in Block 2, most sites conform to a distributed pastoralist settlement pattern, spatial patterning is evident in the distribution of a brushed, unslipped type of pottery in neckless olla forms in Block 2. This pottery type bears resemblance to the Chiquero type proposed for the Formative Period in the main Colca valley by Wernke (2003). However, as will be discussed further, test excavations found pottery with similar characteristics in contexts dated to the 1313±36 B.P. (AA56939; A.D. 650 – 780) in the Block 3 area, suggesting that this pottery style continued to be used in the highland areas. Nevertheless, as shown in Figure 6-57, pastoral sites with wiped and unslipped olla sherds were found in two relatively discrete clusters in the Block 2 survey area. These sherds were found in a large cluster on the north end of the survey, and then none from A03-340 south to A03-442, and a small cluster is found in the southern most group of sites in Block 2. In other words, in the center of the survey was a zone where these pots were not encountered. The spatial patterns associated with the presence of unslipped, unpainted ceramics should not be over-interpreted because undecorated ceramics were not an artifact type that was rigorously sampled in this survey work. Furthermore, a number of small, a-ceramic sites were encountered that had pastoral attributes, such as small corral areas and relatively good access to water, yet no ceramics of any kind were evident. It is difficult to establish the antiquity of such sites, but it is possible they date to earlier stages of the agropastoral economy when ceramics use was .

It is worth noting that there was a strong association observed between high-density lithic loci predominant in obsidian raw material, and sites with this wiped, unslipped pottery type. Of the 22 high density lithic loci, 19 of them (86%) fell in sites that also had the unslipped, possible Formative (Chiquero) pottery in question. Among medium density scatters the pattern was less dominant. Of the 23 medium density lithic loci, 14 (60%) were found in sites with the unslipped pottery. While sites and surface artifacts are highly commingled in this area, these patterns suggest that obsidian production was associated with the pastoralists who made use of the wiped, unslipped olla design. Due to the limited sampling of unslipped ceramics, the associations between this pottery type and obsidian reduction are not certain.

Pastoral site classifications

The evidence of extensive pastoral production along the margins of the pampa in Block 2 consist primarily of the structure bases from pastoral features along the margins of grazing area, primarily corrals, and associated artifact scatters. These pastoral facilities can be subdivided in terms of the size of the corral features and the apparent length of occupation based on artifact densities. Environmental characteristics do not help with isolating pastoral site groups, perhaps because the priority placed upon access to pasture dominates the site placement criteria. The mean slope of pastoral sites of various groupings in Block 2 is between 7-8°, and the most well-represented aspect for sites was the eastern aspect, accounting for 40 Block 2 sites.

Pastoral Bases

These are the largest sites in Block 2. They consist of pastoral facilities, associated residential structures and adjacent middens, and an artifact scatter extending along the margins of the grazing area. These sites are commonly found on a sloping area or a raised area along the margins of the pampa where the drainage is adequate. Animal control structures were frequent on these sites, with the majority of them taking the form of maintained or abandoned corrals of varying sizes. At the sites designated as "Pastoral Bases", corral structures were mapped and they range in area from 62 m^2 to 4,306 m^2 with a mean corral size of 671m^2. Due to high rates of erosion, it was difficult to confirm from the soil consistency if it was largely dung soil inside of structures that appeared to be long-abandoned corrals. However, the raised area of these corrals are effectively low mounds that may be the result of accumulation of dung over long time periods, combined with some building up and filling in of the raised area to lift the corral areas off of the level of the pampa to improve drainage and avoid inundation during the wet season.

Structures

These structures on the puna edge appear to be pastoral facilities containing the bases of walls formed by rocks between 30 cm and 100cm in size that create a circular or elliptical enclosure. The area will often contain smaller enclosures that probably served more specifically as corrals, subdividing the protected area. These corrals might be occupied simultaneously or sequentially, and could contain individual herder's animals, or they may segregate the herd into sex and age categories as a part of pastoral management strategies (Flannery et al. 1989; Flores

Ochoa 1968). The presence of such large rocks at the base of these walls is perhaps explained by the need to keep small animals, such as young camelids, inside and the need to keep small predators out. Modern herder-built walls are often solidly constructed along the base and only along the top of the wall do smaller rocks get used.

These wall bases could be the remnants of corrals used by seasonal residents of this rich pasture region, or if they were used by passing caravans, the corrals could have been important facilities as part of a multi-day rest stop for caravans (Nielsen 2000: 461-462, 500-504; Lecoq 1988: 185-186; T. L. West 1981a: 70).

Artifact scatters

The perimeters of pastoral bases often have dense artifact scatters, including pottery fragments from a variety of time periods, however there was a relatively low frequency of high density lithic loci inside of pastoral bases. When all of the high density loci are considered, only 30 (23%) of the high density lithic loci were located in sites classified as "pastoral bases".

High density lithic loci in this region primarily consist of obsidian flakes and it appears that, despite being located off of the pastoral base sites, these high lithic concentrations still seem to be associated with early pastoral occupations. This inference is based on two aspects of these high density loci: (1) most of the pre-Series 5 projectile points are not obsidian, while most of the Series 5 points are obsidian, and therefore if point production was occurring they were probably making Series 5 points; (2) if merely flakes were being produced, such production was probably linked to pastoral butchering, and therefore the obsidian is again linked to the pastoral occupation of the area. Why, then, were the high concentrations located outside of the pastoral base areas as noted above? One possibility is that one may be seeing a site maintenance pattern where some lithic production is occurring offsite during pastoral herding so that the residential base is not littered with sharp flakes.

A02-39 "Pausa 1"

The site of Pausa 1 was initially visited in 2002 following consultation with Dr. José Antonio Chávez (2001, Pers. Comm.) who explained that this entire area had been visited, and partially collected, by his student groups in the 1980s. Despite the earlier collection programs by Arequipa students, the 2003 survey team was able to locate large quantities of projectile points and some ceramics of both local and non-local stylistic groups. As described above, the raised corral structures are found along the edge of a large pampa paralleling the base of a lava flow from Huarancante. The broadest of these corral structures, and the group with the most interesting wall-base constructions, were the oval structures of Pausa. With a permit from the INC to place up to four 1x1m test units in this site the 2003 field team spent a number of weeks testing this site as reported in Section 7.5. These test units revealed an occupation spanning the Late Formative Period, but ceramics and mortuary structures from later periods were also encountered here.

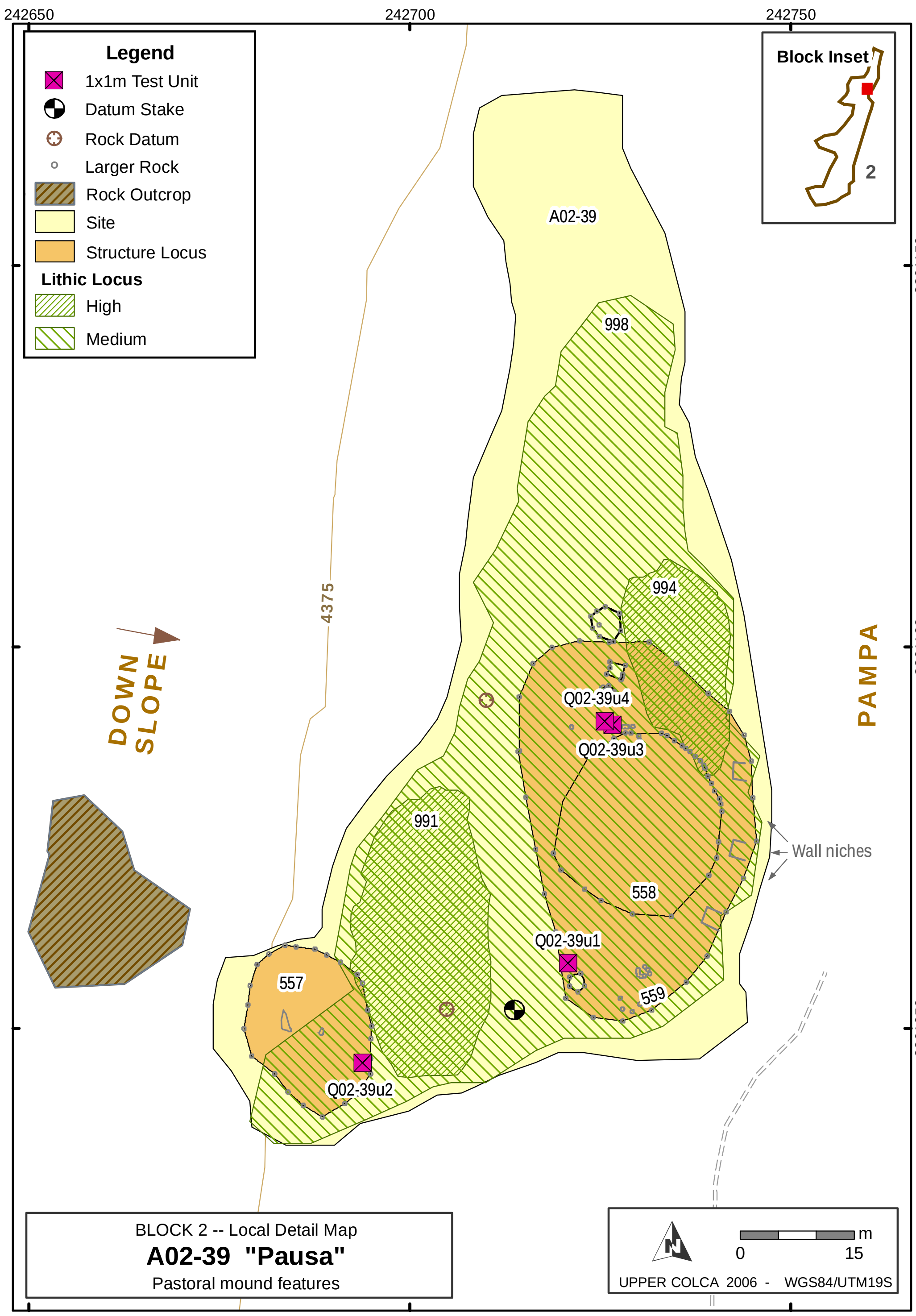


Figure 6-58. Pausa [A02-39] showing raised oval structures, lithic concentrations, large rock forming wall bases, and test unit locations. Site mapped with Topcon total station and dGPS.

ArchID	Description	Number of large rocks	Dimension (m)	Size (m^2)
A03-557	Raised surface on slope to southwest of main Pausa site encircled by large rocks. Fill on downslope edge leveled the internal area.	26	15 x 20m, circular	271.8
A03-558	Area in center of Pausa site encircled by large rocks.	28	20 x 25m, circular	441.7
A03-559	Oval area raised ~1m off of the pampa and encircled with large rocks including a distinctive wall construction on east side with three niches in wall.	27	30 x 50m, oval	1175

Table 6-50. Dimension of structural features at Pausa [A02-39].

The structures at the Early Agropastoralist base of Pausa include two large, raised corral areas that are most evident because large rocks form a circle that appear to be wall bases from old corral walls. The largest of these rings is oval [A03-559] and it contains a smaller, circular structure [A03-558]. The larger rocks that encircle these features and form the wall bases are between 50cm and 100cm across, and the rocks are partially buried. Interestingly, the ovals all have approximately the same number of these large rocks (between 26 and 28), such that encircling the larger ovals the spacing between the rocks is larger than it is around the smaller ovals. As is evident in Figure 6-58, the rock spacing around A03-559 is approximately 5-7m, the spacing in A03-558 is highly irregular, and the spacing between rocks in the A03-557 oval is approximately 2-3m between rocks. The rocks could have represented the foundation rocks for corrals, but these would have been very substantial corrals and far larger than any contemporary corrals that were encountered in the region.

Figure 6-59. Circular structure A03-557 extends from 1m behind the tape to just below the largest rocks at the back of the photo.

Figure 6-60. Testing u3 and u4 on north edge of structures A03-558 and A03-559. This photo is taken from above, from the base of the lava flow.

Lithics

The site of Pausa was somewhat atypical of Block 2 raised corral features due to the size and diversity of materials found there. The material types in use indicate that, while a variety of material types were available, obsidian was more intensively processed in this area than other material types.

	Ob1	Ob2	Volcanics	Chert	Total
Cores	1	1			2
Flakes	52	7	5	10	74
Points & Tools	8	1		1	10
Total	61	9	5	11	86

Table 6-51. Counts of lithics from surface collection at Pausa [A02-39].

Table 6-51 can be compared with the surface collection at Taukamayo in Block 3 (Table 6-54) where surface materials point to a greater availability of chert and quartzite in Block 3. While Pausa is somewhat deflated and eroded in places, it did not have a landslide like the site of Taukamayo exposing quantities of obsidian.

Discussion of Pausa

Pausa appears to have been one of the larger and more varied sites in the Block 3 settlement area, yet, based on surface artifacts, the activities at Pausa were fairly typical for these raised corral features. These include a variety of lithic reduction but, above all, a dominant presence of Ob1 obsidian. This relatively consistent access to Ob1 obsidian suggests that the Early Agropastoralists of Block 2 were affiliated with, or directly responsible for, some of the quarrying and production activities that were observed in the Block 1 Maymeja area.

The size of these structures, the regular spacing of large rocks, and the presence of regular rock “wall niches” on the eastern edge of A03-559 suggest that these platforms served as more than mere corrals and there this was also a locus for ritual activity. Obsidian was widely used in the Block 2 area on the whole, but the quantities at Pausa appear to have been far greater than at neighboring sites. It is possible that this site served as some kind of aggregation spot in the Block 2 puna, although it is difficult to speculate without further examination of this site. Test excavations revealed primarily a small hearth in a very small circular structure (Section 7.5.2), and evidently further excavation work is needed at Pausa.

Pastoral Camps and rock shelters

The two smaller collections of Early Agropastoral sites in the Block 2 are grouped as “Pastoral Camps” and “Rock shelters”. These sites consist of small enclosures and limited surface expression of ceramics from the Formative Period. The rock shelters often have geometrical, abstract parietal art on natural walls drawn in ochre. Often these sites will also have colonial rock art, typically Christian themes (such as the cross, or a Virgin Mary) in ochre as well, but these were excluded here from this review of prehispanic sites. The smaller sites could have been day-use areas as part of a strategy to distribute the impact of grazing. The rock shelters were generally small and may have been day shelters from weather as well as night shelters for very small groups.

Discussion of Block 2 Early Agropastoralists

Depending on the degree of re-occupancy in prehistory, the principal pastoral base sites with their associated corrals that were recorded are larger than one would expect given modern pastoralist behavior in the area. The herd sizes that noted in the Block 2 area during fieldwork between August and December 2003 were not carefully studied, but the herds seemed sufficiently large to use a corral 50m long corral as was noted at Pausa. However, herds would not require many corrals like Pausa in one area unless the herd sizes were significantly larger, perhaps growing and shrinking with the seasons. There are corrals of comparable size in the region, but the uncertainty lies in judging how many of these corrals were in use simultaneously.

It is possible that these corrals were used by passing caravans. As a perimeter settlement represented largely by groups linked to Colca Valley communities (as indicated by ceramics styles), it is possible that these larger facilities were designed to host passing caravans.

6.4.3. Block 3 – Callalli

An Early Agropastoral period occupation of the Block 3 area is evident from survey work, but it is less dense than was encountered for this time period in Block 2, and it is also more faint than the evidence from the Late Prehispanic in this the Block 3 area itself.

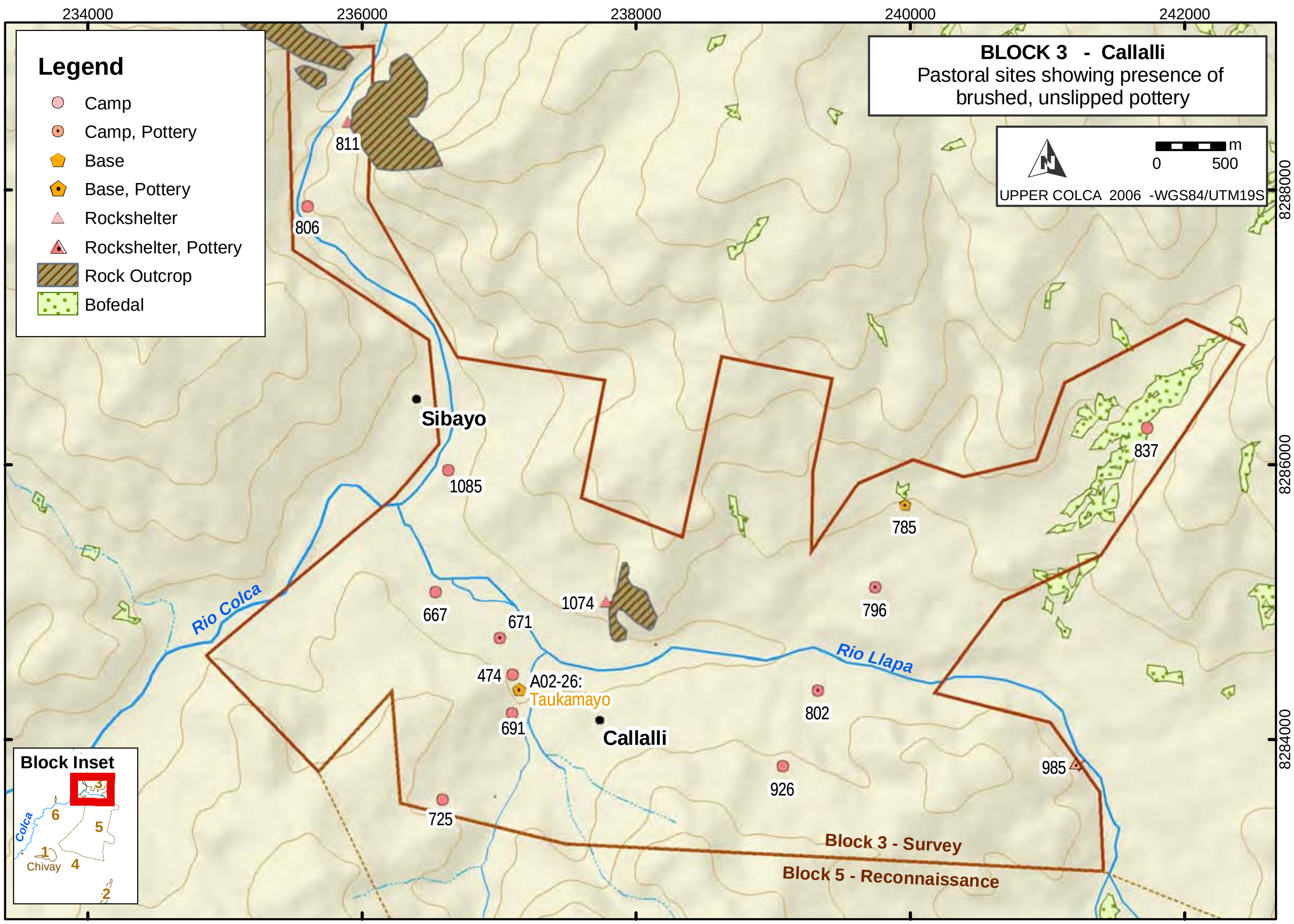


Figure 6-61. Early Agropastoralist settlement in Block 3.

The Early Agropastoral settlement in the Callalli area is difficult to isolate from later pastoral settlement, but the evidence that was encountered suggests that it was a distributed settlement pattern with similarities to the pastoral pattern observed elsewhere in the higher altitude portion study area. The criteria used to discern this settlement pattern were sites with pastoral attributes (grazing lands, water), and the potentially the presence of the unslipped Chiquero type ceramics considered Formative in the main Colca valley by Wernke (2003).

Occupations are generally small and diffuse, with rock shelters and river terraces providing the majority of the settlement locations. The rock shelter of Quelkata [Q03-985], described in the preceding Archaic Foragers – Block 3 section, had a substantial a-ceramic occupation. However the vast majority of the projectile points analyzed by Chavez (1978) appear to fall into Series 5 in the Klink and Aldenderfer (2005) typology, placing the occupation in the Terminal Archaic. Elsewhere in Block 3, several multicomponent sites were occupied during this time period, most notably Taukamayo [A02-26].

A02-26 "Taukamayo"

The multicomponent site of Taukamayo sits on a terrace above Quebrada Taukamayo just west of the modern town of Callalli. In the course of the 2003 survey the site was surface mapped as A03-675 in keeping with the 2003 survey methodology, but the official site number on the test excavation permit is A02-26. The site was tested with a 1x1m test unit and two partial units that produced dates circa cal AD650 (Section 7.6.1).

The site is located on a terrace above a tributary to the Río Llapa immediately upstream of the large confluence with the Río Colca. Located in a parcel owned by Noemi Ramos, who resides primarily in Arequipa, the site is located across Taukamayo creek from the modern village of Callalli. The town site of Callalli has Inka and possibly earlier components evident on the western edge of the town limits, but the occupation encountered at Taukamayo is earlier.

It is possible that Taukamayo was a peripheral site to the principal settlement at Callalli. Nielsen's (2000: 465-468, 490) ethnoarchaeological research on camelid caravans notes that when caravans stop overnight at settlements they will frequently camp in areas segregated from the principal settlement for two reasons. First, interference in the activities of residents, stampedes, and other forms of conflict can be avoided by remaining on the periphery of the settlement. Second, the agricultural fields can be better defended from caravan animals by camping a prudent distance from farm plots. In the modern trail system the principal route linking the Callalli area with the Chivay obsidian source and other high puna regions to the south climbs the Taukamayo drainage. Thus, Taukamayo may have represented a kind node in a larger transportation network because it is a relatively large site lying precisely in the area where the highland trail system joins the river network, but it is across the drainage from the settlement of Callalli.

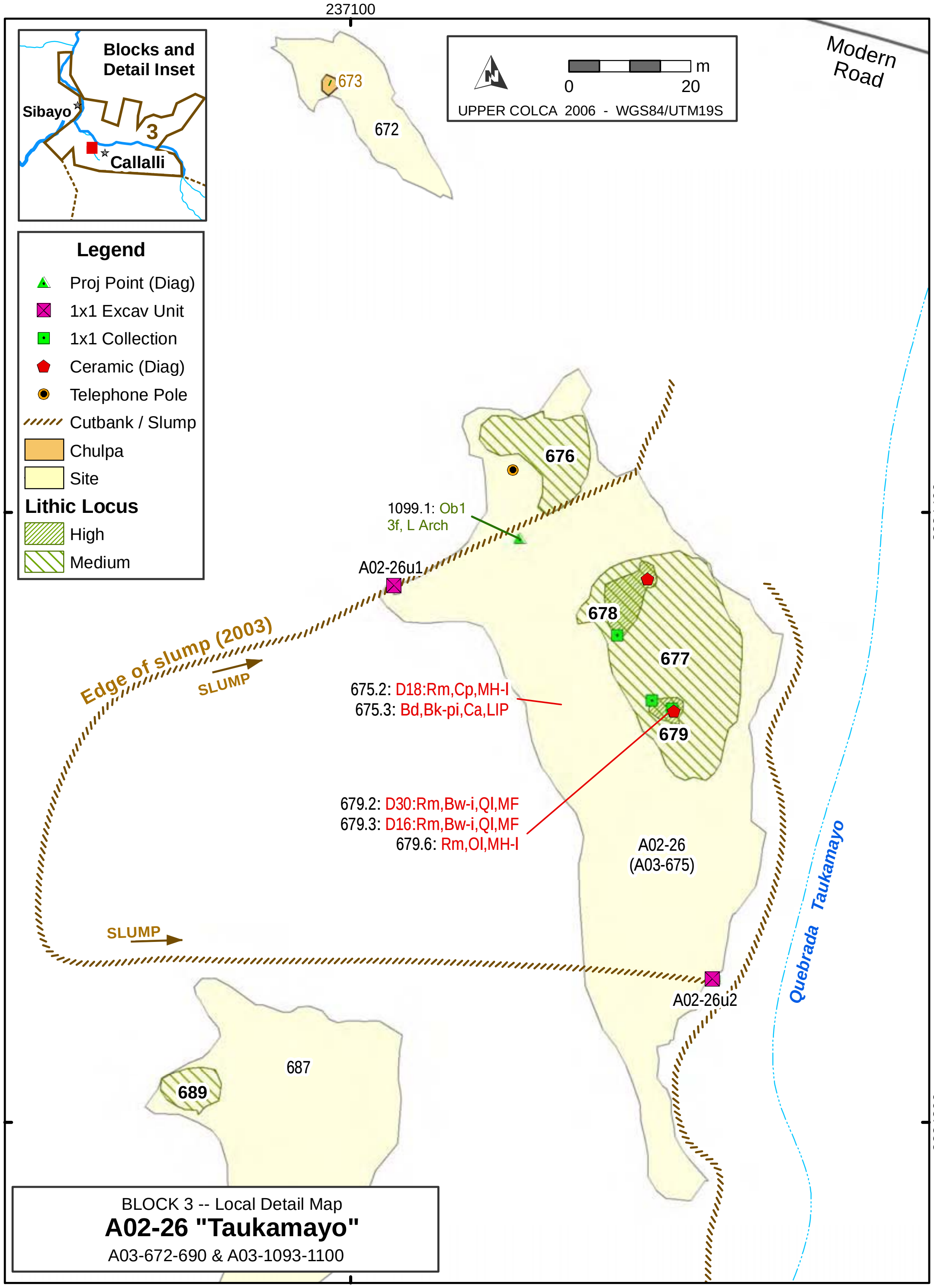


Figure 6-62. Taukamayo [A02-26], a multicomponent site partially destroyed by a landslide.

Figure 6-63. Overview of Taukamayo [A02-26] on slump along base of hillside. Grey box shows area detailed in Figure 6-64, below.

Figure 6-64. Taukamayo [A02-26] detail showing two test units locations on cutbank margins of the creep area. Excavators are visible on right-side at A02-26u1 and provide scale for photo.

Condition of Site

The site was partially destroyed by a broad slumping of the hillside above the site. Callalli residents (Ramos, Ordóñez, Windischhofer) have indicated that the creeping displacement began during the rainy season in early 2001.. Down-cutting in the stream bed of the adjacent Quebrada Taukamayo may have contributed to the recent creep. A historically large El Niño – Southern Oscillation occurred in the years 1997-1998, and a smaller one occurred in 2002-2003, therefore the slumping was not immediately attributable to the unusually heavy ENSO rainfall. Furthermore, a 2.5 m deep trench diverting water from the slope above Callalli was cut in the recent past, and this trench diverts water into the Quebrada Taukamayo watershed. The increased water volume in the quebrada beginning after the 1997-1998 ENSO and with additional water from the Callalli diversion trench, is perhaps contributing to a significant down-cutting of the stream bed which leads to a greater overall gradient of the slope and greater probability of sliding.

In the debris pile at the base of this landslide, ceramics from a variety of time periods were encountered, revealing the multicomponent nature of the settlement. While the landslide has destroyed much of the site, and threatens to destroy more area immediately north and south of the current slide zone, the creep has presented a few opportunities for archaeological observation as well. First, in the debris pile at the base of the slump one is able to observe ceramics from throughout the temporal sequence at the site. Second, in the cut on the north and south edges of the landslide, places where the cut varies between 50cm and 200cm in height, the 2003 survey team was able to observe lenses containing ash, bone, lithics, and pottery, permitting a relatively targeted testing of this deposit.

Ceramics

The multicomponent nature of this site is most evident from the spatial and temporal variety of pottery styles observed here. This site contained the only pottery diagnostic to the Titicaca Basin Formative, and it also has a sherd from a Titicaca Basin LIP beaker. Tiwanaku sherds, however, are conspicuously absent as they are elsewhere in the valley contrasting with regional obsidian distributions.

Period	Estilo	Beaker	Bowl	Olla	Neckless Olla	Plate	Cup	Unknown	Total
LH	Collagua-Inka	2				1			3
LIP-LH	Collagua	1							1
LIP	Colla	1							1
MH	Local MH			1			1		2
F-MH	Chiquero-like	2	1	6	7		1	8	25
MF	Qaluyu-like		2						2
Total		6	3	7	7	1	2	8	34

Table 6-52. All ceramics from Taukamayo [A02-26] and vicinity.

Evidence from ceramics reveal that while the site has components from all ceramics-using periods, the strongest evidence is from the earlier periods, particularly from the unslipped, brushed ware that has similarities to Chiquero style from the main Colca valley. These Chiquero-like sherds at Taukamayo are notable because this style of sherd is abundant at this site, and while this style was widespread in Block 2 the 2003 survey data shows that Taukamayo is the only location in Block 3 where Chiquero style sherds were encountered.

Surface collection in the slump debris at the site also revealed several sherds that appear to belong to Titicaca Basin styles, representing one of the few pieces of possible evidence of reciprocation for the quantities of Chivay obsidian that have been found in the Titicaca Basin. These Titicaca Basin styles include two sherds with similarities to the Middle Formative north Titicaca Basin style Qaluyu or early Pukara.

Figure 6-65. Non-local incised and stamped pottery from Taukamayo [A02-26], in the 2003 provenience these are A03-679.2 and A03-679.3.

Furthermore, a Colla sherd from the Titicaca Basin LIP was found here. The relatively high density of non-local ceramics from Taukamayo supports the idea that Taukamayo was a camp for non-local passersby, and perhaps caravan moving through the upper Colca valley.

Lithics

The most notable feature of Taukamayo was the relatively high density of obsidian as compared with other areas of Block 3. It appears that obsidian reduction occurred here on a number of occasions and due to the landslide, obsidian flakes appear in many parts of the slide deposition pile.

	Taukamayo Cores - Surface				Entire Block 3 Surface Collection			
Material	No.	μ Cortex	μ Wt	σ Wt	No.	μ Cortex	μ Wt	σ Wt
Obsidian	10	25	14.31	7.8	17	5.0	23.2	13.1
Volcanics	-	-	-	-	2	7.5	87.7	42.6
Chalcedony	-	-	-	-	4	16.7	47.5	18.1
Chert	1	0	34.4	-	18	32.1	57.17	33.8
Total	12	32.1	48.4	29.0	41	21.6	43.6	31.3

Table 6-53. Cores from the surface of Taukamayo as compared with the entire Block 3 surface collection.

Obsidian cores (all Ob1) were relatively abundant at Taukamayo but they were not exceptionally common. Nodules of black and tan colored chert were observed in the creek bed at Taukamayo and the material was being flaked elsewhere on terraces adjacent to the creek, but curiously only one core of this chert was found at Taukamayo. The distribution of obsidian material at the site suggests that a range of reduction stages on obsidian were occurring in this location and comparably less of the local chert or quartzite material was in use.

	Ob1	Ob2	Volcanics	Chalcedony	Chert	Quartzite	Total
Flakes	138	199	53	25	181	79	675
Cores	11	8	-	2	4	1	26
Points & Tools	22	15	1	-	1	-	40
Hoes	-	-	16	-	-	-	16
Total	171	222	70	27	186	80	757

Table 6-54. Counts of lithics from surface collection at Taukamayo [A02-26].

This table shows that counts of obsidian are relatively high at Taukamayo. These counts should not be compared directly with other sites in Block 3 because these analysis results reflect two unusual aspects of Taukamayo. First, the high counts at this site are, in part, due the visibility of lithics in the debris from the landslide. Second, a detailed lithics analysis was conducted on the excavated materials from

A02-26u1, as well as on surface materials from this site, and these high counts reflect this detailed analysis.

Chert and quartzite are immediately available in this area, and yet these material types are the minority in representation in flaked stone artifacts at the site. Secondly, Ob2 obsidian was relatively common at Taukamayo. As compared with the Block 2 site of Pausa (see Table 6-51 in Block 2 discussion) where obsidian use is primarily (87%) Ob1 material, at Block 3 Taukamayo there appears to be less concern for the clarity of the material or the presence of heterogeneities because 57% of the obsidian artifacts are Ob2 material. In fact, Taukamayo contains the highest proportion of bifacially flaked tools made from Ob2 material from the entire survey area. Notably, however, these were primarily bifaces not points, as only two of the artifacts made from Ob2 obsidian were projectile points.

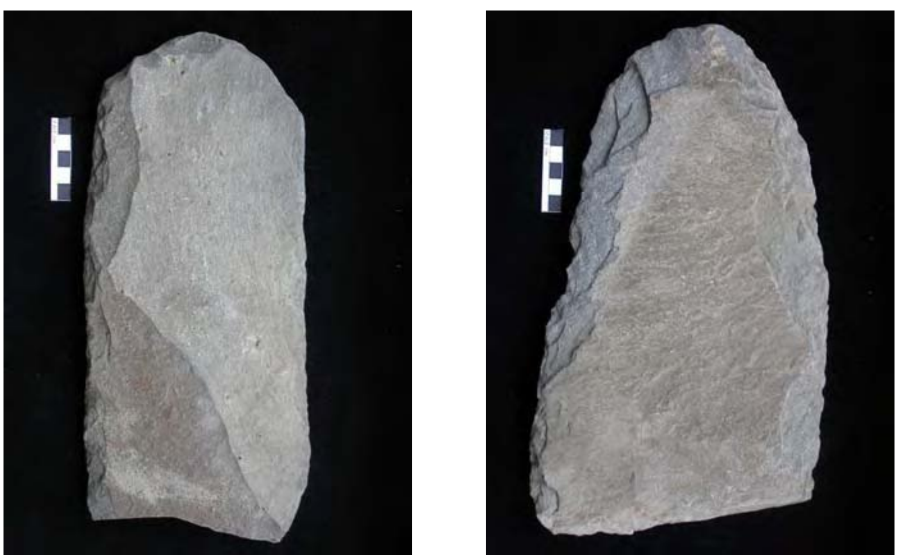


Figure 6-66. Sixteen large andesite hoes were found at Taukamayo [A02-26].

Finally, this site contained an exceptional collection of sixteen large, broken andesite hoes. The hoes varied considerably in size, and it is difficult to assess the original, unbroken size of the items. The hoes ranged in weight from 112g to one as large as 1189g (shown in Figure 6-66, right), with a high variance. All showed signs of intial shaping with percussion flaking as well as flake scars from use. The mean weight was 512g, but with a standard deviation of 483.7.

These hoes had bifacial flaking on the working edge, and most showed polish from use, but no hafting wear was observed under visual inspection. The source of the andesite has not been determined, but if the source lies somewhere distant it is possible that, as with obsidian, Taukamayo contained a high percentage of non-local lithic materials that contrasts with neighboring sites in the area (see lithic analysis data reported in Section 7.6.1).

Discussion

It is immediately apparent that Taukamayo is an unusual site in the Block 3 area. The variety of ceramics and the diversity of lithic material types suggest that the occupants of the site participated in the circulation of goods on a larger geographical scale than did other sites in the region. Furthermore, while bifacially flaked obsidian implements were not uncommon in Block 3, these artifacts appeared to be relatively highly curated. At Taukamayo, reduction evidence from unmodified flakes and cores of obsidian was widespread.

The diversity of ceramic types observed at this site, and the potential for encountering ceramics from various stratigraphic levels in the mixed debris of the slump deposit, was significant. Non-local materials were encountered in styles belonging to the Titicaca Basin dating to the Middle Formative and the Late Intermediate Period, however in the broad sample provided by the Taukamayo landslide debris there was a notable lack of diagnostic ceramics from the time periods featuring the most political integration in the Titicaca Basin: the Late Formative polities and the Tiwanaku period.

6.5. Survey Results: Late Prehispanic Period (AD400 - AD1532)

This temporal period includes the Tiwanaku Period in the Titicaca Basin (AD400) through the Inka Period (AD1532), a time when geographical distributions of Chivay obsidian are strongly influenced by pan-regional political and economic forces. Following anthropological models, it is among ranked or stratified societies that the procurement and redistribution of scarce raw materials is expected to occur as part of elite political strategy (Renfrew 1975; Earle 1991). If obsidian was a sought-after commodity that was controlled and redistributed by among complex polities one might expect restricted access or some other sign of control by the dominant state power at or near the obsidian source. The use of irregularly distributed raw materials, like obsidian, among complex polities may also involve either reciprocation or direct exploitation by agents of those polities, both processes that may leave evidence in the vicinity of the obsidian source.

Archaeological horizons during the Late Prehispanic period in the south-central Andes are demonstrated by stylistic commonalities that include pottery, architecture, and portable goods that were distributed within regional polities. These stylistic similarities are distinctive, well-studied, and often diagnostic to time period. Very little evidence was encountered in the course of this research of obsidian procurement by non-local parties, despite the abundant evidence of Chivay obsidian consumption in the larger region and sometimes in civic/ceremonial core of these regional polities. Nevertheless, the procurement and initial production activities of obsidian under the larger regional influences of the Late Prehispanic period may provide insights into the economy in which obsidian was circulated. When the larger economy was restructured by regional polities, the transformation that occurs in the circulation of goods like obsidian can demonstrate the differences between the older established economic patterns and the establishment of new patterns under the authority of a regional polity.

6.5.1. Block 1 – Source

The 2003 Upper Colca project evidence from diagnostic artifacts indicate that Late Prehispanic activity in the obsidian source area principally took the form of pastoral activities, construction of mortuary architecture, and possible water control projects. Evidence from the Late Prehispanic in this area depends largely on the presence of diagnostic ceramics and architecture, but if the example provided by modern pastoralists in the area may serve as an indicator, architecture was likely akin to the traditional herder’s shelter, and vessels were probably non-diagnostic utilitarian cooking vessels. A few utilitarian vessel sherds were observed in the Block 1 area, but the overall presence of pottery was relatively low. Another pattern that can be safely extrapolated into prehistory is that the residents of Maymeja were probably not wasteful with the pottery that they had transported up to the grazing area, because pottery is relatively scarce in this area. Thus, the ability of archaeologists to perceive activities during the period termed "Late Prehispanic" depends to some degree on recovering diagnostic features that differ from the well-established herder pattern that had predominated in the Maymeja area for probably 5000 years. Other good evidence of Late Prehispanic procurement and processing by local groups would come from consumption patterns observable in adjacent settlements during that time period, principally in Blocks 2 and 3 of the 2003 survey.

From the evidence of Chivay obsidian distributions, the quarry and the associated workshop may be expected to have continued use through the Tiwanaku period or LIP, and then it would decline in use during the Inka and the Colonial period. In the Colonial period with the widespread availability of metals and bottle glass, obsidian use was largely abandoned, except for minor applications by local pastoralists. Therefore, during the Hispanic period the quarry pit may have been abandoned and the quarry and workshop features would perhaps be covered by soil accumulation and ash deposits from nearby volcanoes after more than 500 years with little use.

As will be presented below, the 2003 survey found no diagnostic evidence of Tiwanaku, and no Colla (non-local LIP) materials in the quarry area. Limited Inka and Collagua-Inka pottery were encountered, and these Late Horizon ceramic distributions appear to have been primarily related to mortuary features and to the focus on the water and the grazing opportunities in the Maymeja area.

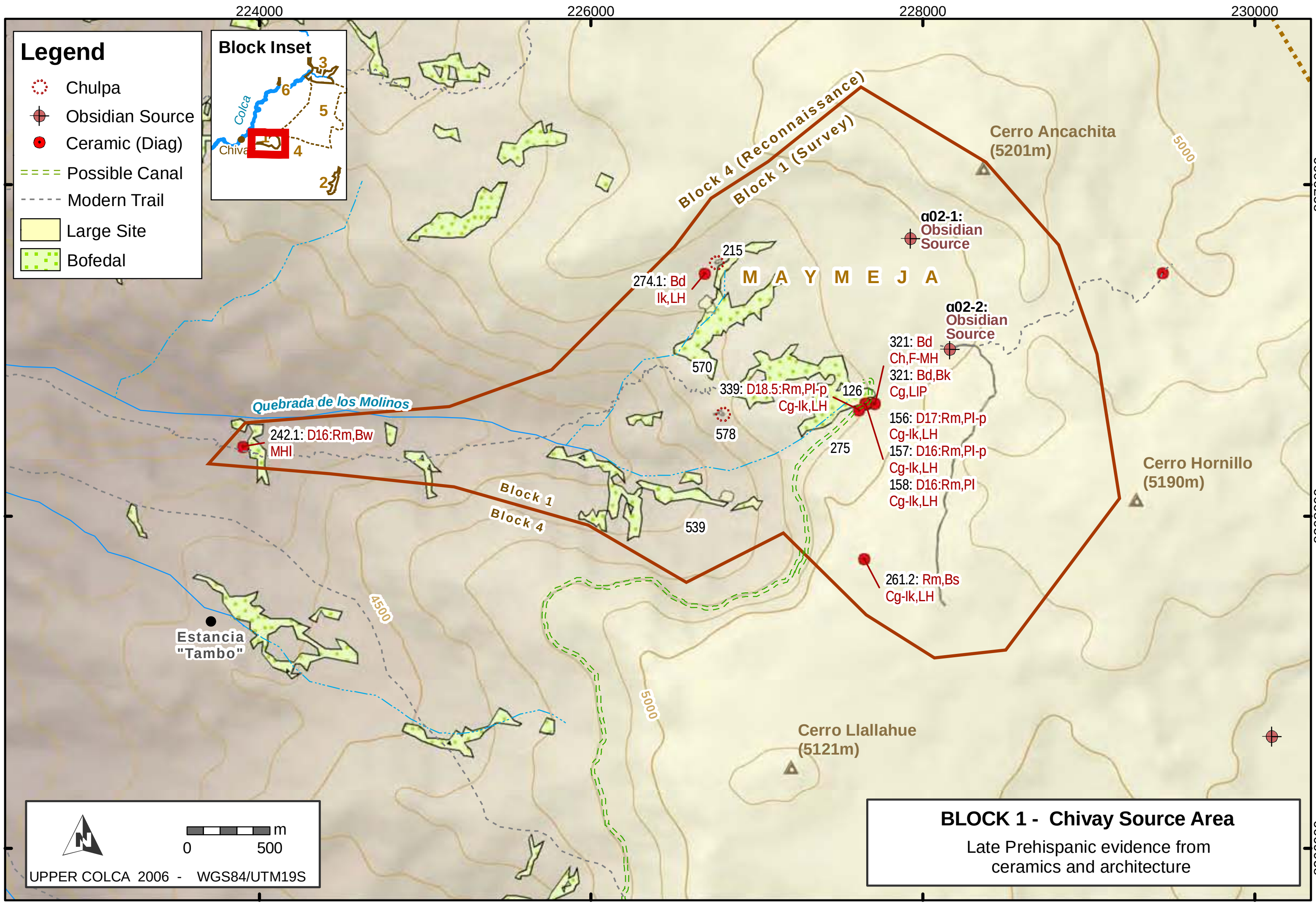


Figure 6-67. Block 1 Late Prehispanic features.

Pastoral activities

Grazing activities appear to have persisted during the Late Prehispanic in Block 1 as they did during the Early Agropastoralist period. Low densities of non-diagnostic sherds from utilitarian wares are found in association with colonial and modern sherds near the estancia in Maymeja A03-570. Pottery is otherwise relatively scarce in the Maymeja area. It is notable that no diagnostic MH, LIP, or LH sherds were found in association with the estancia at A03-570, or at other pastoral occupations in Maymeja, except for the A03-126 workshop area. One can also expect the later occupants of Maymeja to have continued to make use of the "Camino Hornillo" [A03-268] route leading to the quarry pit from the Escalera thoroughfare. However, if Late Prehispanic peoples did make use of this route, they left virtually no ceramics associated with it that would indicate that the quarry pit road was a regularly used feature.

A03-275 "Maymeja 5"

Just southwest of the area of the obsidian workshop, on the south perimeter of Maymeja, an extensive construction area (1 Ha) was encountered on the rocky slope along the edge of the bofedal that was generally terraced although heavily eroded. This area is shown in more detail on the map in Figure 6-54.

Figure 6-68. Three levels of terracing in [A03-275] below glacier polished rhyolite flow. Yellow tape shows 1m.

The construction along the margins of the bofedal was curiously devoid of ceramics, as were the other terraces immediately adjacent to the A03-126 Maymeja workshop. A light scatter of obsidian flakes is found throughout the terraced area, however, and obsidian flakes are concentrated along the base of the slope although these concentrations probably reflect downslope movement of artifacts. In this sector, on the south-west edge of the bofedal, several Late Horizon “Collagua-Inka” plates were encountered, and it is possible that this entire sector was constructed at a later time. The corner of a structure with a possible niche that appears to be built using the Inka-influenced cut-stone masonry technique was found 70m southwest of the obsidian workshop [A03-126] inside the larger terraced site area [A03-275]. Unfortunately, the remaining sides of this structure are too eroded to permit an estimate of the structure size, or to discern if it was a residential or mortuary construction. A pattern discussed by Wernke (2003) in the Colca valley was for circular residential structures to be dominant among pastoral settlements above 3900m. Given this architectural pattern, the structure at A03-339 is perhaps a square *chulpa* rather than a residential structure.

(a) (b)

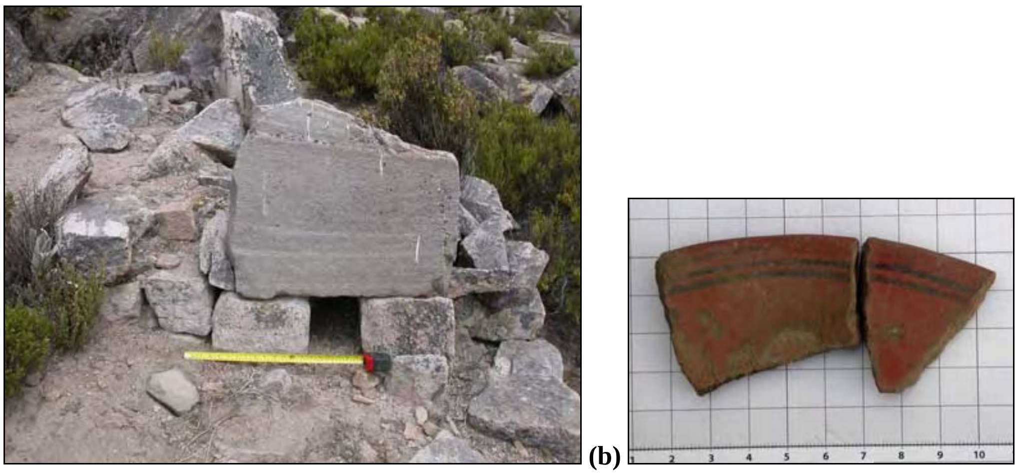


Figure 6-69. (a) Cutstone masonry [A03-339] from site A03-275 close to the workshop area at the Chivay obsidian source. Yellow tape shows 50cm. (b) Rim sherds from an 18cm diameter Inka-Collagua plate were found adjacent to this corner.

The presence of diagnostic Late Horizon materials in the obsidian source area was somewhat unexpected because during the Late Horizon the regional distribution of Chivay obsidian was relatively restricted in comparison with any time period since the Terminal Archaic. It is possible that the Late Horizon occupation in this area, particularly the painted plates, result from ritual functions associated with the abundant spring that irrigates the bofedal in the southern of Maymeja area, and that spring emerges very close to this location. However, if the structure [A03-339] is a looted Late Horizon *chulpa*, then the plate could have been one of the grave goods.

A03-240 “Molinos 1”

The only local Middle Horizon evidence from Block 1 close to the Chivay source comes from a pastoral area part of the way up the Quebrada de los Molinos climbing up from Chivay, 350 vertical meters above the town. This site is found adjacent to several large breccia boulders near a bofedal where the trail climbing from Chivay levels out after a steep pitch. A partially eroded rim sherd [A03-242.1] was found here that is diagnostic to the local Middle Horizon style. The sherd is made of burnished brown paste and with traces of paint on the rim, but the rim was too small to take a measure of the vessel diameter.

Mortuary features

Several *chulpas* were identified in the Maymeja portion of Block 1, the locations of these features is shown on Figure 6-67.

A03-215 “Saylluta 1” appears to be a relatively large *chulpa* (2m in diameter). A mortuary function for this structure is suggested by the doorway which is only 70 cm high. No diagnostic materials were found. The base of a square structure was located just to the east that is possibly an old corral or a shelter, but it appears to be too large to be a roofed space.

A03-274 is a small crevice west of A03-201 with remnants of a wall inside and several small bones that appear to have been animal bones. A diagnostic Inka rim sherd of non-local design [A03-274.1] was found here.

A03-578 is circular *chulpa* made with double-walled construction, but without mortar. The *chulpa* measures approximately 2m in diameter. A site consisting of a light scatter of obsidian [A03-575] surrounds the *chulpa* and extends out onto a large promontory overlooking the Quebrada de los Molinos and the access to Maymeja from the trail climbing up from Chivay. There was also a medium density lithic locus here [A03-576] consisting primarily of flakes in tertiary stages of reduction (0-50% dorsal cortex). This site conforms to the pattern of lithic reduction atop the bluff on the western edge of Maymeja with very high observation potential. Visibility/exposure at this site is 39 by the visibility index, while the mean for sites in Block 1 is 18.5. This high visibility reduction pattern is discussed in Section 8.3.3.

In addition, the corner of the eroded structure at A03-339, described above, is perhaps a LH square *chulpa* (Figure 6-69).

Possible Late Prehispanic canal route

As agricultural intensification and terrace construction accelerated during Late Prehispanic times, the volume of water entering canal systems from the high altitude headwaters would have become increasingly important to the farmers below. The Huarancante canal system that irrigates the southern half of the Colca valley has been discussed in more detail elsewhere (Brooks 1998: 203-213; Wernke 2003: 235-246). This canal irrigates some of the most productive farm land in the main Colca valley, including the area around Yanque, the dominant community during the LIP and LH. Any additional water contributed into the Huarancante canal system would have been of great utility downstream.

While no glaciers are found in the Maymeja area and the precise date of deglaciation of Cerro Ancachita and Hornillo are not known, the spring that irrigates the southern half of Maymeja has a relatively high volume of flow. This flow is particularly notable in this porous volcanic landscape, where much of the surface water disappears underground. The substantial volume of water that descends from here to Chivay was sufficient to justify the construction of a mill during colonial times (the apparent namesake of Quebrada de los Molinos). Today, this water powers a small hydroelectricity plant for Chivay.

According to Sr. Mamami (2005, pers. comm.), the owner of “Tambo”, a rich estancia between Chivay and Cerro Hornillo, a canal existed that connected Maymeja with Huarancante in the past and it traversed high above eastern edge of his land. Upon further discussion with S. Wernke (2005, pers. comm.), the significance of a possible extension to the modern Huarancante canal is explored here, as this extension would have been an important asset had it connected the abundant perennial spring in Maymeja to the Huarancante canal.

A possible route using contours derived from the ASTER 30m topographic DEM layer is presented here. Following Brooks’ (1998: 203) estimate of 1° or less downslope for the canal, the canal is extended up from the point at which the existing canal departs from Quebrada Huanta Occo at 4745 masl on the north slopes of Nevado Huarancante. The contour distance to the Maymeja bofedal is approximately 10.5 km, which, at a 1° slope, would require a vertical change of 183m, indicating that the canal would have had to begin at around 4928 masl. The altitude of the Maymeja workshop in site A03-126 is 4902m, therefore when extrapolated over more than 10km the gradient potential exists for such a canal, but it would have required losing very little altitude across difficult terrain. No specific cliff bands block the construction of such a canal, but a steep lava cliff passes immediately above the canal route and the slopes below this loose cliff consist of an incline of sand and talus at approximately 45°. These features would have presented a difficult obstacle to canal construction.

Under Inka rule, the Collagua extended their agricultural production through projects such as canal expansion, and the construction of such a canal would serve to explain, in part, the predominance of Late Horizon Collagua-Inka ceramics over LIP Collagua ceramics in the Maymeja area. Unfortunately, due to fieldwork time constraints, the Upper Colca survey project was not been able to conduct a pedestrian survey along this potential canal route. The route contours around an extremely high colluvation zone below the lava outcrops of Cerro Llalluhue, and a canal in this area would have required significant maintenance.

The possible canal route shown on Figure 6-67 and Figure 6-70 is 11 km long and drops from 4905 to 4745 masl at a gradient of 0.83°. No features definitively related to canal construction were observed, but further fieldwork could confirm Sr. Mamani's account. Another possibility is that the Inka-Collagua presence in the Maymeja area results from a work-in-progress where feasibility study measurements and initial work were perhaps underway for the construction such a canal in the 16th century when the Spanish arrived. A scenario such as this would have left somewhat ambiguous evidence in the Maymeja area.

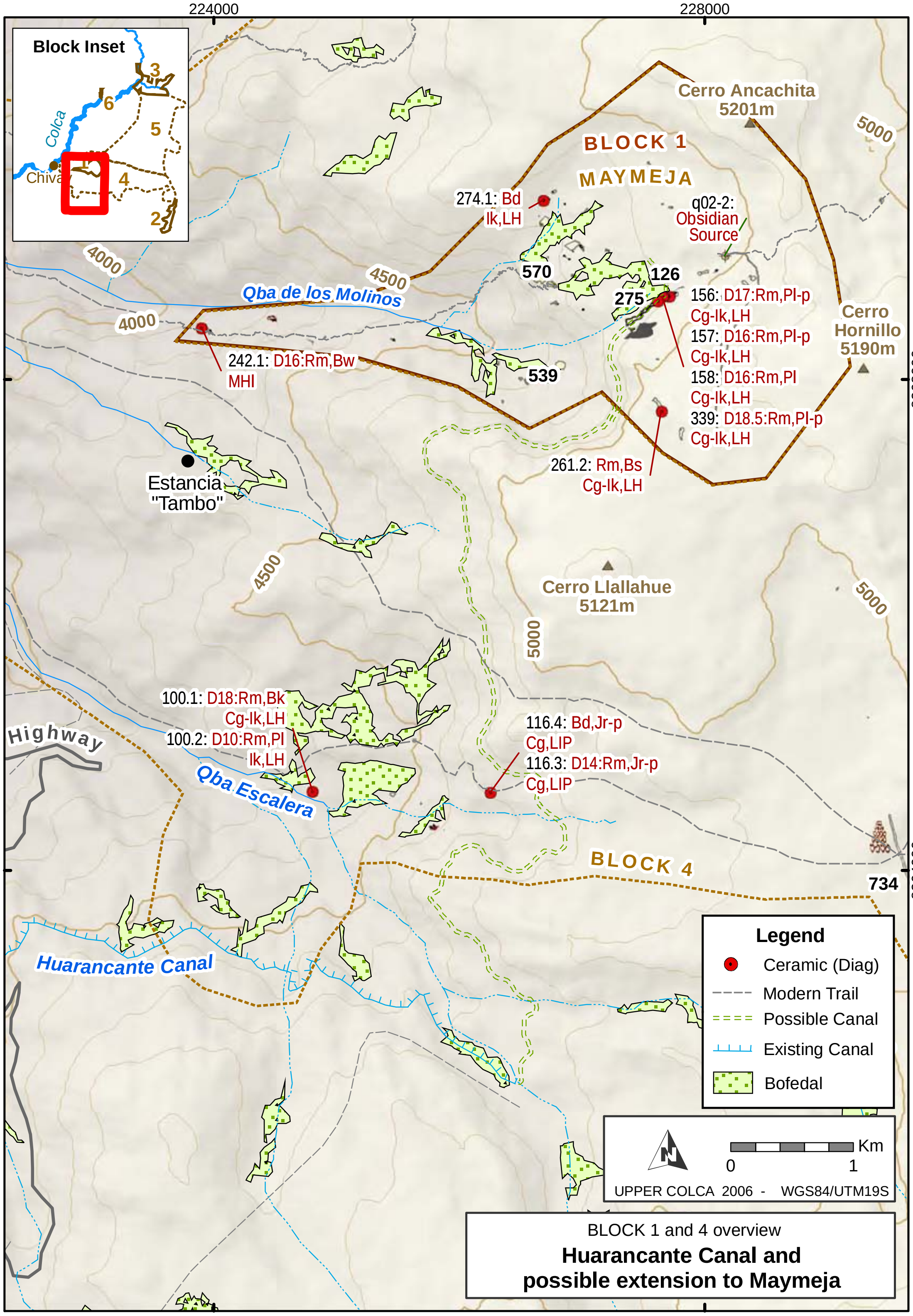


Figure 6-70. Blocks 1 and 4 overview showing possible route of Late Prehispanic canal.

Block 4 and 5 Reconnaissance Area

During the Middle Horizon, LIP and Late Horizon in the high altitude reconnaissance area near the Chivay source, several clusters of sites were observed that testify to the variety of lands used by pastoralists in this period. During the 2003 survey non-local Inka ceramics were encountered even in small, distributed pastoral sites, a higher frequency of use of obsidian with heterogeneities (Ob2), and a spatially distributed occupation pattern. These distributions perhaps reflect the growing herd sizes in the Collagua domain during the Late Prehispanic, and the need to exploit the resources in the puna as they become seasonally available.

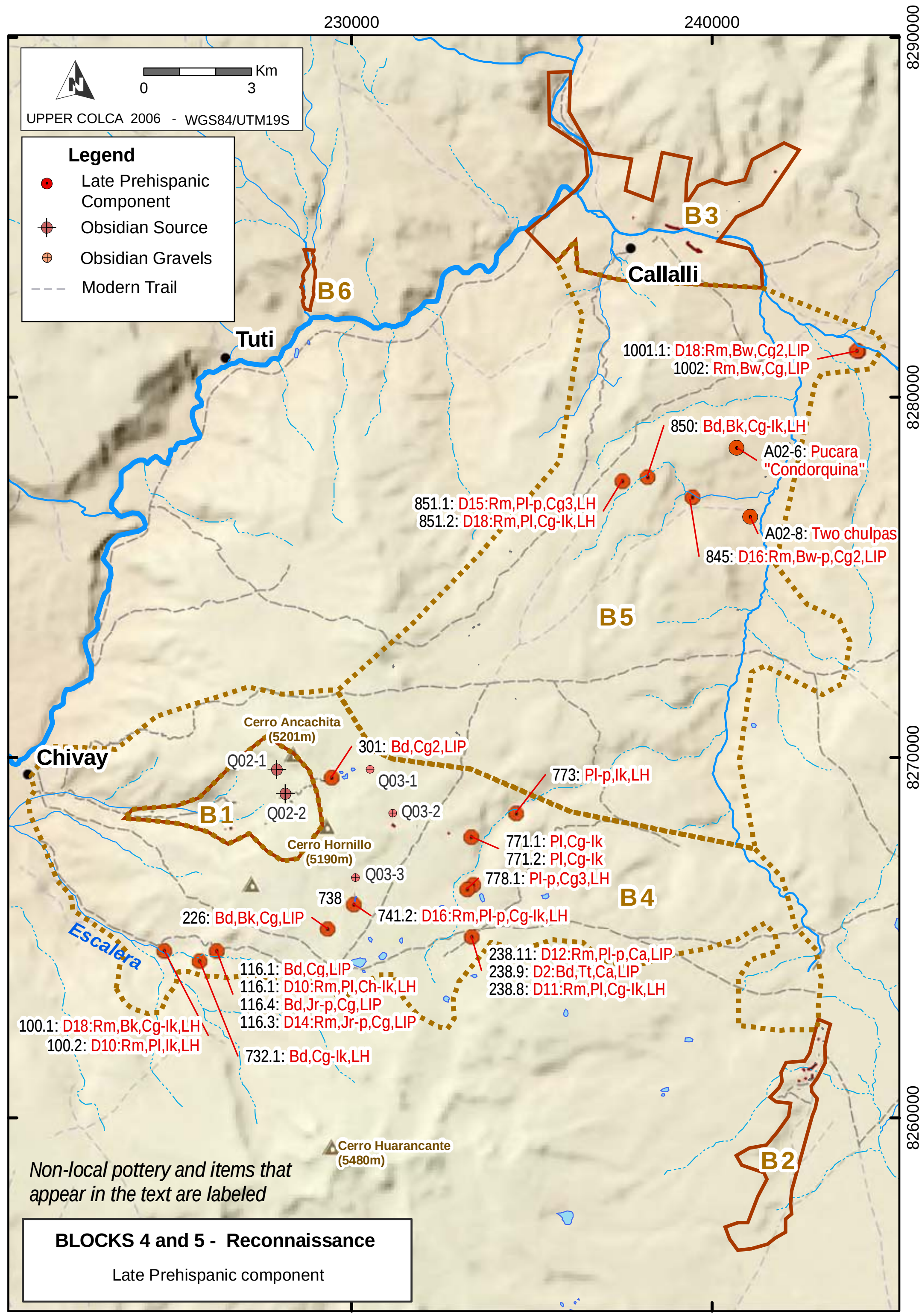


Figure 6-71. Blocks 4 and 5 Reconnaissance - Late Prehispanic component.

An example of this distributed occupation pattern was apparent in the arid area on the south-east flanks Cerro Hornillo. Surveying across this arid area, the 2003 survey team encountered a settlement close to two ponds A03-738 “Lecceta 1” consisting of two small rock shelters and open air sites containing LIP and LH ceramics. The site includes a light scatter of obsidian flakes over the larger region, and two sectors with medium and high density obsidian scatters. The interesting thing about this site is the high incidence of use of Ob2 obsidian.

Between 500m and 1000m north of this settlement surveyors encountered surface obsidian lag gravels eroding from the base of the south-east flank of Hornillo in a formation that appears to represent a secondary obsidian quarry area. In fact, on further investigation of the source materials, it was noted that much of the obsidian on this side of Hornillo had heterogeneities (Ob2) consisting of <1 mm air bubbles trapped in the glass, as well as what appear to be ash particles. The nodules in this area were as large as 15cm long, but the typical large nodule for the area was only < 8 cm on a side. It seemed like the larger nodules had more Ob2 heterogeneities, as if perhaps there had been a preferential collection of large Ob1 nodules from this area.

The site of Lecceta 1 [A03-738] had unusually high levels of use of Ob2 obsidian. The Ob2 material was being knapped more extensively than anywhere else in the survey area.

Form	Ob1 – homogeneous				Ob2 - heterogeneous			
	At site A03-738		Project surface collection		At site A03-738		Project surface collection	
Tools	2	100.0	290	92.7	-	-	23	7.3
Cores	17	70.8	201	84.5	7	29.2	37	15.5
Flakes	17	60.7	201	84.5	11	39.3	101	21.4
Total	36	66.7	861	84.2	18	33.3	161	15.8

Table 6-55. Ob1 and Ob2 obsidian use at A03-738 "Lecceta 1" compared with entire project.

While there were more Ob1 cores, flakes, and tools collected at A03-738, there was a fair amount of reduction was occurring on the Ob2 material that was available near this camp. In particular, Ob2 cores and flakes are used at a much higher percentage in this site on than on average for the project on the whole. Given the Late Horizon evidence from this site, these data could be interpreted as supporting the notion that during the Late Prehispanic the acquisition of “high quality” obsidian, represented by Ob1 material, was deprioritized because obsidian was primarily used for the basic pastoral functions of butchering and shearing.

6.5.2. Block 2 – San Bartolomé

The Late Prehispanic occupation of the high puna area of San Bartolomé shows a continuation of earlier pastoral uses of the Block 2 grazing lands, but the ceramic assemblage reveals the strong links between this area and the main Colca valley. The modern political structure of Block 2 links this area to the town of Yanque in the Colca valley. Political hierarchy related to the structure of *ayllu* organization in the Colca valley was reflected in the *estancias* and *anexos* of the herding areas such as Block 2 (Maria A. Benavides 1989; Wernke 2003: 359-368).

Despite the ascendancy of Chivay in the early twentieth century (Guillet 1992: 27-29), the regional dominance of Yanque in the Late Prehispanic and colonial period is reflected in the large number of Collagua *anexos*, such as the communities of Chalhuanca, Pulpera, and the estancias that fall within the Upper Colca Project Block 2 survey area. These *anexos* all belong to Yanque, despite being geographically closer to Chivay. Straight line distance from the site of Pausa [A03-39] in Block 2 across to Chivay is 22 km, while the distance to Yanque is 28 km. When traveling from Pulpera one would walk through Chivay to get to Yanque most directly. Residents in these Collagua *anexos* travel to Yanque to vote in elections; and, fittingly, the family name of virtually everyone encountered in Block 2 was "Callagua". The ties between residents of Block 2 and the Colca valley appear strong in the ethnohistoric and modern records, but the archaeological evidence from Block 2 reveals that this area was also a place of contact with Titicaca Basin communities. The ceramic evidence is strong, at least, for Titicaca Basin interaction during the Late Intermediate and Late Horizon.

Middle Horizon and Late Intermediate Period

The evidence for Middle Horizon occupation in the San Bartolomé area is confined to the northern part of Block 2. A number of beaker rims in local Middle Horizon styles were found in this area in association with pastoral features. A sherd of undetermined stylistic origin was found [A03-1056.1] with geometric elements that suggest a Middle Horizon or perhaps LIP date (B. Bauer, 2004 pers. comm; K. Schreiber, 2004 pers. comm.).

Figure 6-72. Non-local sherd with geometric elements akin to Middle Horizon or LIP styles [A03-1056.1].

It is not evident whether the pattern of Middle Horizon settlement in the north part of Block 2 predominantly reflects cultural relationships, environmental conditions, or some combination of the two. Culturally, the settlement in the northern parts of Block 2, in particular the Huañatira area, may have maintained close links with the Colca valley and therefore the pottery better reflects styles that were documented by Wernke (2003) in his seriation of pottery in main Colca valley.

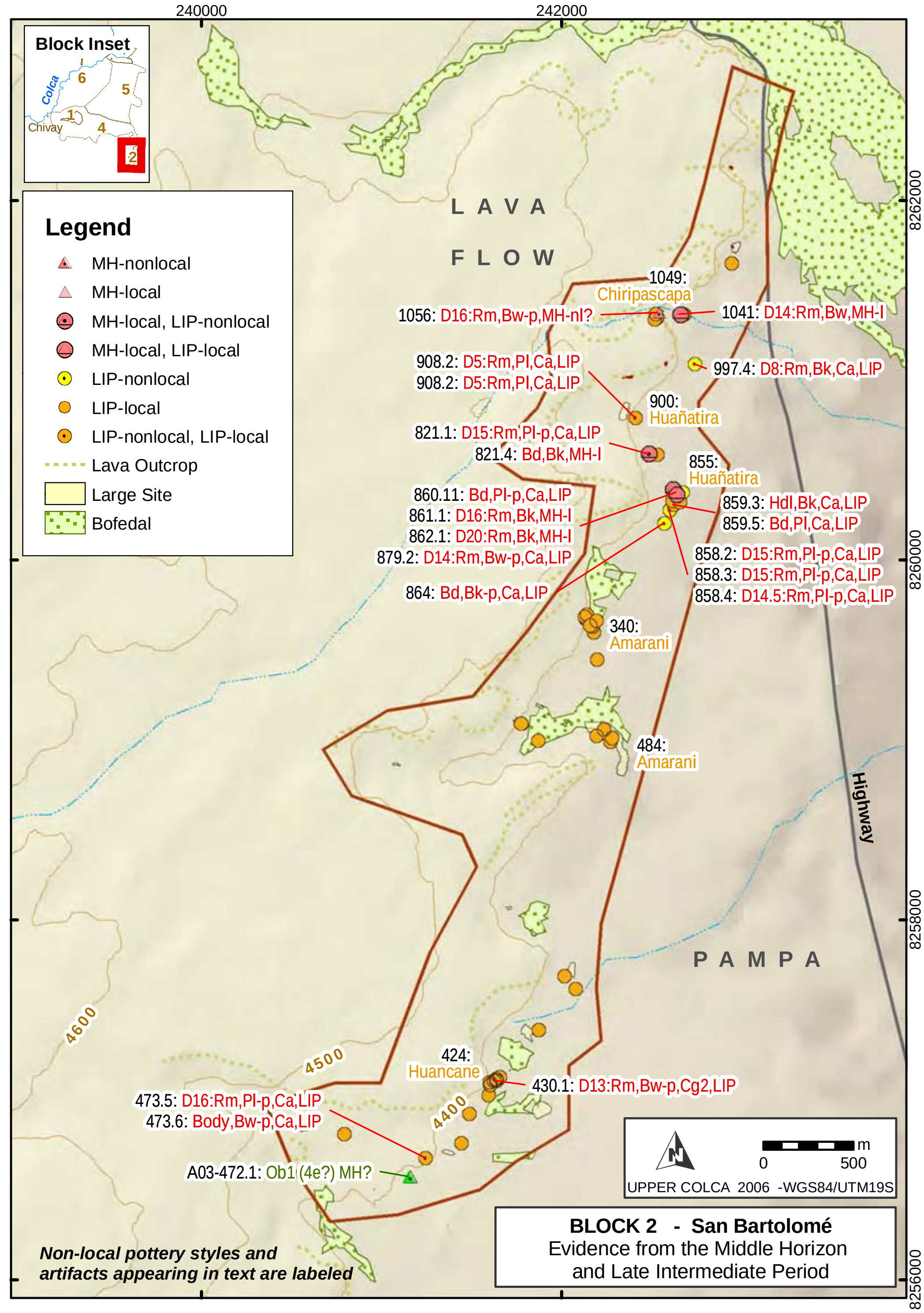


Figure 6-73. Block 2 diagnostic artifacts from the Middle Horizon and Late Intermediate Period.

From an ecological perspective, the bofedal along the northern part of Block 2 has significantly greater dry season water flow than the smaller bofedales in the southern parts of the survey block, and perhaps settlement was concentrated in the northern area of Block 2 during the Middle Horizon in order to exploit the large bofedal that lies to the north-east. During the October dry season, when the Upper Colca Project surveyed in this area, grazing was only occurring at the bofedales that are depicted on Figure 6-73.

The local Late Intermediate period evidence in this region consists primarily of sherds from Collagua-1 and Collagua-2 style bowls (Wernke 2003), some of which were painted. Significantly a number of sherds from Colla style beakers and plates from the Titicaca Basin were encountered, some of which were painted, that belong to the “Altiplano” LIP pottery tradition. The sherds from painted plates observed here belong to a style that is also found in the mid-sierra of Moquegua (Stanish 2004, pers. comm.).

These beakers and plates artifacts, the proveniences of which are labeled on Figure 6-70, are part of a larger suite of shared traits between the Collagua of the Colca and the Colla of Lake Titicaca. These traits include the construction of fortified pukaras, mortuary architecture, cranial modification, and the Aymara language (Section 3.5.3). Despite this apparent affinity, obsidian is not abundant on the Late Intermediate sites of northern Late Titicaca Basin (Arkush 2005: 247, 709-711).

A03-855 "Huañatira 2"

This site shows the pattern of reoccupation of these enclosed raised corrals as were discussed above with the Early Agropastoralist occupation of A02-39 "Pausa 1", and it is also adjacent to a Archaic Foragers occupation described above in the Archaic Period discussion of A03-900 "Huañatira". This site contains components from a variety of time periods, and it demonstrates the redundancy, the non-contemporaneous occupation, and the shallow refuse disposal that were encountered in most pastoral sites (Nielsen 2000: 480-483).

Figure 6-74. Huañatira [A03-855]. Corrals, structures, and artifacts scatters wrap around the base of the lava escarpment. A small figure is visible on the right edge for scale.

Time Period	Style	No.	% of Column
Non-local LH	Chucuito-Inka	1	1.1
	Inka	3	3.2
Local LH	Collagua-3	11	11.8
	Collagua-Inka	13	14
Non-local LIP	Colla	9	9.7
Local LIP	Collagua	9	9.7
	Collagua-2	7	7.5
Local MH	Local MH	3	3.2
Poss. Formative	Brushed, no slip	37	39.8
Total		93	100

Table 6-56. Diagnostic sherds from Huañatira 2 [A03-855].

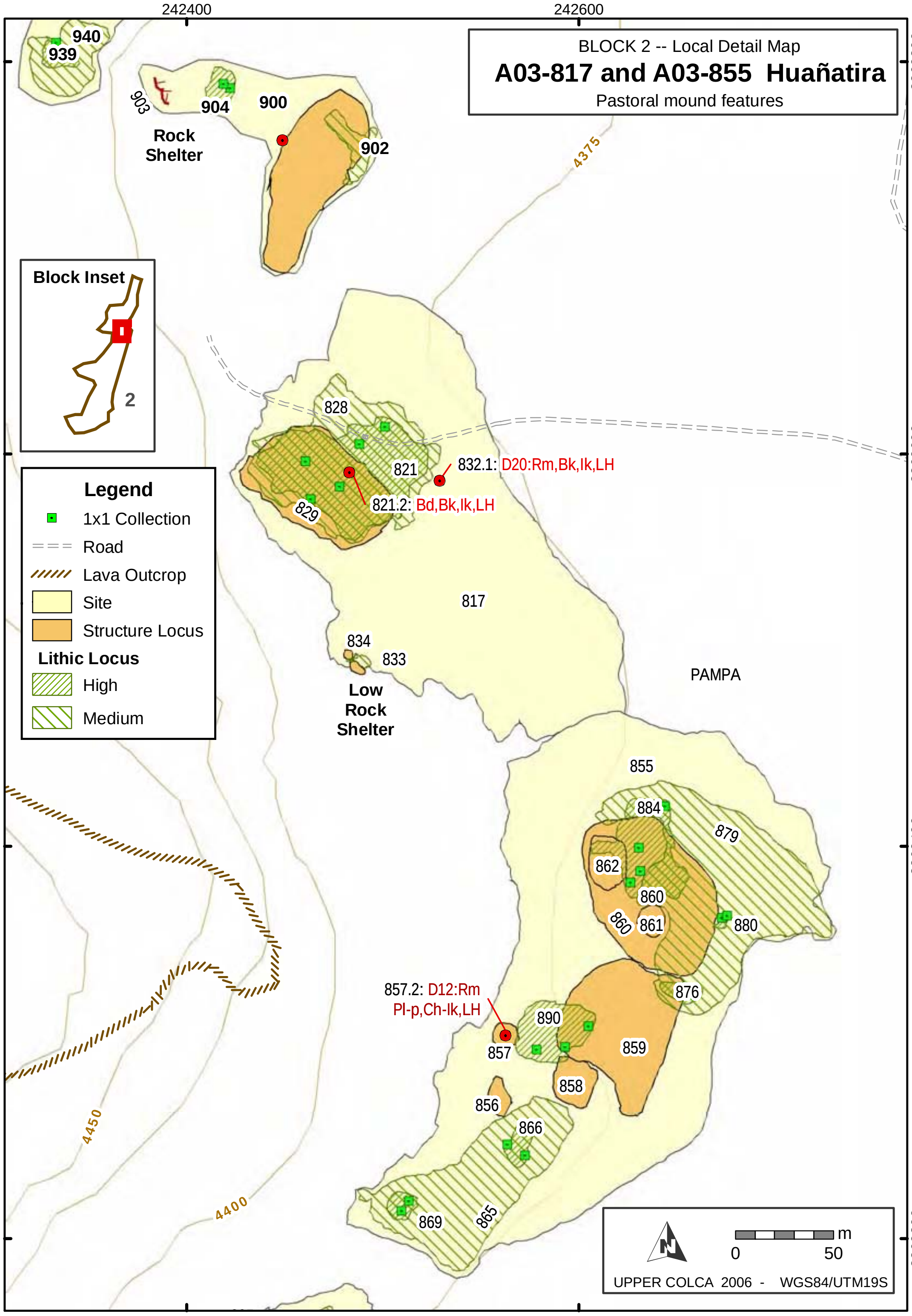


Figure 6-75. Huañatira A03-817 and A03-855 multicomponent site showing corral structures.

Lithic reduction activities in this site complex appear to have been similar to those encountered at Pausa where obsidian reduction seems to have been occurring with frequency. The pattern results in a large percentage of small obsidian flakes and relatively small cores as compared with other material types.

Immediately to the north of the Huañatira sector described here, a rock shelter [A03-957] with an Archaic Period component was encountered that also contained the remnants of a cist tomb (shown on Figure 6-20). The cist consists of a recessed circle [A03-958] that is 3.17m in diameter north-south, and 3.22m in diameter east-west, and 54 to 60cm deep. Twenty slab stones were used to face the circle. The remnants of a wall is visible just inside the dripline of the shelter, and the circle is 2.16m to the north of this wall.

Figure 6-76. Cist tomb with mortared stonework, view from inside shelter (see also Figure 6-21). Shrubs are growing on remains of wall, visible in background. A 1m tape is visible inside the stone circle for scale.

Two crania were found with notable bilobate deformation. A number of long-bones were also evident (MNI = 2). The feature appears to have been a walled-in cave tomb that was perhaps looted long ago. The shelter is in a south-east orientation and so the area remains cool much of the time. It would make a tomb with cool temperatures that would slow down decomposition.

Late Horizon

The Late Horizon evidence from the San Bartolomé area comes primarily from sherds of the Inka-influenced local ceramic style described as Collagua-Inka (Wernke 2003). A number of Collagua-Inka plates and beakers were found in Block 2, and approximately half of them were painted. A number of painted, non-local Inka plates were found in this area as well, particularly in the northern Chiripascapa area. Ethnohistoric sources document the vast herds of camelids tended by the Collagua (Crespo 1977; Wernke 2003: 83-84). From his survey work, Wernke (2003: 184) reports a distinct expansion of herding in the LH where "…nine of the 16 Late Horizon herding settlements that lack LIP components are pastoralist settlements located in the *puna*". Wernke also reports finding a small number of LH sherds with similarities to the Chucuito (Late Horizon Titicaca Basin) style in the course of his survey, and these sherds were observed in herder settlements in the puna on both the north and south sides of the main Colca valley.

In the Block 2 area a relatively consistent occupation was encountered in the 2003 Upper Colca survey that includes both LIP and the LH settlement. There is some suggestion of slightly lower occupation during the LH, but this may be the result of concentration of settlement into a fewer but larger pastoral bases.

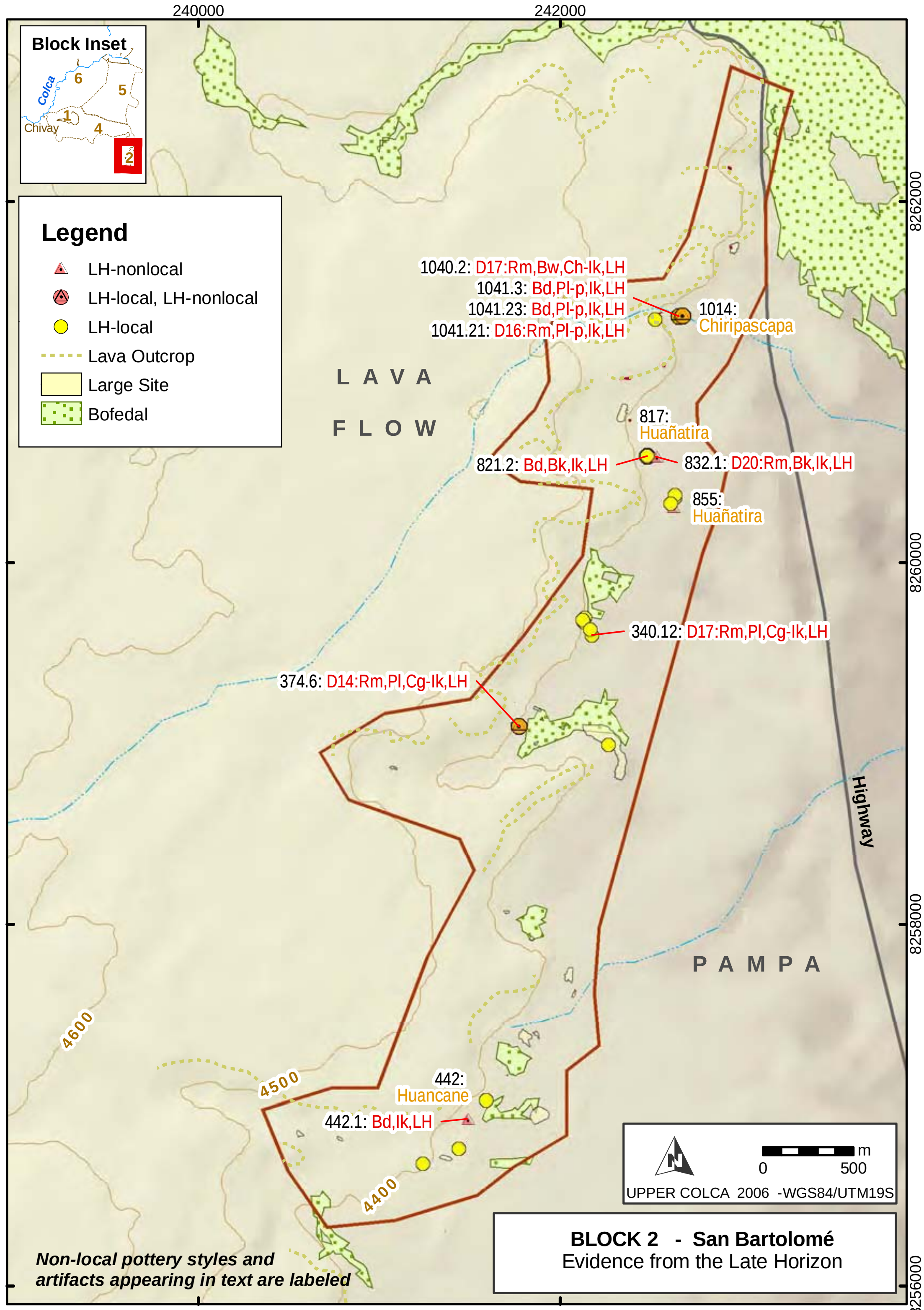


Figure 6-77. Block 2 diagnostic artifacts from the Late Horizon.

Two LH sherds from the 2003 survey were of the Titicaca Basin Late Horizon Chucuito style and they were both observed in the Block 2 survey area. The presence of only two Titicaca Basin sherds is a notable a reduction from the LIP when 14 Colla sherds were encountered in this area. The LH is a much shorter time period than the LIP, but nevertheless the reduction is notable and perhaps reflects a deliberate effort by the Inka to regionally isolate Aymara polities and intercede in Colla and Collagua economies.

Discussion

The Late Prehispanic occupation of the Block 2 area appears to have been oriented towards maintaining herds in this grazing area. Small quantities of non-local pottery were encountered here, but the overwhelming majority of the styles demonstrate the close connection between this area and the main Colca Valley.

6.5.3. Block 3 – Callalli

In the Block 3 area, in the upper Colca valley, a significant increase in population and land use intensity is apparent from the distribution of settlement, mortuary features, and fortifications encountered in this region.

Middle Horizon and Late Intermediate Period

As has been discussed above, the role of regional states in the Colca valley during the Middle Horizon is somewhat enigmatic. Wari influences are apparent in architecture and ceramic attributes, but direct evidence of Wari control has not been encountered. No evidence of Tiwanaku, a principal consumer of Chivay obsidian, has been encountered in the region. The local Middle Horizon ceramic type defined by Wernke (2003) was encountered in low densities in Block 3, although generally in spatial association with LIP sherds suggesting a continuity of economic and settlement patterns.

During the Late Intermediate Period there appears to have been a significant increase in population in the Block 3 region. The founding myth of the Collagua people, as recorded by a Spanish ethnohistoric source, has them conquering the Colca valley upon their descent from the Mount Collaguata near Velille in Espinar (Cusco) 120 km north of this region (Ulloa Mogollón 1965 [1586]; cited in Wernke 2003: 80). Data is not available from this surface survey to test the alleged population replacement, but some continuity in land use pattern is apparent from the occupation of areas with both local Middle Horizon ceramics and LIP ceramics.

One site that shows ceramics from throughout the sequence that includes the possible Formative Period (Chiquero), the Middle Horizon, LIP, and Late Horizon, is the site of Taukamayo [A02-26] discussed in more detail in Early Agropastoral section (see Figure 6-62). This site has been partially destroyed by a creeping landslide that has resulted in shuffling of stratigraphy within the displaced slump deposit and the exposure of a variety of artifacts from the prehistoric sequence. In the creep debris there are concentrations of stone associated with LIP and LH ceramics that suggest that *chulpas*, perhaps similar to the one observed at a site immediately to the north [A03-673], were built along the terrace that has since collapsed in the creep.

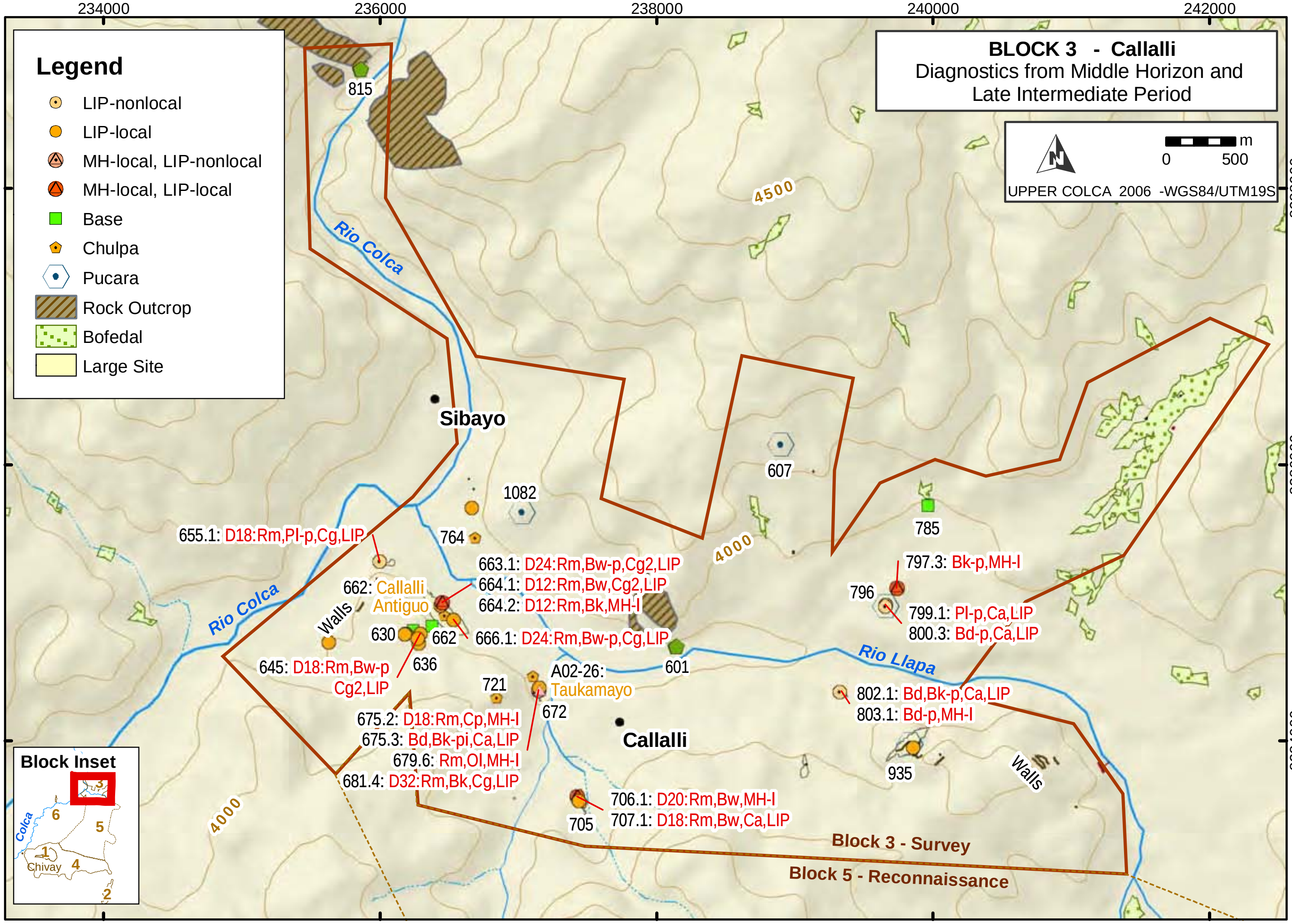


Figure 6-78. Block 3 Middle Horizon and Late Intermediate Period features.

Distinctive features from the LIP include a number of shared features from the Titicaca Basin mentioned previously. These consist of pukaras, *chulpas* and distinctive types of cave burials. Pukaras are fortified hilltops settlements usually occupied only for short-term, defensive purposes (Arkush 2005; Stanish 2003: 209-218; Wernke 2003: 251-265).

Pukaras

A number of pukaras were encountered in the Block 3 area survey. Several of these [A03-607 and A03-796] include only small construction efforts on single walls, while a few pukaras had two or three defensive walls and structures on top, such as A03-1082. The most extensive evidence of pukara construction in Block 3 comes from A03-935, a large pukara on top of the lower sector of the Castillos de Callalli (the lower formation is also known as Cabeza de Leon) with natural escarpments over 50m high that were supplemented by four rows of walls on various areas of the hill. Three rows of walls were also encountered blocking access via the gullies close to Quelkata cave. This pukara represents a large, defensible zone.

Another relatively large pukara, Condorquiña [A02-6] was encountered in 2002 just over 5 km south along the west side of the Pulpera drainage (shown in Figure 6-69). Pukara Condorquiña has three major rows of walls and the remains of 10 oval structures on the summit the majority of them measuring about 1.8 x 2.3 m across.

Mortuary features

Chulpa burial towers (Stanish 2003: 229-234; Wernke 2003: 225-233) are found throughout the Block 3 area on promontories and sometimes in caves or niches in cliff faces. *Chulpas* were constructed during the LIP and LH in this region, while cist tombs are known to date from the preceding Middle Horizon. Few Block 3 *chulpas* are standing, and many of the stones appear to have been reused in nearby modern field walls. Cave burials were also encountered where the interments were “cocoon bundle” burials (de la Vega et al. 2005; Wernke 2003: 233-234); this kind of interment was evident in the partially looted cave burial of A03-815 on the north end of the Block 3 survey area.

Figure 6-79. Recently looted cocoon-type interment from A03-815.

Agricultural production

While agriculture is very limited in the modern economy of the Callalli area, evidence of relatively extensive past agriculture is apparent along the Terrace 1 and 2 margins of the Río Llapa. In the vicinity of A03-785 and A03-797 on the east side of Block 3, extensive areas of previously furrowed agricultural lands are evident. Artifact associations with these agricultural lands primarily belong to the Late Intermediate Period and Late Horizon, but the remains of a colonial site near A03-785 is apparent as well.

Late Horizon

In the Block 3 area the Late Horizon appears to involve the settlement of larger communities along the wide terrace margins of the Río Llapa. Sites associated with cultivated areas that had a slight Middle Horizon component and a stronger LIP component, appear to be the most extensively occupied under Inka dominance in the Late Horizon. The LH pattern of large settlements adjacent to agricultural lands is consistent with the pattern observed elsewhere in the highlands of southern Peru. In the Lake Titicaca Basin, Stanish notes that the settlement hierarchy for sites under 2.5 Ha remained mostly unchanged with the onset of the LH, but under Inka rule new large administrative sites were founded (Stanish 2003: 253-258). In the main Colca valley, Wernke (2003: 217-224,439-441) concludes that Inka administrative strategy involved ruling through local elites using the pre-existing *ayllu* structure of community organization. The effect on the settlement system was to promote a single administrative center, Yanque, to the top of the settlement hierarchy and other LIP sites became second-tier centers.

In the Callalli area, Late Horizon diagnostic ceramics were appear to have been concentrated along the south margin of the confluence area, known as Callalli Antiguo, and a small concentration of Late Horizon materials were found on the south-western edge of modern Callalli. The town of Sibayo, on the north side of the river confluence, was outside of the 2003 survey boundary, but it is possible that a Late Horizon settlement exists in that area as it complements Callalli Antiguo on the south. It is worth nothing that a principal prehispanic road along the Upper Colca valley lay on the south bank of the river where the route passes through to Canocota en route to Chivay. This road appears to have passed by the confluence area in the vicinity of Callalli Antiguo and as a major thoroughfare it is an appropriate place to position an administrative center.

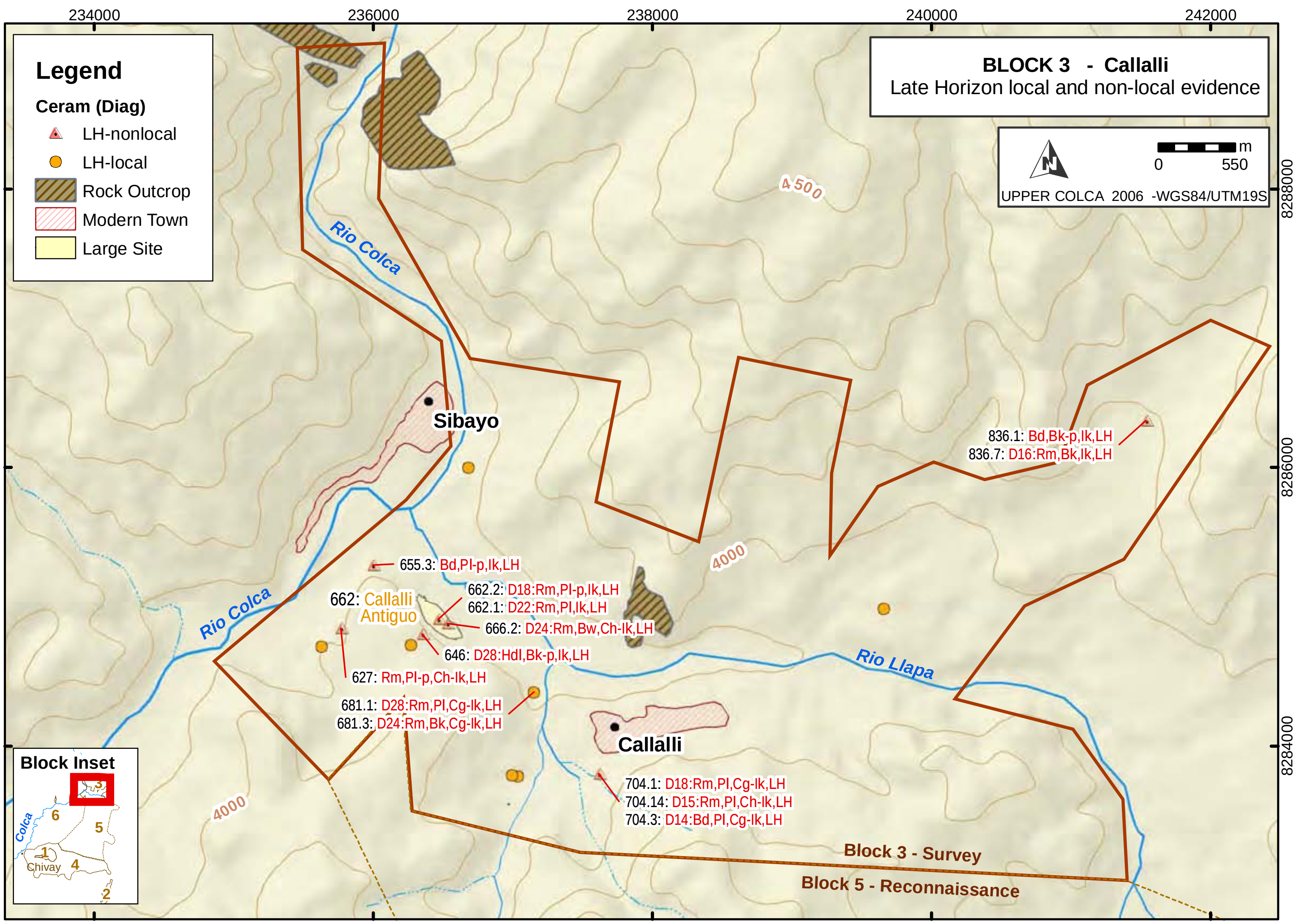


Figure 6-80. Block 3 Late Horizon diagnostic materials

To the west of Callalli the 2003 survey encountered a settlement that is known locally as “Callalli Antiguo” (F. Windischhofer 2003, pers. comm.). The site sprawls over the natural terraces just south of the confluence of the Colca with the Llapa, across from Sibayo. An extensive part of the site is located adjacent to the main road, while a cluster of collapsed structures, including houses and *chulpas*, are located just on the southern side of a ridge that divides the site in half. One might expect to find an Inka administrative site in this area. If this were an administrative site, however, it would also be fitting to encounter a number of well-constructed structures with Inka features, such as trapezoidal doors and cut-stone masonry as observed by Wernke (2003) at a number of sites in the main Colca Valley

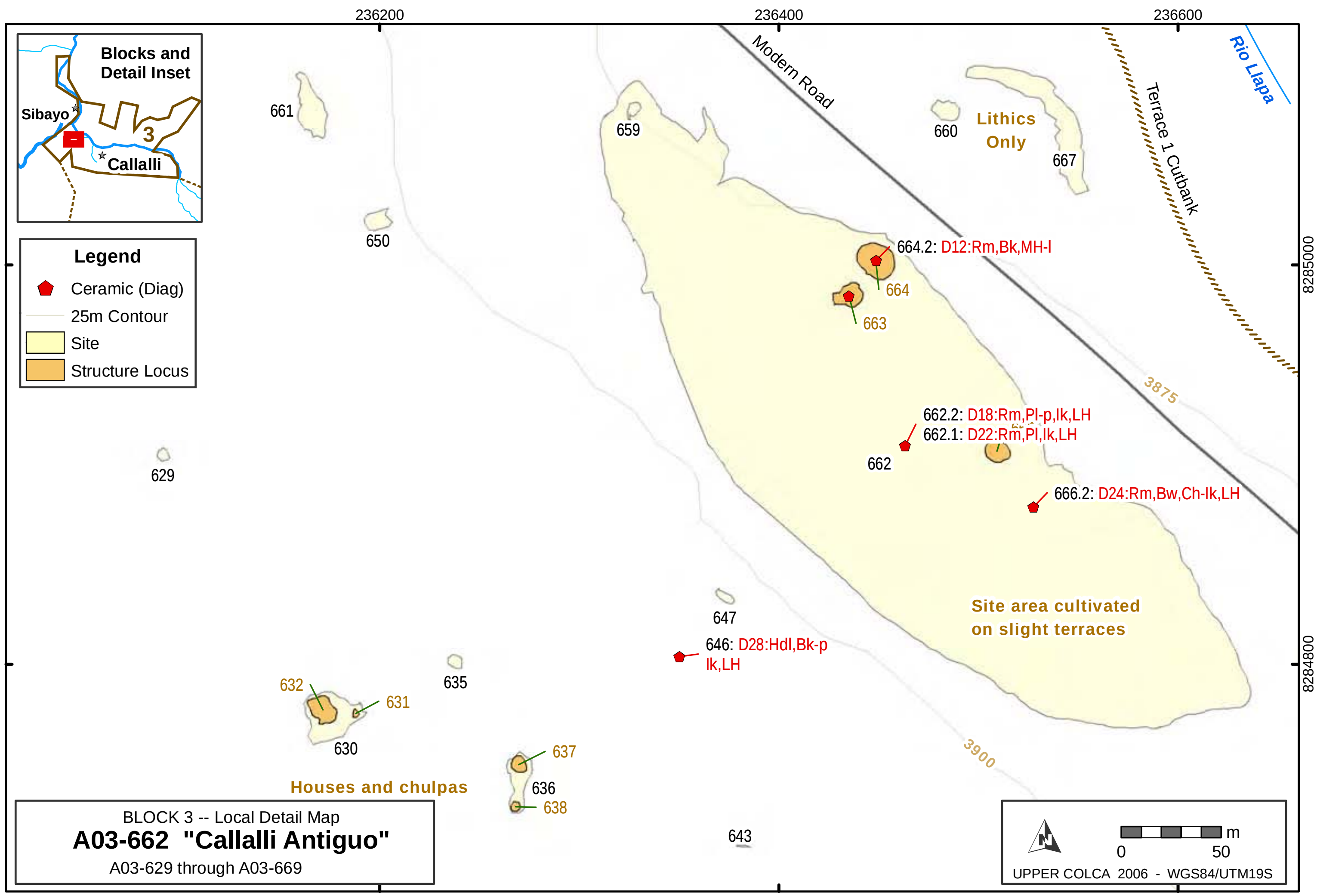


Figure 6-81. Callalli Antiguo [A03-662] and surroundings.

Figure 6-82. A03-662 north sector of Callalli Antiguo agricultural sector, with two individuals walking together in the center of the photo providing scale and the Río Llapa and the town of Callalli in the background.

Vestiges of terraces are apparent in this larger, 4.2 hectare cultivated area of A03-662, and the sector appears to have been in agricultural production at one time where it is may have been involved in dry land production of high altitude seed-plants *Chenopodium*. Old natural terraces of the Río Llapa, slight terraces visible in the site overview photo below (Figure 6-82), were plowed and planted using field boundaries that follow terrace edges accentuated by the rocks that were thrown along the margins during field clearing. Some suggestion of eroded canal features were evident as well, implying that some form of irrigation was achieved, although such irrigation would likely have required diverting water from Quebrada Taukamayo to the east (adjacent to A02-26, see Figure 6-62)

Structures

On the north side by the road an agricultural sector was encountered with a half-dozen collapsed rock structures including three structures of rounded rectangular form that may have been domestic. These three structures have walls that were constructed using a double coursed design with mortar, and the walls tilt slightly inward. Wernke (2003: 197-199) describes circular houses as being common for pastoral peoples in the higher altitude portions of the Colca valley beginning at the site Laiqa Laiqa near Tuti around 3900 masl. Rounded-rectangular structures are therefore unusual at this altitude in the valley. The double coursed walls of A03-663 measured approximately 90cm in thickness. Other possible explanations for these structures are that they served as storage silos (although the Late Horizon Qolqa storage silos are not found in the Colca valley), or these buildings could have been large burial towers. The ceramics collected in the immediate vicinity of these buildings span the Late Prehispanic with a single local Middle Horizon sherd, several LIP Collagua sherds, and Collagua-Inka LH sherds.

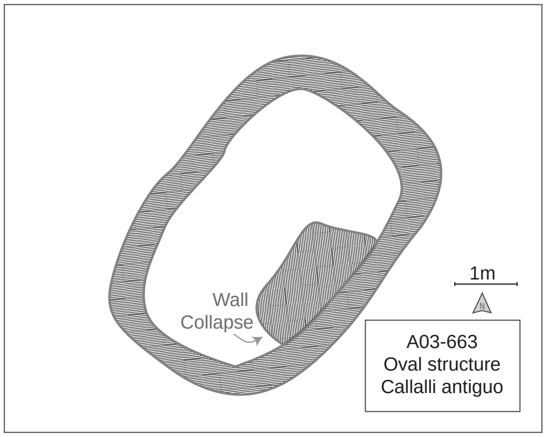


Figure 6-83. Base of walls of structure A03-663 in Callalli Antiguo.

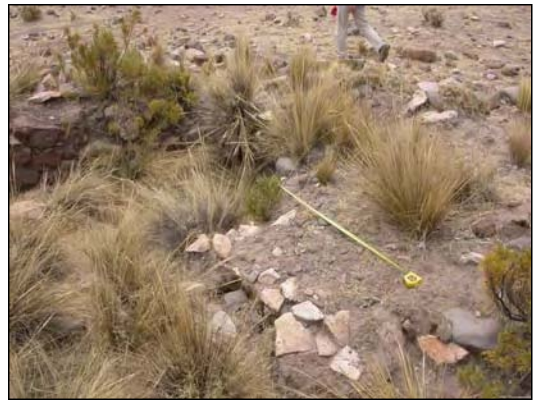


Figure 6-84. Collapsed wall of A03-663 structure.

Ceramics

Surface collections of pottery from the area of Callalli Antiguo reveal that the site is a multicomponent occupation, but that the area appears to have been primarily a Late Horizon settlement. No brushed, unslipped pottery similar to the Chiquero Formative described by Wernke (2003) for the main Colca valley was found in this area.

Period	Style	Beaker	Bowl	Pitcher/Jar	Plate	Unknown	Total
LH	Chucuito-Inka		1				1
LH	Inka	1			2		3
LH	Collagua-3		2		2		4
LH	Collagua-Inka					1	1
LIP-LH	Collagua		1	1		1	3
LIP	Collagua-2		3				3
MH	Local MH	1					1

Table 6-57. Diagnostic ceramics from Callalli Antiguo [A03-662] and vicinity.

The ceramics data suggest that this area, which does not have a pukara adjacent to it, was settled following the Inka conquest in the Late Horizon.

Lithics

A relatively large percentage of obsidian cores were observed at this site, particularly in the southern sector by the houses and *chulpas* shown on Figure 6-79. It is notable that one half of the fifteen Ob1 cores found in Block 3 were found here, and they are relatively large cores for Block 3.

	Callalli Antiguo Cores				Block 3 Surface Collection			
Material	No.	μ % Cortex	μ Wt	σ Wt	No.	μ % Cortex	μ Wt	σ Wt
Obsidian	7	10	35.9	6.82	17	5.0	23.2	13.1
Volcanics	1	20	117.8	-	2	7.5	87.7	42.6
Chalcedony	1	20	27.1	-	4	16.7	47.5	18.1
Chert	3	42.1	61.6	32.3	18	32.1	57.17	33.8
Total	12	32.1	48.4	29.0	41	21.6	43.6	31.3

Figure 6-85. Cores at Callalli Antiguo [A03-662] and vicinity compared with all of Block 3.

It appears that obsidian cores were being transported here from the Maymeja area disproportionately to the rest of Block 3. The other site with a large number of Ob1 obsidian cores (n=6) is Taukamayo [A02-26] that was tested with the A02-26u1 unit and the u2 profile.

Discussion

The evidence from the Late Prehispanic occupation of Block 3 suggests that a significant population increase occurred during this time in the upper Colca valley. The evidence from the Tiwanaku period and the Middle Horizon appear to show small settlements with an economy focused primarily on pastoralism. Despite the wide circulation of Chivay obsidian during this period, there is no evidence in Block 3 of outside contact during the Middle Horizon except for the Wari influence in the local Middle Horizon ceramic technology, as described by Malpass and de la Vera

Cruz (1986) and by Wernke (2003). During the Late Intermediate Period, dramatic changes are notable in a variety of forms of archaeological evidence in a pattern that is consistent with that observed by Wernke in the main Colca valley. Some limited agricultural cultivation appears to have been practiced given the association of LIP ceramics with cultivated areas. Pukara construction and some types of *chulpa* burial monuments are further evidence of LIP period occupation.

Block 6

Block 6 is located along the Challacone drainage just upstream from the town of Tuti, on the western edge of the study area. A map showing this survey block appeared in Figure 6-42. In addition to an interesting Archaic component, this area contained local MH, LIP, and local LH ceramics. Furthermore, the bases for five *chulpas* were encountered along the ridgetop just east of Quebrada Challacone.

6.6. Chapter summary discussion

These data demonstrate that while obsidian procurement and local consumption had notable variation in certain prehispanic periods, some structuring aspects of regional obsidian consumption remained stable. Some of the expectations of distance-decay are borne-out diachronically. For example, despite the proximity of the Chivay source to Block 2 and Block 3, obsidian never dominates the lithic assemblage in Block 3, and by weight obsidian never dominates in Block 2 despite wide evidence from many small flakes. Although the manufacturing advantages of obsidian are well known, it appears that its utility was sufficiently specific that it was not widely used by local populations despite abundant access only a few hours from their communities. The following chapter will explore in more detail the results of test excavations in each of the three blocks discussed here, and subsequently Chapter 8 will discuss synthetically the implications of these data in light of regional obsidian consumption patterns from Chapter 3.

– Chapter 7 –

Results and Analysis of

Data from Test Excavations

Diachronic changes in extraction and production are particularly difficult to detect from surface materials at raw material sources because source locations are characterized by an abundance of non-diagnostic artifacts from an early stage of production. Test excavations in stratified desposits in production areas can provide diachronic evidence of changing reduction methods in the form of measurable differences in reduction strategies used in different time periods. Further, such excavations provide temporal control that may link production evidence to the regional archaeological sequence, particularly if datable materials are found in stratified contexts.

The surface survey data that reviewed in Ch. 6 will be complemented with temporal data from selected excavation units. In total, eight 1x1m test units were excavated in three areas of the 2003 survey, and profiles were cleaned and mapped at two additional locations. Basic analyses were completed on the materials from all of these test units. Subsequently, detailed attribute analyses were conducted on materials from five of the units. The analysis results of the five most well-stratified and informative test units will be presented here.

7.1. Goals of the analysis of production

Tthe aim of this analysis was to document changes in lithic reduction strategies over time in the vicinity of the Chivay obsidian source. The research focus was on obsidian procurement and production, and here the emphasis is placed on detecting changes in the morphology of flakes and cores that were collected both in the source area and the blocks immediately surrounding the source. As quarry workshops frequently do not include recognizable artifact types, the focus of this analysis was on the changing nature of reduction through prehistory at the source using technical analysis of flakes, cores, and tools both at the obsidian source and at sites further away from the source.

Evidence from consumption contexts frequently contains a high percentage of artifacts discarded at an advanced stage of reduction or broken in use, however the typical production site in a quarry zone overwhelming consists of non-diagnostic flakes and cores discarded during production. In other words, such areas are rich in negative evidence concerning the artifacts that were not transported and consumed. For example, one could assume that the goal of obsidian reduction in the Early Pastoralists and Late Prehispanic times was the production of type 5b and 5d projectile points, as those were the dominant forms for bifacially-flaked obsidian tools in the time periods covered by the excavated sequences. However, this focus on projectile point production ignores the wide utility of simple obsidian flakes. In other words, a variety of potentially useful flake forms could be struck from a high quality core, and therefore procuring and exporting cores may have been a central goal at in the obsidian source area.

Rather than to attempt the construction of linear sequences linking nodules and cores with specific artifact forms, the focus here is on describing attributes of assemblages per level in order to document changes empirically. Comprehensive sequence models such as *chaîne opératoire* often incorporate procurement and quarry production in the earliest stages of a more elaborate sequence. However, detailed examinations of the initial stages of production are typically often not addressed in these comprehensive sequence models because the focus is on behavioral context of consumption and resharpening (Section 2.4.4). While implementing a *chaîne opératoire* approach is occasionally attempted at quarries (Edmonds 1990), the value of constructing "chains" appears to be limited at quarry workshops where the bulk of the evidence is constituted by only the first few "links" in the chain. Archaeologists have presented more truncated sequential approaches for bifacial reduction at obsidian sources (Darras 1999: Ch. 7; Pastrana and Hirth 2003), where reduction strategies are largely based on the starting shape and size of the nodule which, in turn, may reflect quarrying behavior and procurement effort. In the present analysis of five stratified 1x1m test units: the quarry pit (1 unit), workshop (1 unit), and two consumption contexts (3 units) the focus here is on describing morphological properties of production and consumption rather than constructing sequences based only five test units.

		Fraction of Advanced Analysis		Total Analyzed Flaked Stone
	Site	No.	Percent	No.
Surface		1289	68.5%	1883
Q02-2u1	Source (Corral)		0.0%	108
Q02-2u2	Source (Pit)	73	66.4%	110
Q02-2u3	Source (Workshop)	1487	96.3%	1544
A02-26u1	Taukamayo	333	58.4%	570
A02-26u2	Taukamayo		0.0%	15
A02-39u1	Pausa		0.0%	15
A02-39u2	Pausa	4	13.8%	29
A02-39u3	Pausa	166	68.0%	244
A02-39u4	Pausa	238	72.1%	330
Total		2301	77.6%	2965

Table 7-1. Lithics Phase II analysis showing fraction of artifacts with detail measures.

Nevertheless the lithics analysis of five of the excavation units produced exhaustive empirical evidence. As described in Chapter 5, the Lithics phase II: Advanced analysis stage involved taking up to 30 measures per flake.

Some preliminary sequences can be explored with the workshop data. For example, two principal reduction trajectories appear to have their roots in the evidence apparent in workshop production. These two sequences can be described as (1) “core reduction” and (2) “flake as core reduction”.

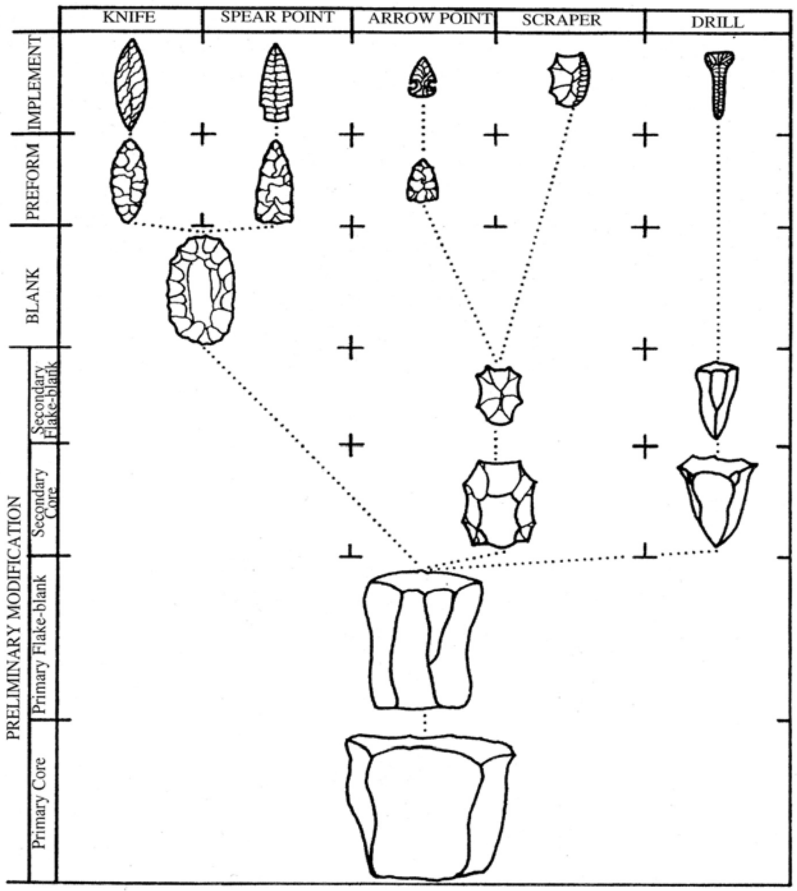
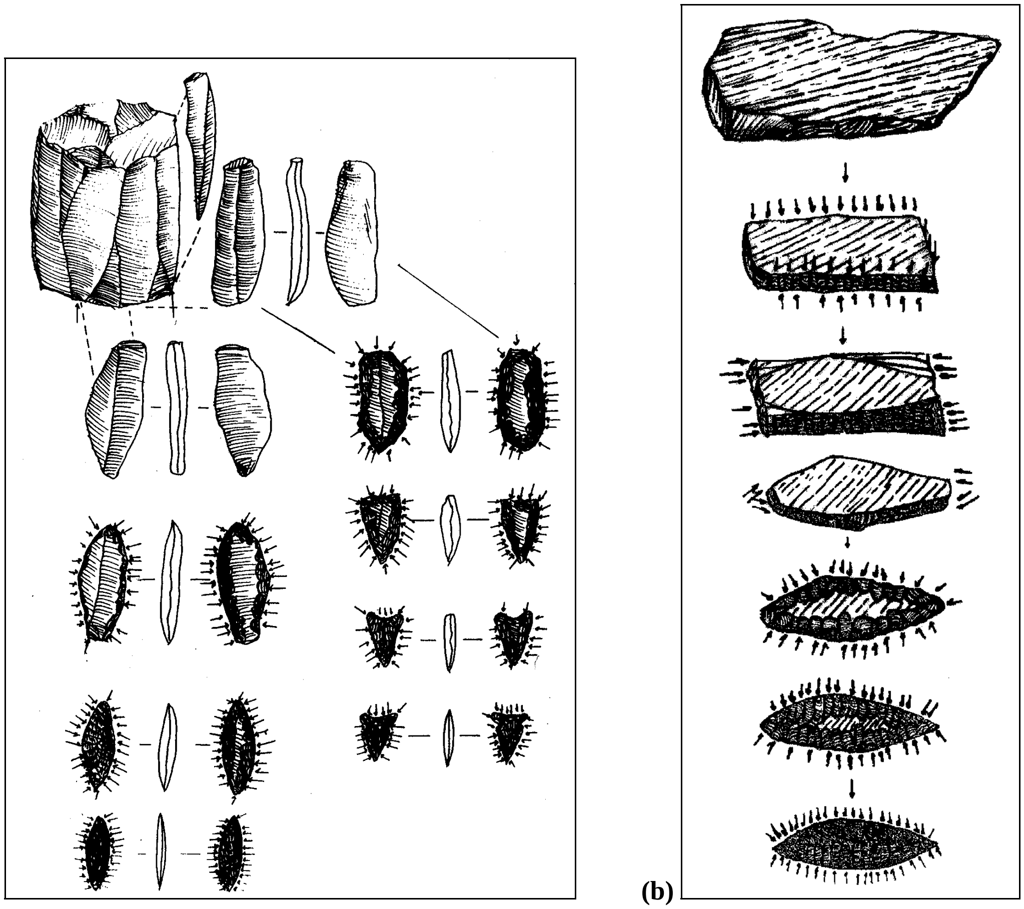


Figure 7-1. Principal lithic reduction in the northern African Gumu-sana assemblage (from B. A. Bradley 1975: Fig. 1).

Described by Bruce Bradley (1975) in as “secondary core”, the flake-as-core sequence begins on a large flake with a single positive percussive feature, but this flake serves as a core for the production secondary flake blanks. In Bradley’s example, three possible sequences are described from a single core form, and the variability in sequences is compounded by variability in the size and shape of starting nodules.


(a) (b)
Figure 7-2. Bifacial sequences diverge based on the original nodule form with arrows showing percussion direction (Pastrana and Hirth 2003: 204-205): (a) block nodules for the production of flake-cores, (b) flat slabs of tabular obsidian for shaping preforms.

At the Sierra de las Navajas (Pachuca) obsidian source in central Mexico, both prismatic blade manufacture and bifacial reduction occurred at workshops adjacent to the source. Focusing on the bifacial industry, Pastrana and Hirth (2003) describe two distinct bifacial reduction sequences. One begins on block nodules that are developed into prepared cores, the other sequence exploits the occurrence of long, narrow nodules described as “tabular obsidian”. This study underscores the importance of core form variability in the ensuing reduction sequences and it highlights the challenges inherent in reconstructing detailed sequences from quarry workshops based on assemblages that are principally discarded by-products.

In lieu of attempting to develop specific sequences the focus in the Upper Colca project analysis is on describing attributes in Chivay obsidian production and focusing on more general questions.

Principal questions driving the analysis of excavated materials include the following:

(1) What characteristics of reduction strategies changed through time?

(2) How did changing availability of raw material through quarrying change the strategies at the workshop?

(3) How does obsidian production at the quarry area compare with consumption in the immediate vicinity of the Chivay source and with distant consumption in the Titicaca Basin?

These questions frame the research at the Chivay source. The lithic assemblages are approached through quantitative and qualitative description, and also through an investigation of regular change through time at the quarry workshop through clustering of quantitative attributes of cores and flakes.

7.2. General Indices of Production

Chapter 6 began with general production indices for obsidian distributions throughout the survey blocks. Here the same indices are presented by excavation level for obsidian artifacts assemblages. These indices were described by Ericson

(1984: 4) and while these measures are extremely general, the indices provide a basis for comparability between quarry studies in different regions of the world.

Briefly, the measures are calculated as follows, using counts.

Debitage Index: (Flakes) / (Flakes + Tools)

Cortex Index: (Flakes ≥20 % cortex) / (All Flakes)

Core Index: ("Spent Cores" with ≥3 rotations) / (All Cores and Tools)

Biface Index: (All Flakes with BTF ≥7) / (All Flakes)

Section 6.2.2 provides a more detailed explanation and discussion of these production measures, and the Bifacial Thinning Flake Index is developed in Section 5.9.3. The production indices for excavated units are as follows.

Level	No. Flakes	Debitage Index	Cortex Index
1	6	1	0.667
2	16	1	0.438
3	8	1	0.5
4	11	0.917	0.545
5	12	0.923	0.334
6	1	1	0
7	2	1	0
8	6	1	0.334
10	7	0.875	0.571
11	10	1	0.4
Total	79	0.963	0.443

Table 7-2. Q02u2 "Quarry Pit" obsidian production system indices.

Note that there was a low total number of flakes from the quarry test unit (n = 79). No *Core Index* was calculated because only three cores, and no spent cores (≥ 3 rotations) were encountered in the Quarry pit test unit. The indices from this test unit are characteristic of very early stage reduction. There is a very high Debitage Index because there were virtually no "Tools". There was only a moderately high Cortex index, perhaps because relatively little reduction occurred at this location as it appears that nodules were knapped elsewhere.

Level	No. Flakes	Debitage Index	Cortex Index	BTF Index	Core Index
1	151	0.944	0.470	0.007	0.129
2	151	0.938	0.675	0.026	0.127
3	279	0.952	0.631	0.014	0.025
4	204	0.919	0.794	0.015	0.130
5	187	0.940	0.818	0.016	0.052
6	55	0.873	0.564	0.036	0.286
7	50	0.943	0.440	0.000	0.368
Total	1077	0.936	0.666	0.016	0.110

Table 7-3. Q02u3 "Maymeja Workshop" obsidian production system indices.

At the Maymeja workshop an extremely high Debitage index shows that blank production was probably the dominant pattern, as few identifiable tools were encountered in the test unit. The cortex index is higher than any other excavated context in this study, but it is still relatively moderate, perhaps because by Count the medium-stage flakes prevail. Very low BTF indices support the assertion that little advanced reduction was occurring here. Finally, the Core index values appear to be low, but these values are actually the highest in the study area. The Core Index calculation is complicated by the fact that cores and blanks were probably the principal items exported from the quarry workshop area.

Level	No. Flakes	Debitage Index	Cortex Index	BTF Index	Core Index
2	5	1	0	0	0
3	6	1	0	0	0
4	16	0.941	0.063	0.063	0
5	44	0.880	0.045	0.023	0.167
6	50	0.943	0.040	0.040	0
7	69	0.920	0.029	0.043	0
8	31	0.861	0.065	0.032	0.167
9	9	1	0	0	0
10	7	0.875	0	0	0
11	9	1	0.111	0	1
12	5	1	0	0	0
13	5	1	0	0	0
14	1	1	0	0	0
15	1	1	0	0	0
Total	258	0.921	0.039	0.031	0.120

Table 7-4. A02-26u1 "Taukamayo" obsidian production system indices.

At Taukamayo in Block 3 a high percentage of Ob2 obsidian was in use (Table 7-4). The debitage index is relatively high, but Cortex is quite low as this site lies relatively far from the source. Very few bifacial thinning flakes (BTF) are present except in the levels 4 through 7 which date to the early part of the Middle Horizon. At Taukamayo these test units were placed in a residential portion of a raised corral area with a hearth in levels 5-7 that dated to the Late Formative. The debitage index but low cortex index shows that there were a great number of tiny flakes of advanced reduction level here. The BTF index numbers are relatively high for excavated contexts.

Level	No. Flakes	Debitage Index	Cortex Index	BTF Index
1	76	0.894	0.039	0.053
2	53	0.946	0.094	0.019
3	55	0.887	0.036	0.018
4	51	0.927	0.039	0.039
5	110	0.932	0.045	0.036
6	45	0.865	0	0
7	11	0.917	0	0
8	2	1	0	0
Total	403	0.912	0.042	0.030

Table 7-5. A02-39 u3 and u4 “Pausa” obsidian production system indices.

At Pausa, in Block 2, these numbers (Table 7-5) compare on a relative basis with the surface indices by survey block, shown above, because Block 2 has the highest BTF index in the survey. The high numbers of projectile points collected in the Block 2 region attest to the advanced obsidian reduction occurring in that zone. No Core index was calculated because no cores were fond in this test unit. It appears that obsidian cores were not discarded in this area; it is likely that they were used or exported.

7.3. Test excavation units

In the course of fieldwork in 2003 test excavations were conducted in Blocks 1, 2, and 3 of the study area. The excavations complied with the stipulations of the survey and test-excavation permits acquired from the Peruvian Instituto Nacional de Cultura. The research plan involved excavating a number of 1x1m units in different areas of the three intensive survey blocks, as per the limitations of the test excavation permit. Excavation methods were described in Section 5.6.1. The focus in this chapter is on presenting the results of excavation in the five test units together with evidence most relevant to the larger research project.

2002 Site	Test Unit	Block	2003 Provenience	Description	Total 2σ calibrated date range
Q02-2	1	1	A03-201 "Saylluta 2"	Corral	Samples not analyzed
Q02-2	2	1	A03-219 "Quarry Pit"	Quarry debris pile	No datable materials: inferred to be largely Early Formative
Q02-2	3	1	A03-330 "Maymeja"	Maymeja workshop	Term. Archaic – E/M Formative: 2880 – 1260 BCE
A02-26	1	3	A03-675 "Taukamayo"	Edge of landslide	Tiwanaku: AD 650 – 870
A02-39	1	2	A03-559 "Pausa"	Raised corral area	No datable materials
A02-39	2	2	A03-557 "Pausa"	Raised corral area	Early Tiwanaku: AD 400 – 470
A02-39	3	2	A03-559 "Pausa"	Raised corral area	Late Formative: AD 80 – 420
A02-39	4	2	A03-559 "Pausa"	Raised corral area	Late Formative: AD 80 – 420

Table 7-6. 1x1m test excavation unit proveniences from 2003 fieldwork.

Due to the higher resolution of the 2003 mobile GIS survey work, the proveniences of surface features were redefined from the 2002 site numbers in some cases using the locus system as per the survey results in Chapter 6. In this dissertation, the 2002 site names (Q02-2, A02-26 and A02-39) were largely used to avoid confusion, but the 2003 locus numbers of these features are provided in Table 7-6 for reference.

Radiocarbon dates were retrieved from the majority of the excavation units and eight charcoal samples were analyzed using Accelerator Mass Spectrometry ^{14}C dating at the NSF's University of Arizona AMS lab. Test excavations served the important role of providing diachronic insights into obsidian production, and testing also frequently provided temporal control in the form of ^{14}C datable charcoal

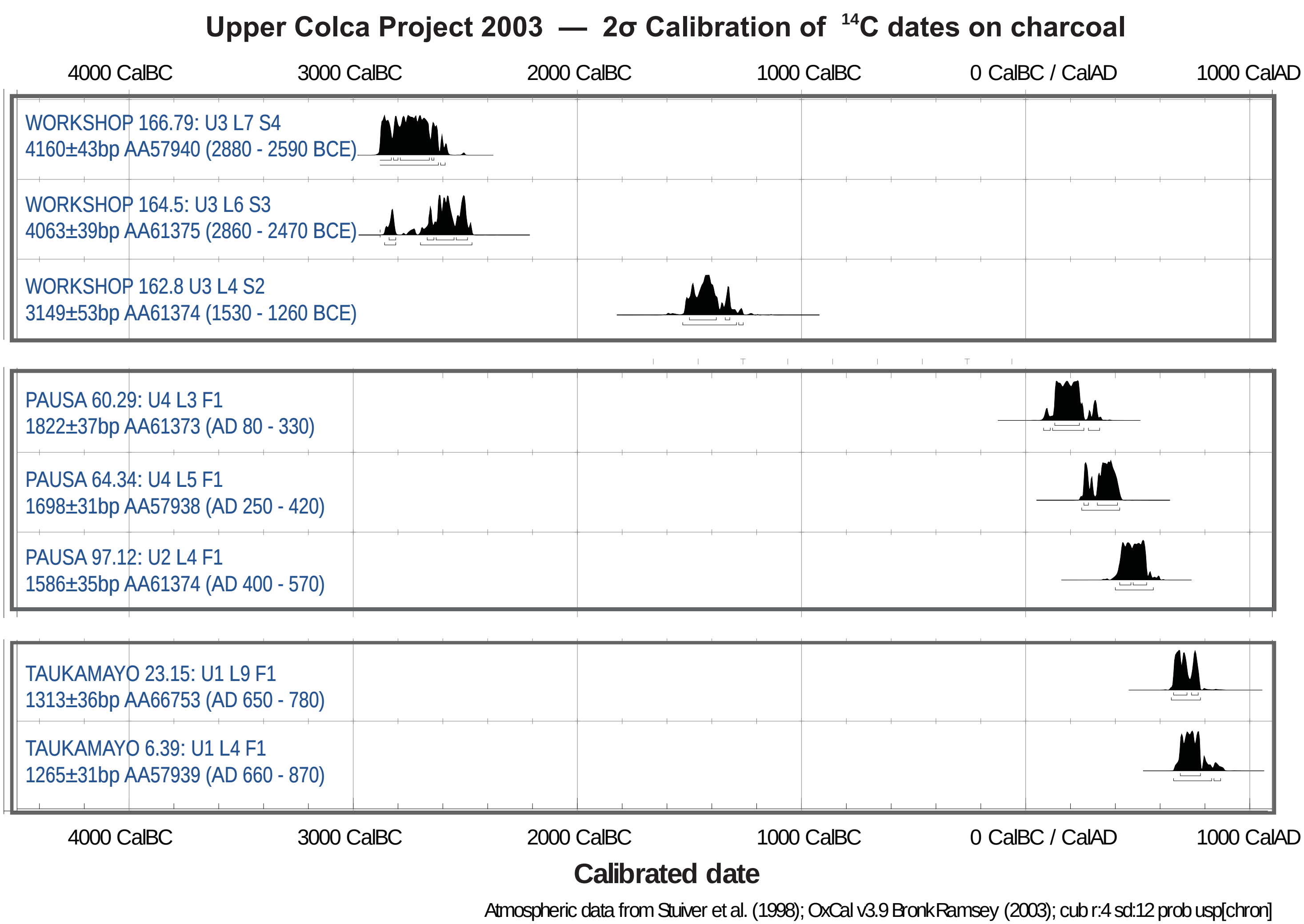


Figure 7-3. Radiocarbon dates on charcoal from test excavations in 2003 showing uncalibrated and calibrated dates as BCE from OxCal v3.9 (Ramsey 2003).

The ranges of the 2003 project radiocarbon dates unfortunately do not overlap between survey blocks, which makes it more difficult to study obsidian production activities in the three survey blocks synchronically. Nevertheless these dates provide some important controls to production activities, particularly in Block 1 workshop where Terminal Archaic through Early Formative dates were acquired.

7.4. Block 1 Test Excavations at Maymeja Q02-2

Test excavations in the Maymeja area of the Chivay source occurred at three units. Test Unit 1 in the Block 1 quarry area was placed on the north side of Maymeja in a corral with ample evidence on the surface of obsidian reduction, but the test unit results were of limited value and they will not be presented here. Test Unit 2 was placed in the debris pile associated with the Q02-2 Quarry pit. Test unit 3 was placed in a mound of flaked obsidian that appears to have been a quarry workshop. These latter two test units will be described in more detail.

7.4.1. Q02-2, Test Unit 2

The broader context of Q02-2 and a map of the quarry pit vicinity are shown in the Early Pastoralists section of Chapter 6 (see Figure 6-45). Few concentrations of cultural artifacts were found on the surface of the quarry pit that would have aided in selecting a location for the 1x1m test unit. There was a great quantity of fractured obsidian, but as will be described below, the test excavation showed that geologically fractured obsidian was the rule and culturally produced flakes were rare in this area. Lag gravels consisting of small, 1-5cm obsidian nodules were observed in a very light tephra-rich soil that formed the context of the quarry pit. The area had little evidence of cultural activity except the excavated pit itself, the associated debris pile, and the greater concentration of dozens of 5-15cm nodules in the bottom of the quarry pit.

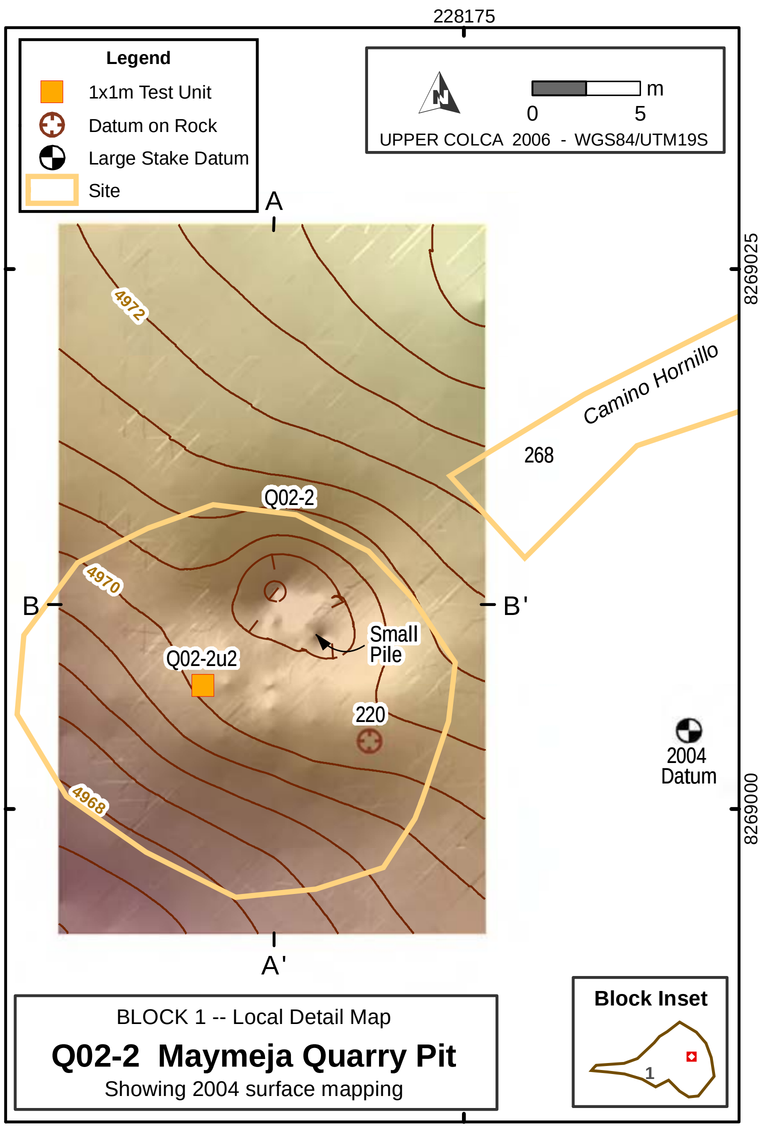


Figure 7-4 Map of quarry pit showing topographic surface acquired using a total station.

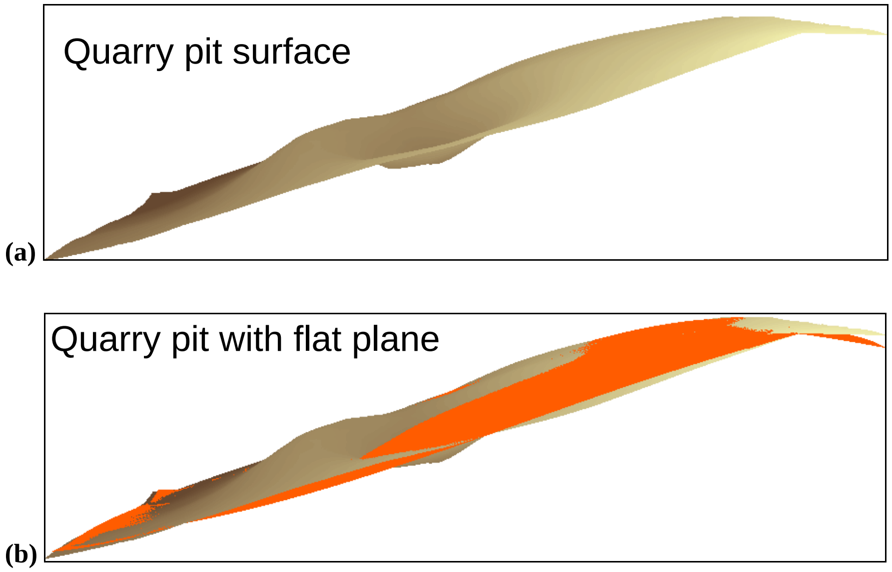


Figure 7-5. (a) Perspective view of quarry pit, (b) Perspective view bisected with an inferred natural slope.

The Q02-2 pit is a depression that measures approximately 4m by 5m, with a depth of 1.5m despite evidence that this pit, excavated into sandy soils, has collapsed margins and has been partially refilled over the years (Figure 7-4). If the area that deviates from the natural slope, including the accumulation pile downslope, is included the disturbed area grows to measure 10m by 12m. Oblong quarry pits ringed by semi-circular debris piles are described at obsidian sources in central Mexico by Healan (1997) and by Darras (1999: 80-84), although this quarry pit falls in the medium size range by Mexican standards.

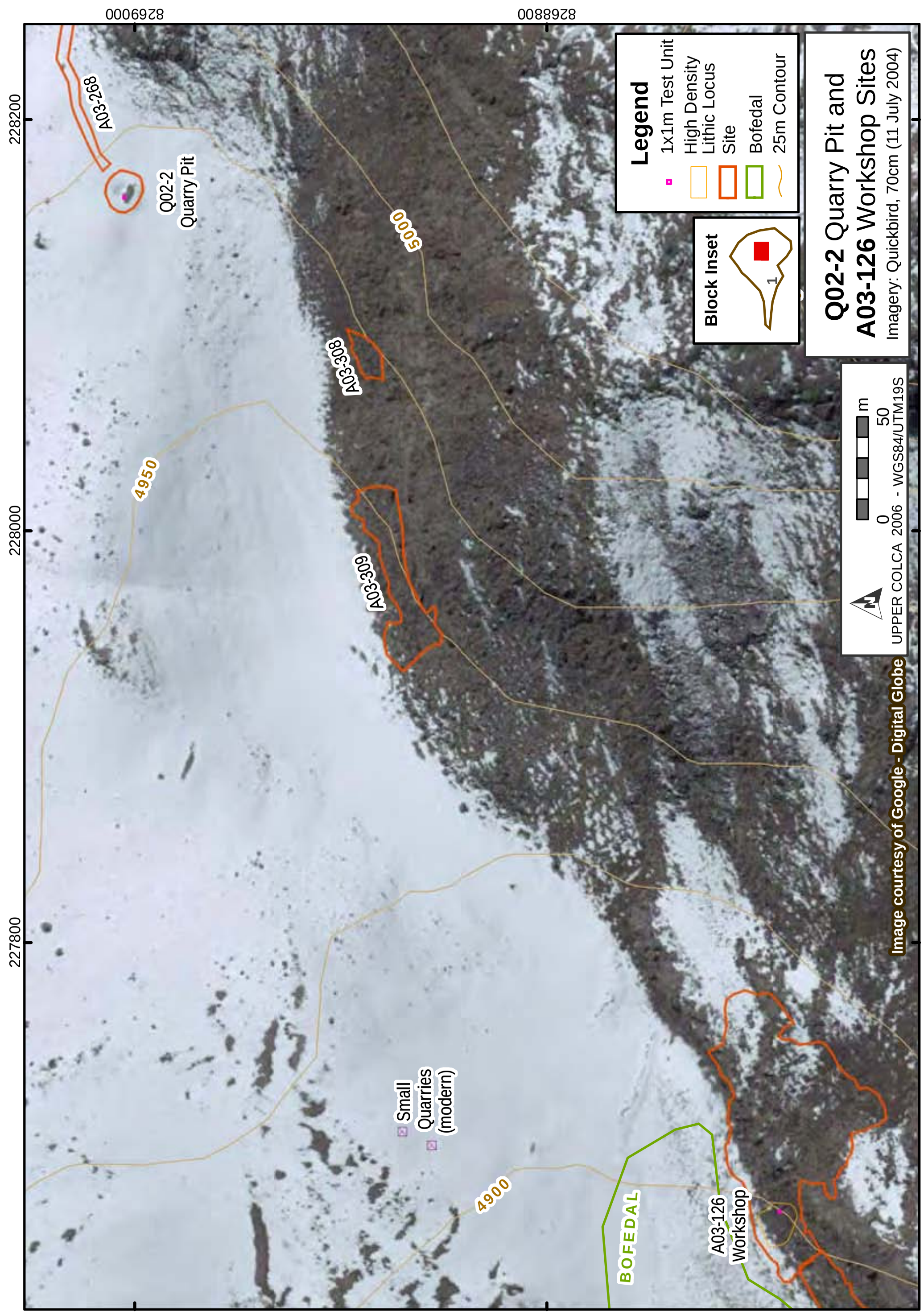


Figure 7-6. The quarry [Q02-2] and workshop [A03-126] are 600m apart. In this image snow blankets most south-facing slopes but the quarry pit debris pile is visible protruding through the snow mantle.

The deepest part of the Maymeja quarry pit at Chivay tends to retain snow (see photo in Figure 6-45), and in the southern half of the quarry depression it was evident that more recent disturbance had occurred. A small mound of light, sandy soil and many small nodules of obsidian are labeled as “small pile” in Figure 7-4. This small mound measures 1m by 1.5m and is 30cm in height. This small pile appears to be the result of recent excavation work and perhaps resulted in the exposure of the 5-15cm nodules currently visible in the pit.

History of study of quarry pit Q02-2

During a preliminary visit in 2002, I climbed to the Maymeja area using the description and GPS-derived UTM coordinates provided in Burger et al. (1998a:205) where I spoke with a herder named Mattias Sarallasi who was working for the land owner from Callalli, Eliseo Vilcahuaman Pambra, and living in the estancia at the base of Maymeja. Sarallasi grabbed a shovel and led me up across the moraines past several small and shallow (1-2m diameter) quarry holes that he indicated to me, and finally to the Q02-2 quarry pit.

In Burger, et al. (1998a:204) the authors write that in their 1995 visit Burger and Salas “encountered a local farmer who had been collecting quantities of obsidian from these deposits for future sale.” Further, they note that “according to a local farmer, a German resident of Bolivia had visited this obsidian deposit in order to collect obsidian for export to La Paz where it was transformed into craft products”. An initial concern for the Upper Colca Project was establishing that the extant pit was not the result of this modern quarrying in the Maymeja area. Directly datable materials were not located in the 2003 research to confirm the antiquity of the pit, but the integrity of the stratigraphy in the test unit, and the presence of cores and bifaces in the excavation, strongly suggest that the quarry pit feature is not a recent excavation. The conclusion here, based on the soil characteristics and the small quarry pits along the ridges below Q02-2, is that recent quarrying work was responsible for the small pile of light soil inside the q02-2 quarry, and for the small quarry pits downslope. The small pile encountered inside the quarry pit feature resembles the level 2 soil encountered in the test unit, suggesting that this modern quarrying entered at least as far as the stratum that was found 15cm below the surface in the 1x1m test unit.

The regional context of this quarry pit, including the relationship between the quarry pit, a Precolumbian road leading to the quarry, and other archaeological features, are described in Section 6.4.1. A discussion of the quarrying methods that may have been used at this location can be found in Ch..

Testing in the debris pile in 2003

In the course of the 2003 Upper Colca Project a 1x1m test unit was placed at Q02-2 in the debris pile immediately downslope of the quarry pit. The unit was aligned to true north and placed on the uphill side of the summit of the debris pile with the aim of bisecting the widest range sizes of pre-existing debris piles as the pile had accumulated below the quarry during ancient use. In the course of the test excavation, the team avoided filling the quarry pit feature with soil or other materials and instead positioned the backdirt piles and screened dirt on the south-east end of the quarry feature.

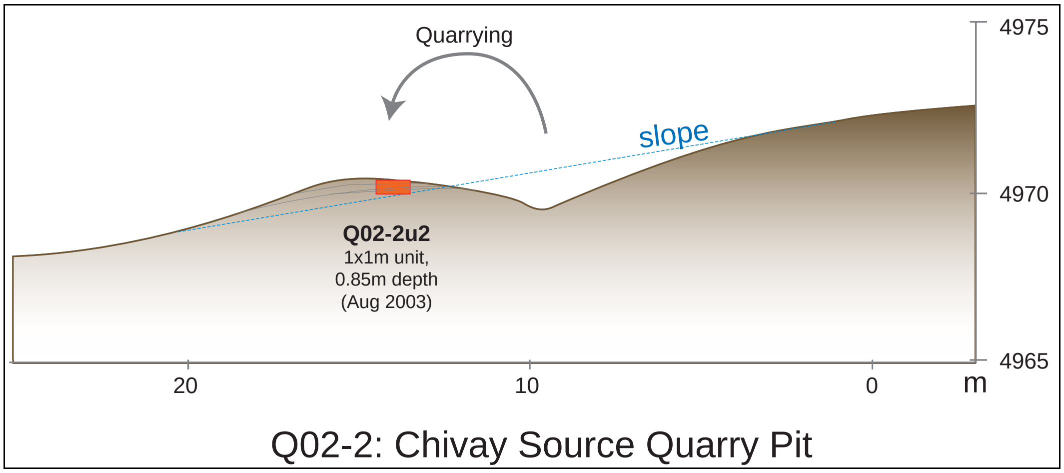


Figure 7-7. Diagram of Q02-2 quarry pit and position of the Q02-2u2 test unit relative to quarry debris layers and natural slope. By virtue of the quarrying history, levels are inverted in the 1x1m test unit so upper levels came from lower (earlier) levels in the quarry pit.

The quarry pit debris pile included relatively few culturally modified artifacts. While thousands of obsidian "flakes" with conchoidal fracture were encountered, closer inspection revealed that a very small minority were fractured by the human hand. Cortex is sometimes very thin on many of the flakes and nodules at the Chivay source (Section 4.5.1), which complicated the task of differentiating cultural and non-cultural flakes. Non-cultural flakes had no clear bulb or striking platform, or the geometry of the bulb was such that the force responsible for fracturing the rock was evidently far away and was geological in scale. In other words, one would see bulbs of percussion that appeared to have been initiated on adjacent rocks by geological or environmental processes, and the force of the fracture transferred through the obsidian matrix.

Figure 7-8. Q02-2, view of quarry pit and u2 test unit from the north.

Characteristics by level

While the test unit did not expose diagnostic artifacts or datable material, such as carbon, that would have facilitated identifying the culture group associated with the quarrying, it revealed changes in stratigraphy and material that contribute to understanding the prehistory of the Chivay source. Provisional estimates, based on comparisons with dates from the adjacent workshop test unit Q02-2u3, suggest that the bulk of quarrying at Q02-2u2 occurred in the Early Formative. It should be stressed here that because the test excavation is into a debris pile in Q02-2u2, *levels are inverted* so higher levels in the test unit came from lower in the Q02-2 quarry pit.

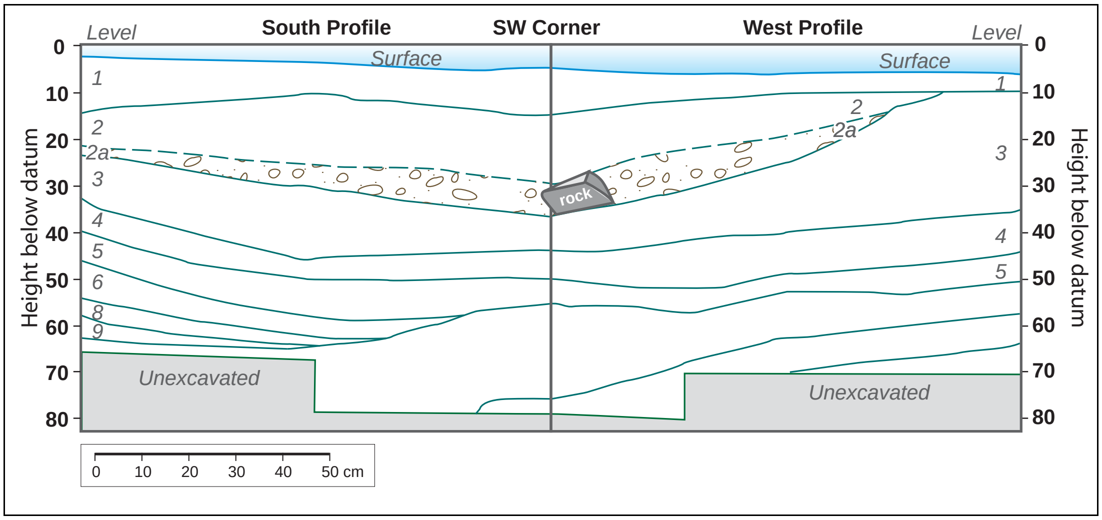


Figure 7-9. Q02-2u2 quarry pit south and west profile diagrams showing excavation levels.


Figure 7-10. South profile of Q02-2u2 at quarry pit at the top of levels 11/12.

The test unit Q02-2u2 stratigraphy indicates that episodic filling events occurred in this location. In the profile figure, excavation levels are represented approximately as indicated by strata lines. The profile photo (Figure 7-10) shows the south profile wall, therefore the quarry pit is located off of the left side of the photo frame. As expected, the stratigraphy generally slopes downwards towards the right. However, in level 2 and to a lesser extent in level 3 the stratigraphy levels out and even rises slightly, indicating there was major deposition on the quarry debris pile. These profiles suggest that the quarrying took place in two major episodes with what appears to have been some minor quarrying activity before and after each larger episode. The soil characteristics and artifact evidence provides more insights in to the circumstances surrounding the quarrying.

Level	HBD*	Comments / Interpret.	Soil	Photos #s
1	5		Pale brown 10YR6/3, Sand, Fine grain, Poorly sorted, .5/.1	2010
2	15	*Intensive quarrying*	Very pale orange 10YR8/2, Sand, Med grain, Poorly sorted, .7/.5	2014
2a	21	Obsidian nodules ~7cm	Concentration of larger nodules in v. light sandy soil.	
3	24	*Intensive quarrying*	Light brownish grey 10YR6/2, Sand, Coarse grain, poorly sorted, .5/.5	2025
4	35.5		Pale brown 10YR6/3, Sandy loam, Fine grain, Poorly sorted, .5/.3. Ave grain size: .25, subangular to rounded.	2026-2028
5	46.5		Very pale brown 10YR7/3, Sand, Fine grain, Poorly sorted, .5/.3. Ave grain size: .25, subangular to rounded.	2029-2030
6	56	Increased moisture in soil, reduced frequency of larger obsidian pieces.	Pale brown 10YR6/3,Sand, Med. grain, Poorly sorted, .7/.3. Ave grain size: .25-.5mm, subrounded.	2030
7	59	Less obsidian, greater moisture.	Pale brown 10YR6/3, Sand, Med. grain, Poorly sorted, .7/.3. Ave grain size: .5mm, subrounded.	2031
8	66	Greater compaction, less rocky. Possibly entering natural slope. Small: .5-1mm, Med: 1-2mm	Light yellowish brown 10YR6/5, Sand, Med. grain, Poorly sorted, .7/.3	2033-2036
9	69		Pale brown 10YR6/3, Sand, Coarse grain, Poorly sorted, .7/.7	2084-2085
10	72		Pale brown 10YR6/3, Sand, Coarse grain, Poorly sorted, .7/.7	2086
11	74		Pale brown 10YR6/3, Sand, Coarse grain, Poorly sorted, .7/.3	2087
12	85		Light brownish grey 10YR6/2, Sand, Fine grain, Poorly sorted, .3/.5	2090-2091
* HBD = mean height below datum in centimeters for the top of each level based on five depth measurements.				

Table 7-7. Q02-2u2 Excavation levels from test unit at quarry pit. Excavation photos available online.

Level	Flakes	Cores	Biface	Ret'd Flake	Preform	Total
1	6					6
2	16					16
3	8					8
4	11				1	12
5	13		1			14
6	1	1				2
7	2					2
8	6					6
10	7	1		1		9
11	10					10
Total	80	2	1	1	1	85

Table 7-8. Q02-2u2 lithic technical class by test unit excavation level.

The vast majority of obsidian fragments at Q02-2 were non-cultural in origin. The artifact data show that culturally derived flakes were found as low as level 11, and cores and retouched items were found in level 10. These data suggest that the quarry pit area was being exploited for obsidian production with in-situ production before it was being excavated on the scale of the later pit. The distributed nature of the cores, flakes, and retouched artifacts in a stratigraphic profile that is predominantly made up of excavation debris, points to a general focus on procuring whole nodules from this location.

Level	Ob1	Ob2	% Ob2	Clear-Banded	Clear	Grey-Banded	Grey
1	4	2	33.3		1	2	2
2	16		0.0	4	4	2	5
3	8		0.0	2	2	1	2
4	11	1	8.3	3	4	1	3
5	12	1	7.7	5	5	1	1
6	1		0.0				
7	2		0.0	1			
8	4	2	33.3		2		4
9			0.0				
10	9		0.0	1	5		2
11	10		0.0	3	4	2	1
Total	77	6	7.2	19	27	9	20

Table 7-9. Q02-2u2 quarry pit obsidian artifact material type and color by level.

A principal question concerning the ancient excavation of the quarry pit is: why excavate for obsidian when it is available on the surface? What desirable characteristics of subsurface obsidian justify the effort expended in digging this quarry pit? Here, the consistency and visual qualities of the obsidian artifacts excavated from Q02-2u2 are examined in order to determine if there were patterns in those characteristics of the material. As shown in Table 7-9, Ob2 obsidian accounted for 7.2% of the artifacts analyzed from the test unit at Q02-2u2, which is comparable to the ratio of projectile point use in the project overall where just 7.8% of the obsidian projectile points observed in the course of 2003 fieldwork were produced on Ob2 obsidian.

Color of obsidian	Artifacts from Q02-2u2		All Obsidian Projectile Points from 2003 Fieldwork	
Clear	27	36.0%	43	35.3%
Clear_Banded	19	25.3%	23	18.9%
Grey	20	26.7%	35	28.7%
Grey-Banded	9	12.0%	21	17.2%
Total	75	100.0%	122	100.0%

Table 7-10. Q02-2u2 Color in quarry pit artifacts compared with all obsidian projectile points from fieldwork.

These data indicate that obsidian from the quarry pit had variability in color of material that was comparable to obsidian use over the entire region. In other words, quarrying individuals at the Q02-2 quarry in the past could expect a relatively low percentage of Ob2 material and color distributions that are consistent with the percentages used for tool production. However, as obsidian was acquired from a number of surface sources, the material quality and color of obsidian from the Q02-2 quarry pit does not appear to have been a principal motivation for excavating in that location. It appears that the quarry pit was relatively typical of the tool characteristics in the region.

However, a difference in cortical flake size from the quarry pit was noted.

	Flake Length in mm						
Level	10 - 20	20 - 30	30 - 40	40 - 50	50 - 60	60 - 70	Total
1				1	1		2
2	1		2	1	3		7
3		1		1			2
4			1	1	2	1	5
5			4				4
8			2				2
10		1	2	1			4
11		1		1			2
Total	1	3	11	6	6	1	28

Table 7-11. Q02-2u2 quarry pit: Lengths of flakes and cores with >20% cortex.

Because production appears to have been largely conducted elsewhere, the counts for cortical flakes are relatively low. The pattern here suggests that larger nodules were available in deeper in the quarry. Again, *levels are inverted* in the test unit because the excavation is into a secondary debris pile (Figure 7-7), so higher levels in the 1x1m test unit came from lower levels in the original Q02-2 quarry. It appears that there was an abundance of large nodules and limited flaking was occurring later in the use of the quarry, and therefore larger flakes were being discarded. In a later discussion below, these data are compared with data presented in Table 7-26, from test unit Q02-2u3 at the A03-126 quarry workshop, in order to explore the connection between the quarry pit and the workshop.

A natural slope has been estimated from the surface map created using a total station in 2004 (Figure 7-7). Subtracting the surface map elevation from the calculated natural slope elevation at the location of the Q02-2u2 test unit allows for an estimate of depth at which one would encounter the sterile natural slope in the excavation unit.

Surface elevation	-	Natural slope	=	Depth of cultural strata
4980.10	-	*4979.27*	=	*0.83*

Table 7-12. Calculated depth of strata in Q02-2u2.

This independent calculation is confirmed by the Q02-2u2 excavation because sterile soil was encountered at approximately 85 cm depth. Based on the thin strata in the test unit profile, it appears that quarrying in this location was initially low-intensity, but that two episodes of large scale quarrying appear to have occurred in level 3, and especially level 2, of the strata profile which correspond to *later episodes* in the history of the quarry pit.

7.4.2. Q02-2, Test Unit 3

At the closest habitable area to the quarry pit, the Maymeja workshop was identified. At this workshop, located downslope of the quarry pit, a 1x1m test unit was placed in the highest part of a gentle mound sloping gradually from the warm, sheltered foot of the cliff band to the edge of the bofedal (see context description in Section 6.4.1). This location, 600m downslope to the west of the quarry pit Q02-2, represents the closest location for stone working adjacent to quality grazing and a perennial water source. While the Chivay source Maymeja workshop [A03-126] is modest in size compared to obsidian workshops elsewhere in the world, many of the same analytical and sampling challenges were encountered that have been faced by researchers at larger workshops. The goal of this study was to document variation in reduction strategies and to attempt to determine if the variation was linked to cultural, temporal, or behavioral changes at the workshop. To be clear: the Q02-2u3 test unit is located inside of the site A03-126 workshop in a high density lithic locus labeled A03-330.

The Maymeja workshop at the Chivay source consisted primarily of flakes and cores, but a small fraction of other artifact types were found here. In the abundance of flakes and cores it may be estimated that the 1x1m unit, with a mean depth of 72cm, produced approximately 750 kg of cultural debris. As was discussed in Chapter2, a basic challenge of workshop studies is in capturing variability through the proper balance of sampling and detailed measures of artifact characteristics.

The 2004 lab analysis included taking several dozen measures on 1,544 artifacts from this pit alone (Section 5.7.2), and the focus was predominantly on analyzing complete flakes and complete cores. The principal morphological changes could be observed in the most well-represented technical classes by summarizing results and also by using clustering techniques and Principal Components Analysis on numerical measures.

Change through time at the workshop

The environmental context of the workshop area on the south side of Maymeja has several characteristics commonly associated with residential base camp sites and these environmental features appear to have contributed to the concentration of obsidian production activities that occurred in this area. These site characteristics include perennial water nearby, grazing, long hours of direct sunlight with a relative abundance of shelter providing partial protection from wind.

The artifactual evidence from the A03-126 workshop, bracketed by three 14C dates between the Terminal Archaic and the Middle Formative, suggest that there were three principal episodes of activity at the workshop. First, in the early history of the workshop obsidian knappers took advantage of relatively large obsidian nodules that were apparently available in Maymeja. Next, the production pattern shifted and long, narrow obsidian cores of Ob1 material became abundant. Subsequently, after a brief ambiguous phase that perhaps reflected the exploitation of residual materials from the preceding stage, there was return to a pattern that is similar to the earliest occupation levels in terms of flake morphology and technical class variability. These episodes can be interpreted as demonstrating (1) initial local, irregular production, (2) intensive procurement and production that perhaps involved larger scale quarrying, (3) a return to irregular production and occasional quarrying. This evidence will be explored below.

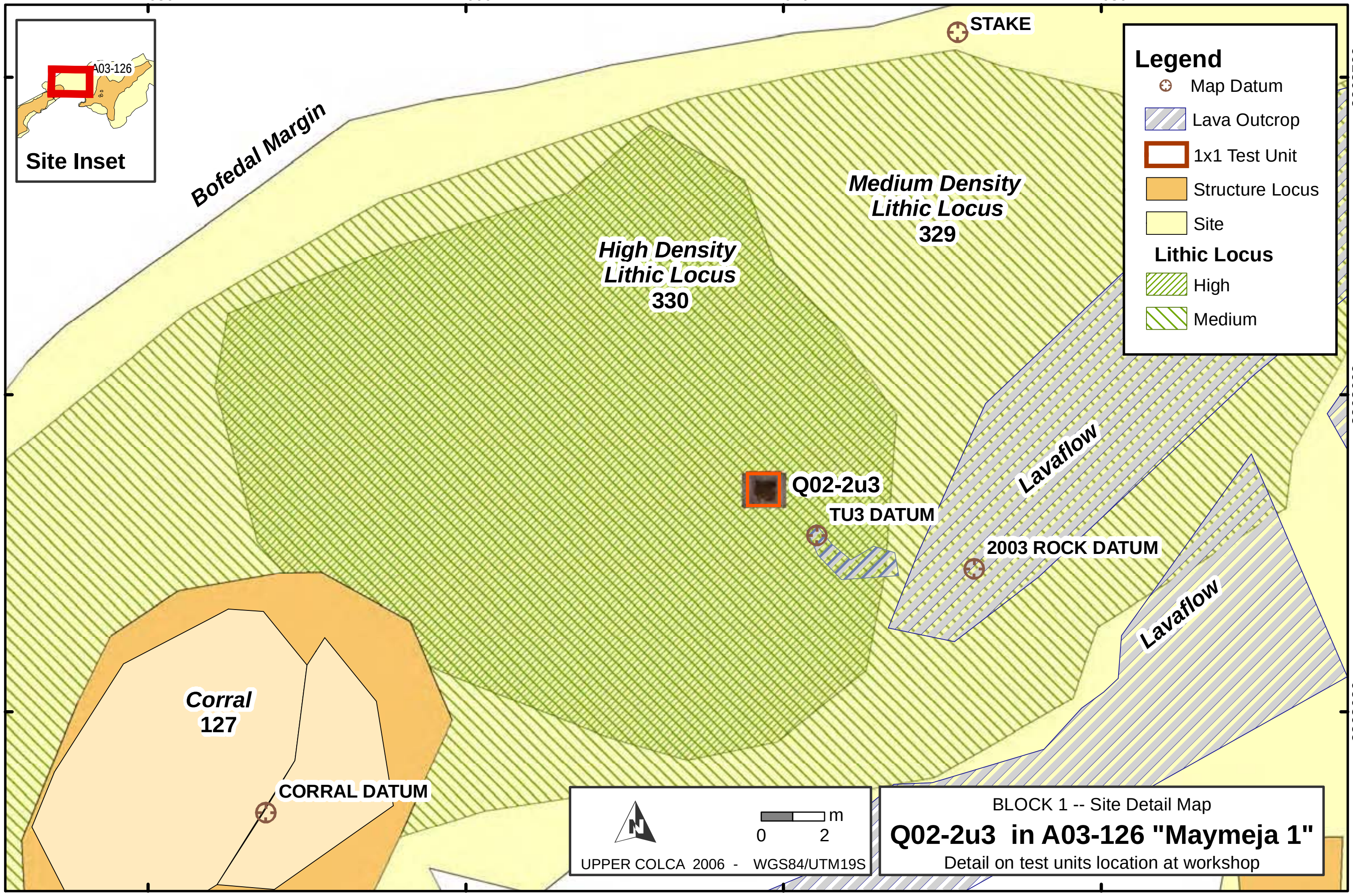


Figure 7-11. Location of test unit Q02-2u3 in site A03-126 workshop.

Q02-2u3 Descriptive Characteristics by Level

The stratigraphy at the Maymeja workshop contains layers at two distinct angles that suggest that mounding occurred initially downslope of where the mound is located today. The Q02-2u3 test unit measured only 1x1m and provided little spatial evidence for architectural interpretation, but the yellow surface labeled as S3 is suggestive of some kind of prepared surface associated with obsidian production at the workshop. Radiocarbon samples recovered from levels 4, 6, and 7 indicate that the sequence in this test unit spans the middle of the Terminal Archaic through to the Early/Middle Formative and probably well into the Middle Formative. A soil sample examined by UC Santa Barbara volcanologists from level 6 contained grains of biotite and hornblende but these grains may have derived from the older bedrock (Sarah Fowler, pers. comm., 27 Feb 2006). The sampling strategy during excavation at the obsidian source involved collecting 25% of flakes being excavated per level by retaining flakes from a single quad, while carbon samples, cores and retouched artifacts (most of which were presumably observed by the excavator) were collected from throughout the 1x1m unit. Thus, flake counts and weights are proportionally ¼ of the amount of other artifact types collected from the Q02-2u3 excavation.

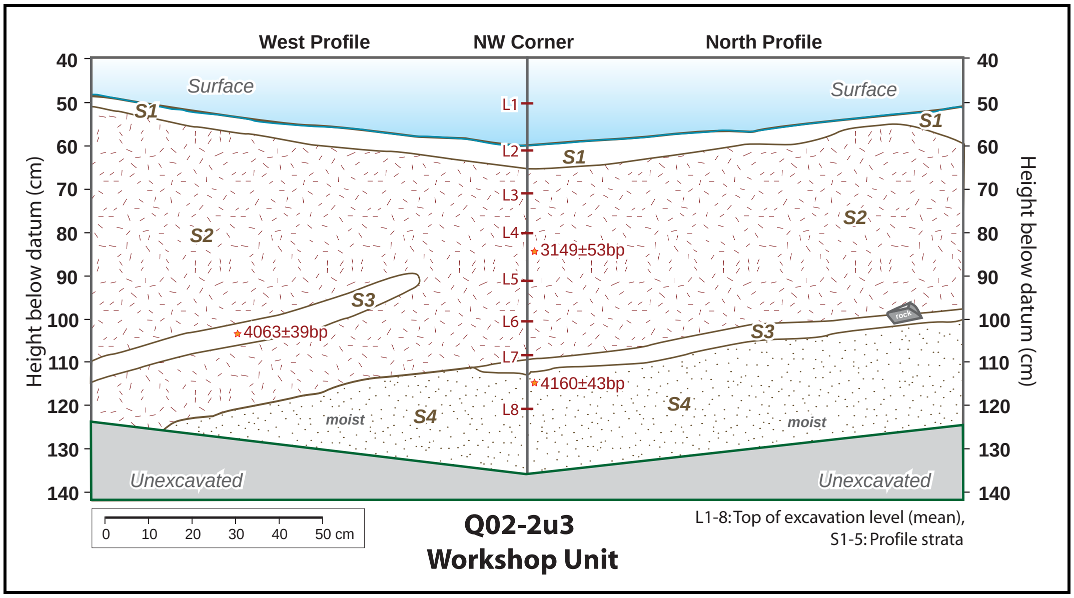


Figure 7-12. Q02-2u3 workshop test unit west and north profile diagrams showing strata.

Figure 7-13. Q02-2u3 west profile at Maymeja workshop site [A03-126].

Lvl	HBD*	Contents	Soil	Photos #s
1	51	S1 Strata. 1 projectile point.	Dark brown 7.5YR3/2, Silty loam, Med grain, poorly sorted, .7/.7	243
2	62	S2	Dark greyish brown 2.5YR4/2, Sand, Coarse grain, poorly sorted, .9/.5	244-245
3	72	S2	F1; Dark brown 7.5YR4/2, Silty sand, Medium grain, poorly sorted, .9/.5	246-249
4	81	S2.^{14}C: 3149±53bp	Dark brown 10YR3/3, Silty loam Fine grain, well sorted, .3/.7	N950:250-251 N4100: 2329-2330
5	93	S2,S3. Midden with yellow stains. Floor surface?	Dark yellowish brown 10YR3/4, Silty clay, Fine grained, well sorted, .3/.7	252-253
6	101	S3, S4: midden, F4&F5: depression on west edge, poss postmolds. Charcoal. S3 ^{14}C: 4063±39bp	Dark yellowish brown 10YR3/4, Silty loam Fine grain, well sorted, .3/.7. Grains of biotite and hornblende encountered in soil sample.	254-256
7	108	Charcoal, Moist soils. Fewer lithics. S4 ^{14}C: 4160±43bp	Dark greyish brown 10YR4/2, Silty loam, Fine grain, poorly sorted, .5/.7, F2: Dark yellowish brown, Silty loam, 10YR3/4, Fine grain, poorly sorted, .5/.7	258-259
8	122	Very moist, poss. altitude of bofedal.. Near sterile.	Brown 7.5YR4/3, silty sand, Med grain, poorly sorted, .7/.3	258-259
** HBD = mean height below datum in centimeters for the top of each level based on five depth measures per level.*				

Table 7-13. Q02-2u3 Excavation levels from test unit at the A03-126 workshop.

As with other units in Maymeja, TU3 consisted of almost exclusively obsidian artifacts in a matrix of tephra-rich soils. As would be expected at a workshop site, there was a great deal of redundancy both in material types and technical classes. Hammerstones were not found in abundance in the excavation, but cores made a large contribution to the assemblages in most levels. This is considerably more than are encountered in consumption sites. For example, in all 13 levels in the test unit A02-26u1 (Taukamayo) only 15 cores were found.

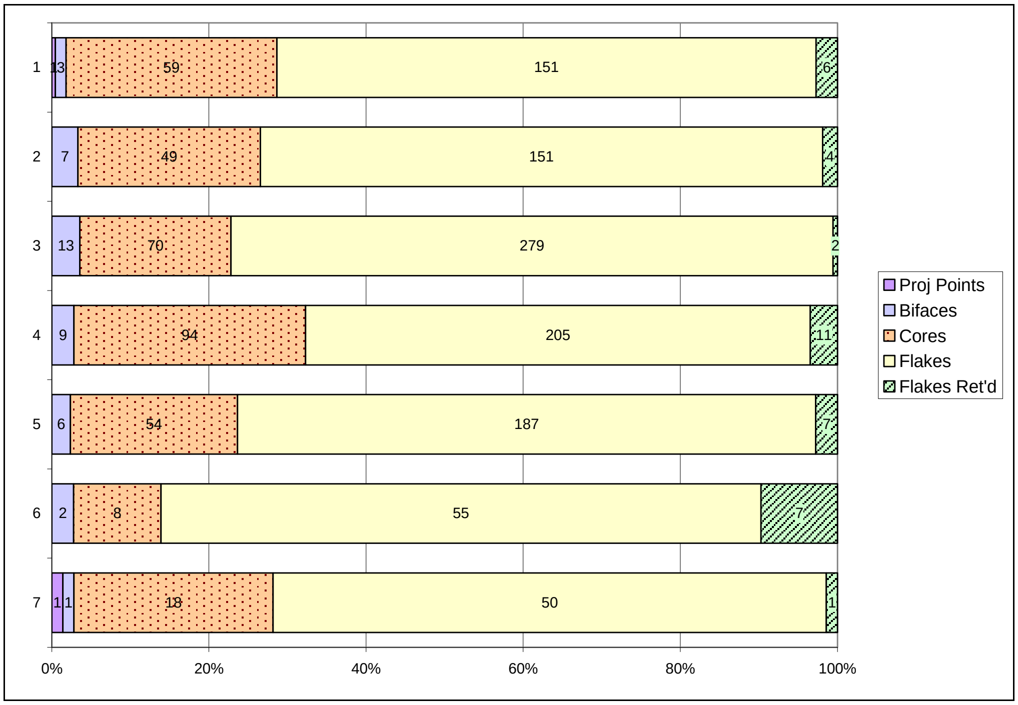


Figure 7-14. Proportions of Tech Classes in excavation levels by count in Q02-2u3.

Lvl		Biface		Core		Flake		Flake Retouched		Total	
		No.	*Wt.(g)*	*No.*	*Wt.(g)*	*No.*	*Wt.(g)*	*No.*	*Wt.(g)*	*No.*	*Wt.(g)*
1	*No. and Wt.*	3	31	59	1484.1	151	765.2	6	73.7	219	2354
	Std. Resid.	-1.2		1.1		-.4		.2			
2	*No. and Wt.*	7	52.4	49	1218	151	699.4	4	29	211	1998.8
	Std. Resid.	.5		0		0		-.6			
3	*No. and Wt.*	13	100.5	70	2703.4	279	602.1	2*	60.2	364	3466.2
	Std. Resid.	1.0		-1.6		1.2		-2.4			
4	*No. and Wt.*	9	60.1	94*	2915.4	205	998	11	209.9	319	4183.4
	Std. Resid.	.1		2.3		-1.5		1.0			
5	*No. and Wt.*	6	60.9	54	1500.8	187	558.7	7	71.2	254	2191.6
	Std. Resid.	-.3		-.7		.4		.2			
6	*No. and Wt.*	2	15.5	8	306.3	55	406.4	7**	33.3	72	761.5
	Std. Resid.	0		-2.1		.5		3.9			
7	*No. and Wt.*	1		18	582.3	50	618.7	1	9.7	70	1210.7
	Std. Resi.	-.7		.4		0		-.6			
Total	*No. and Wt.*	41	320.4	352	10710.3	1078	4648.5	38	487	1509	16166.2

Table 7-14. Q02-2u3: χ^2 showing Technical Class by Level with the Standard Residual.

The variety of technical classes by level is shown above, with very significant counts of retouched flakes in level 6, and significantly low counts of retouched flakes in level 3. There are also a significantly high number of cores discarded in level 4. The weight of these assemblages is also important because, for example, while the count is high in level 3 the weight is relatively low as the assemblage consists of many small flakes. The thickness of each layer (HBD in Table 7-13) can be compared with weight.

Nominal Attributes of obsidian raw material in the quarry test unit: Color, Cortex Type, Heterogeneities

An examination of obsidian by color per excavation level, and color by rotations as a measure of investment but discard, reveals that grey and black obsidian artifacts had the greatest number of rotations while clear and clear-banded obsidian, while making up over 50% of the obsidian present, was seldom rotated more than twice. A number of researchers have observed that Chivay obsidian is unusually transparent. Yet, this evidence indicates that grey and black obsidian was predominant in certain levels at the workshop and these artifacts were rotated more extensively.

Q02-2u3 Obsidian Characteristics by Level			
Level	Prevalent	Rare	Comments
1	*Color:* Grey; *Cortex:* Irregular, Tabular	*Color:* Black; *Cortex:* Tabular Rounded	
2	*Color:* Brown Banded, Grey Banded	*Color:* Black	
3	*Color:* Clear	*Color:* Grey, Grey Banded. *Cortex:* Tabular	
4	*Color:* Black, Grey, Grey Banded *Cortex:* Tabular	*Color:* Clear	
5	*Color:* Black, Clear; *Cortex:* Tabular Rounded	*Color:* Grey, Grey Banded	
6	*Color:* Clear Banded	*Cortex:* Tabular Rounded	
7		*Color:* Clear; *Cortex:* Tabular Rounded	Ob2 (9%)

Table 7-15. Attributes of obsidian artifacts from Q02-2u3.

In the course of the analysis, Alex Mackay noted the presence of Kombewa flakes (Schick and Clark 2003; Tixier et al. 1980), also as known as “Janus flakes”, in analysis. This a flake-as-core technique where

(1) A relatively large flake, Flake A, is struck from a core.

(2) Flake A then becomes Core A when a flake is struck from the ventral surface of Flake A removing the bulb of percussion from step 1 as a thinning technique and producing Flake B.

(3) Flake A is a Kombewa core, and the Flake B that results from step 2 is a Kombewa flake that has bulbs of percussion on both sides.

Level	Kombewa Flakes	% Flakes	Total Flakes
1		0	149
2		0	151
3	4	1.45	276
4	1	0.49	204
5	6	3.21	187
6		0	53
7		0	43
Total	11	1.03	1063

Table 7-16. Proportion of Kombewa flakes by level in Q02-2u3.

The Kombewa core is a flake that is thinned by this process, and the Kombewa flake that is produced is small and triangular. Mackay observed that a number of series 5 projectile points had vestiges of a bulb of percussion on one of the proximal tangs on one side, and a bulb of percussion in the middle of the piece on the other side, which suggests that it was produced on a Kombewa flake. The only other location where Kombewa flakes were encountered in significant quantities was on the surface of the site of Collpa [A03-910] in Block 5 midway between the Chivay source and Callalli. Seven Kombewa flakes (6 of obsidian, one of chert) were encountered on the surface at Collpa. A number of series 5 points were also encountered at Collpa.

Further examination of Q02-2u3 "workshop" sequence

Fluctuations in the presence of particular stone artifact types in the excavation test unit at the Maymeja workshop provides insights into changing reduction activities at the workshop area through time. As described above, radiocarbon dates for the unit place the lower parts of the excavation in the Terminal Archaic, while the middle of the sequence (around level 4) falls at the Early / Middle Formative transition. As was reviewed in Chapter 3, these are times of interest in terms of obsidian distributions throughout the region.

Shifting production for export at the source

Diachronic changes evident from the 2003 testing at the workshop suggest that shifts in production occurred that were consistent with the development and decline of an obsidian production system responding to the demands of regional consumption. It can be inferred from changing flaked stone artifacts at the workshop that a local production regime was replaced with an approach maximizing flake blanks for export that persisted for a time and, subsequently, shifted into biface production strategy, prior to reverting to a local production. This sequence of events occurs in the Terminal Archaic and Early Formative just as obsidian frequencies regionally reach their apex (e.g., at Qillqatani, see Figure 3-7). The evidence of these shifts appear in retouched artifacts, in cores, and in the changing morphology of complete flakes at the workshop test pit.

This in depth analysis involves an investigation of diachronic change in three separate groups of lithic artifacts. First, retouched flakes are briefly compared with bifaces. Next, multivariate analysis is used on cores to investigate changes across time. Finally, saving the best for last, the attribute analysis for 1063 complete flakes from the test unit is presented that reveals changes in reduction strategies and complementing the evidence from cores, bifaces, and retouched flakes.

Bifaces and Retouched Flakes

Changes in the frequencies of bifaces and retouched flakes by excavation level, though relatively few in number, are one indicator of diachronic changes in production, and a notable pattern in these variables emerges from the 38 retouched flakes and 41 broken bifaces found in the workshop unit. The Q02-2u3 unit contained predominantly broken bifaces in level 3, and a statistically significant decline ($\alpha < .05$) in relative prevalence of retouched flakes when comparing level 6 to level 3 in the workshop.

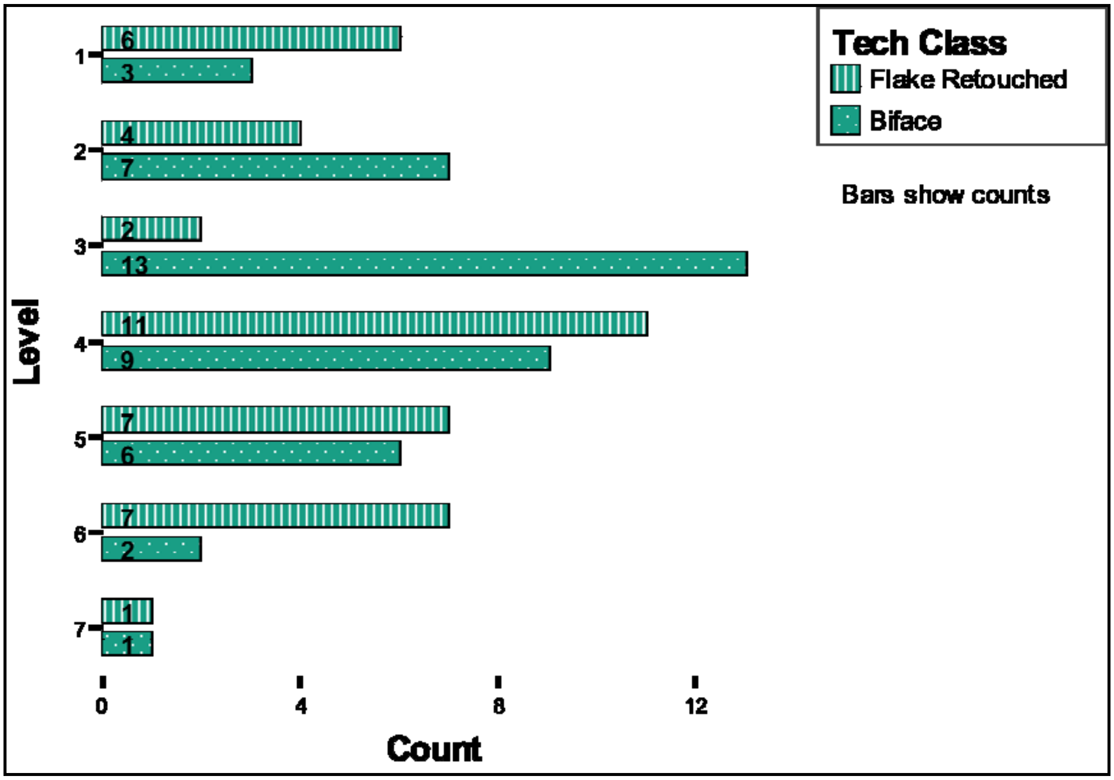


Figure 7-15. Retouched artifacts by Excavation Level.

As this is a workshop production site, not a consumption context, formal artifact classes are of limited utility in discerning changes in activities taking place. Notable changes appear to have occurred between level 4 and level 3. These inferences are reinforced by excavation data presented earlier (see section above "Q02-2u3 Descriptive Characteristics by Level"), where the high discard of cores in level 4 switched to a low discard of retouched flakes in level 3. Further detail into reduction trajectories by level requires investigating cores and flakes discarded at the workshop.

Cores

A very high number of cores were recovered from the 1x1 m workshop test unit (n = 352) and these cores were classified using the strict definition that the cores have not a single positive percussive feature. In the excavated sequence at Q02-2u3, cores show a distinct standardization in production between level 5 and level 4, a change in reduction strategy in level 3, and finally in the upper most levels 1 and 2 the pattern reverts to characteristics similar to that observed in the lowest levels.

Level		Obsidian		Rotations						Total
		Ob1	*Ob2*	*0*	*1*	*2*	*3*	*4*	*5*	
1	*No.*	57	2	15	21	15	6	2	0	59
	% Lvl	96.6%	3.4%	25.4%	35.6%	25.4%	10.2%	3.4%	0%	100%
2	*No.*	46	3	18	20	4	6	1	0	49
	% Lvl	93.9%	6.1%	36.7%	40.8%	8.2%	12.2%	2.0%	0%	100%
3	*No.*	65	5	31	25	11	2	0	0	69
	% Lvl	92.9%	7.1%	44.9%	36.2%	15.9%	2.9%	0%	0%	100%
4	*No.*	90	4	25	31	24	10	3	0	93
	% Lvl	95.7%	4.3%	26.9%	33.3%	25.8%	10.8%	3.2%	.0%	100%
5	*No.*	53	1	26	17	7	3	0	0	53
	% Lvl	98.1%	1.9%	49.1%	32.1%	13.2%	5.7%	0%	0%	100%
6	*No.*	7	1	1	3	0	1	1	0	6
	% Lvl	87.5%	12.5%	16.7%	50.0%	.0%	16.7%	16.7%	0%	100%
7	*No.*	15	3	4	3	3	3	2	2	17
	% Lvl	83.3%	16.7%	23.5%	17.6%	17.6%	17.6%	11.8%	11.8%	100%
Total	*No.*	333	19	120	120	64	31	9	2	346
	% Lvl	94.6%	5.4%	34.7%	34.7%	18.5%	9.0%	2.6%	0.6%	100%

Table 7-17. Cores at Q02-2-u3 by excavation level showing counts and proportions of Ob1 and Ob2 material and rotations.

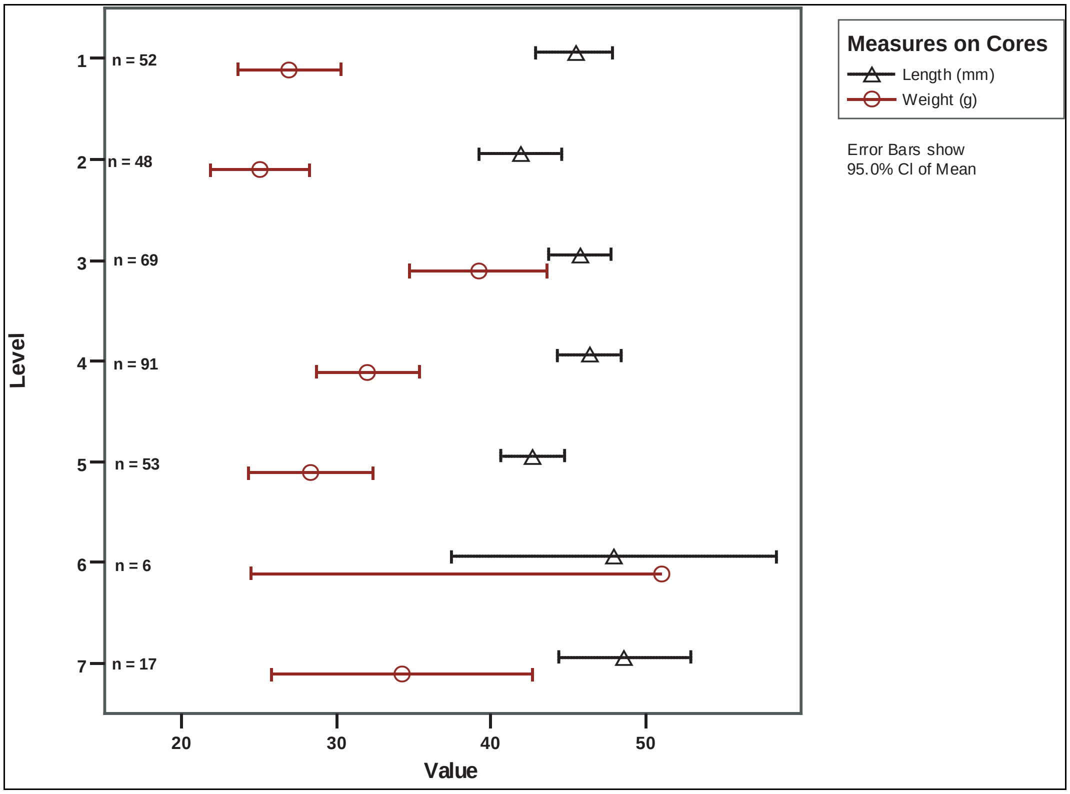


Figure 7-16. Q02-2-u3 Cores by Level showing changes length and weight.

These patterns can be summarized as follows. First, in the early levels, such as in basal level 7, large nodules were available and they were knapped more extensively, and then the cores were discarded while they were still relatively large in size, particularly if they were made of Ob2 obsidian. *Rotations:* In these earlier levels a high proportion of cores were rotated extensively, showing conservation behavior. *Ob2 obsidian:* three cores (16%) in level 7 contained heterogeneities. Some of these cores had a relatively high number of rotations, with three rotations on an Ob2 core in level 7 and there were four rotations on a lone Ob2 core from level 6. It appears that the presence of bubbles and other heterogeneities was a less significant deterrent to production in the early levels of workshop activity.

Subsequently characteristics of intensification and decline were observed in middle and upper levels of Q02-2u3. Discarded cores became increasingly more ovate through the intensification period of levels 5 through 3 (see Figure 7-16), where weight increased without a concurrent increase in length. Higher up, in level 2, the mean weight of cores plummeted by 15 grams. These changes in the morphology of discarded cores suggest that more detail on size variability among cores could shed light on the processes at work. These multivariate patterns can be illuminated through cluster analysis.

Cluster Analysis with Cores

Using the cluster analysis of cores from the workshop test unit, a few groupings of cores emerge from clustering on six variables. These more general groupings permit the examination of changes in core attributes in terms of types that reflect the underlying variability in the dataset.

Cluster analysis is a classification method that arranges a set of cases into clusters that are more similar to each other than they are to cases from other clusters (Aldenderfer 1982; Shennan 1997:234-258). The values from six ratio and scale variables of 334 complete obsidian cores from Q02-2-u3 workshop test unit were examined using hierarchical cluster analysis. Hierarchical clustering produces nested clusters with increasing variance within clusters as one ascends the cluster hierarchy.

Cores were clustered by first exploring different clustering methods on the Z scores of following measures: Weight, Length, Medial Width, Medial Thickness, Rotations, and Percent of Cortex. The four common hierarchical clustering methods:

Single Linkage, Complete Linkage, Average Linkage and Ward's Method were conducted. This exploration revealed that regardless of the method selected, three cluster solutions were most commonly observed in the clustering agglomeration schedules. Three clusters generated by a Complete Linkage clustering solution provide the tightest clusters with measures on cores. Complete Linkage clustering, also referred to as "Maximum" and "Furthest-Neighbor" Method, is an approach where the dissimilarity between two groups is equal to the greatest dissimilarity between a member of cluster 1 and a member of cluster 2. Complete Linkage clustering tends to produce tight clusters of similar cases and the algorithm delays including new members in a cluster; furthermore, it does not tend to produce chaining.

	Function	
	1	*2*
Weight (g)	.803*	.537
ThickMed (mm)	.723*	.109
% Cortex	.476*	-.366
Rotations	-.304	.654*
WidthMed (mm)	.193	.514*
Length (mm)	.264	.486*

* Largest absolute correlation between each variable and any discriminant function.

Table 7-18. Canonical discriminant function for Q02-2u3 Cores.

Clusters derived from cores are expressed in two discriminant functions shown in Table 7-18. This table shows the structure matrix for cores in order of size of correlation. Function 1 describes core sphericity using the Weight and Thickness measures, while Function 2 describes tabular shaped cores (Width and Length) with high Rotations.

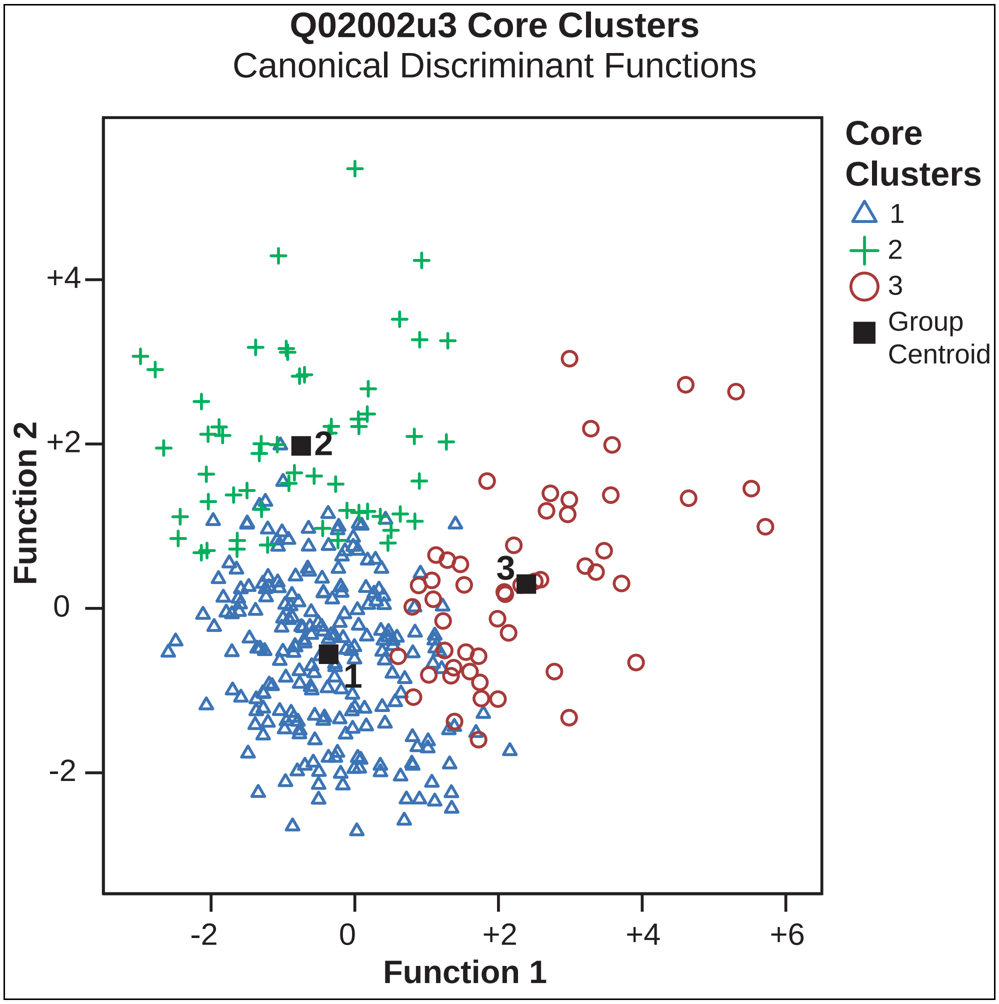


Figure 7-17. Canonical discriminant chart for core clusters from Q02-2u3.

The variables were standardized using Z scores so that they had a mean of 0 and a standard deviation of 1, which has the result of regularizing measures like Percent Cortex (ranging from 0-100%) so that they cluster more effectively against the values of measures like Medial Thickness (ranging from 0.5 to 34cm). A description of the morphology of these three core clusters will be followed by an examination of the relative frequencies across levels.

Cores were clustered into three groups with low eigenvalues and relatively proportional counts in each cluster. An inspection of the clustering measures across the three groups revealed that the three clusters described three types of cores that were apparent during the lithic analysis.

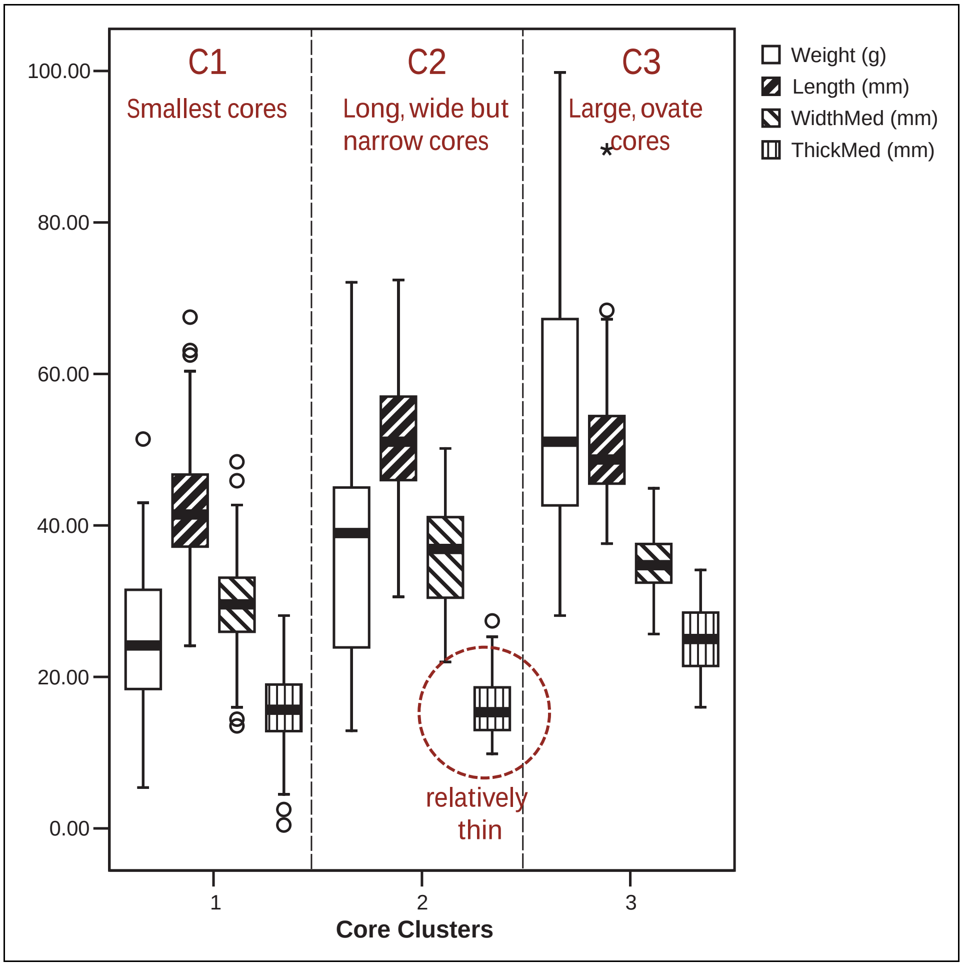


Figure 7-18. Boxplots showing three clusters of Q02-2u3 cores with size measures. The tabular shape of C2 cores is apparent in their thinness relative to their length and width.

Characteristics of Three Core Clusters from Q02-2u3			
	C1 (n=226)	C2 (n=56)	C3 (n=52)
Size	Light, short, narrow cores that started on small nodules.	Mid-weight, and long and wide, but as thin as C1 cores.	Heavy, long, wide, and very thick. Ovate in shape. From larger nodules relatively unreduced.
Cortex and Rotations	Moderate amounts of cortex, moderate number of rotations on large number of cores.	Virtually no cortex and high number of rotations on cores.	High amounts of cortex, few rotations.
Ob2 Fraction	Few (n=10), or 4%.	Moderate (n = 8), 14%	None (n=0)
Comments	Smaller initial nodules.	Started on large nodules, and most heavily reduced.	Sampled but discarded early.

Table 7-19. Q02-2-u3 characteristics of three clusters from core attributes.

Did these clusters of cores result from intrinsic characteristics of three types of starting nodules, or are the clusters the result of reduction strategies and the particular reduction history of that core? C2 cores, for example, appear to have started as "tabular cores" but following some reduction they were discarded at the workshop despite being fairly large.

There is little correlation between clusters and attributes of the material such as Ob2 (hetereogeneous), cortex type, or color and banding characteristics. C1 and C2 cores separate easily into two groups: the C1 consisting of small cores and C2 with long, narrow cores that were heavily reduced. However, the cluster 3 (C3) cores are more enigmatic because they were discarded relatively early in the reduction sequence and these cores are evident throughout the sequence the workshop so the reason for their discard is not immediately obvious.

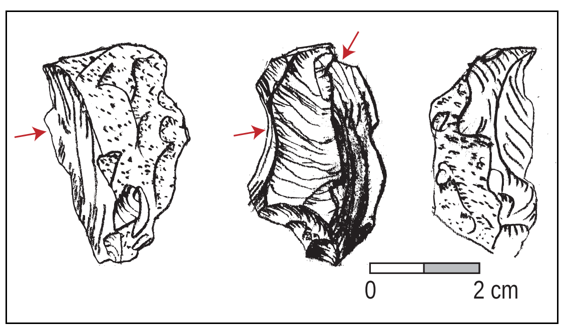



Figure 7-19. An example of a C1 core [L03-162.303], arrows indicate percussion.

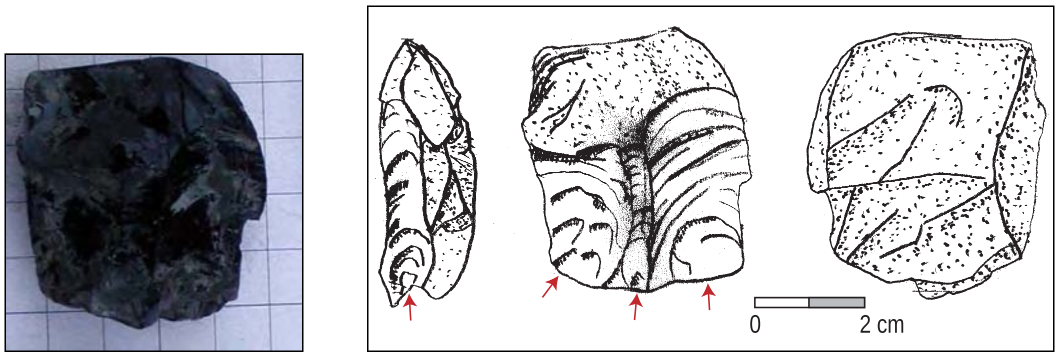


Figure 7-20. An example of a C2 core [L03-162.305].

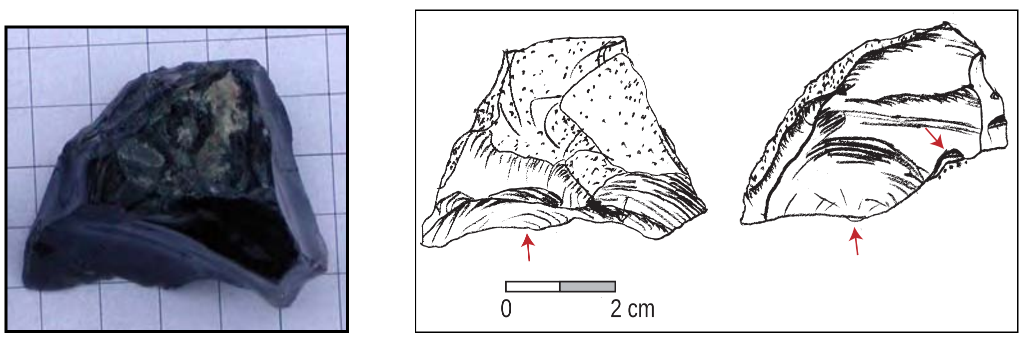


Figure 7-21. An example of a C3 core [L03-162.280] showing a small area of thin cortex.

Raw material availability and the opportunities for reduction in the particular reduction trajectory of a given core appear to determine the cluster in which a discarded core is categorized using this system. Following this logic, if the abundance beginning in Level 5 is due to quarrying work at the quarry pit, 600m up the slope, then additional large nodules would have become available from this quarry and with increased raw material availability, larger cores were discarded at the workshop during this time of abundance.

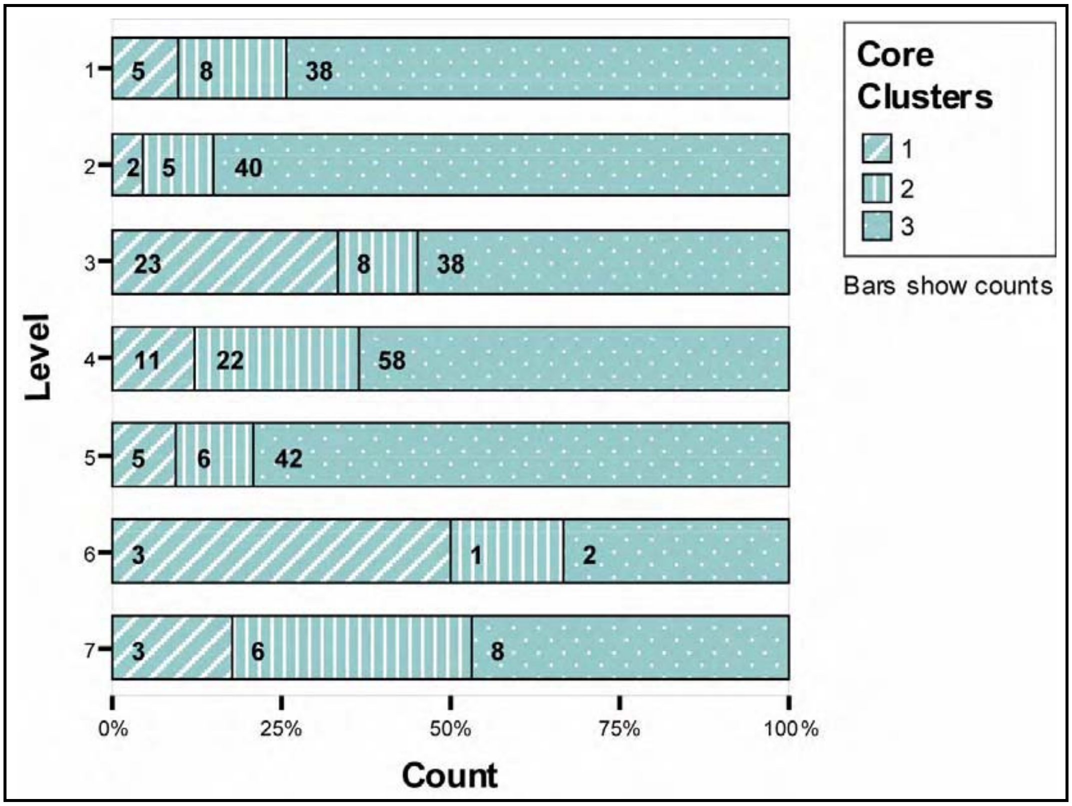


Figure 7-22. Clustered Cores from Q02-2u3 workshop test unit showing counts by level.

Changing proportions of these clusters of cores between levels, particularly between levels 5 and 2, suggests that there was a changing availability of raw material. A distinctive pattern emerges that centers on level 4 as the probable apex of production of large flake blanks for export from the workshop. In level 4 there are a relatively large number of C2 cores with 3 or 4 rotations and yet they are over 50mm long and appear to have been discarded far earlier than would have occurred in other levels in the workshop. The varying counts and weights of these clusters evident in Figure 7-22 show a peak in large, cortical cores (C3) in level 5 that are replaced by heavily reduced tabular cores (C2) in level 4, and finally both groups give way to an increase in counts of small, moderately retouched cores (C1) in level 3.

The presence of quantities of C2 cores in Level 4 is particularly intriguing because the discard of cores with little cortex (and thus heavily worked), yet still evidently long and tabular, suggests that very large cores were abundant in this phase. By level 3 the C2 cores were replaced by the smaller C1 cores that are moderately reduced, which are taken to mean that large cores were no longer available and surpluses of large cores remaining in the system from earlier times had been consumed. The most parsimonious explanation for this abundance of large, tabular C2 cores in level 4 is that a new source of obsidian were being exposed through labor investment in quarrying in the vicinity of the workshop. A ^{14}C date from level 4 calibrates to between 1500 – 1380 BCE, or the end of the Early Formative, precisely when obsidian is most abundant at consumption sites like Qillqatani (discussed in Section 3.4.2).

Cores compared with Cortical Flakes

Measuring changes in the maximum size of obsidian nodules over time is complicated by the fact that cores become smaller through use. If cores are the subject of export then one can compare the maximum length of early stage reduction cortical flakes (where dorsal cortex ≥ 50%) with the maximum length of cores as an indicator of the maximum possible size of cores during a given period. However, if large flake blanks are being further reduced and/or exported then large flakes will not be discarded at the workshop and core length may exceed cortical flake length.

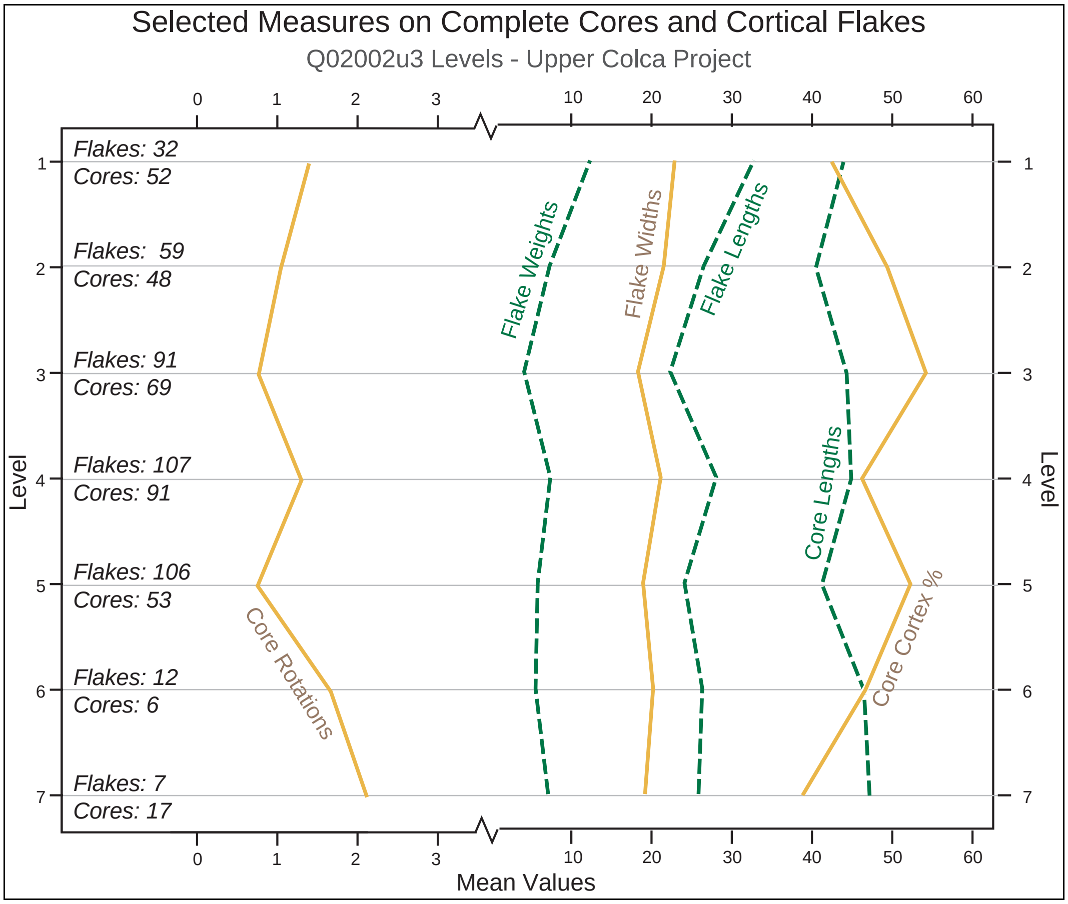


Figure 7-23. Q02-u3: Graph showing means of complete cores and cortical flakes.

First, consider the mean values of cores and cortical flakes across excavation levels in their aggregate. The differences between excavation levels using the measures displayed in Figure 7-23 are extremely significant using an ANOVA test of variance.

Tech. Class	Measure	df	F	Signif.
Cores	Length (mm)	6	2.589	.018*
	# Rotations	6	6.241	.000***
	% Cortex	6	3.834	.001***
Flakes	Length (mm)	6	7.168	.000***
	Width (mm)	6	4.529	.000***
	Weight (g)	6	5.968	.000***

Table 7-20. Q02-2u3: ANOVA on complete cores and flakes with at least 50% dorsal cortex.

In Table 7-20 the observed differences in means are extremely significant ($p \leq .001$) except for the means of core lengths which are significant ($p < .018$), confirming that the variability presented in Figure 7-23 is meaningful. The variability in means suggests that specific measures should be investigated in more detail across excavation levels. Changes in means by level on complete cores and cortical flakes as a whole are shown in Figure 7-23 where notable fluctuations on a variety of independent measures that converge around level 4 can be observed.

These differences by level show the relationship between discarded large cores and the cortical flakes that were struck from them. The measures Flake Lengths and Core Lengths show that mean core lengths exceed flake lengths by about 10 cm. The relative decrease of long cortical flakes in level 3, despite the continued availability of long cores, suggests that there was an export of long, heavily reduced cores and large flakes; artifacts that were probably exported as flake blanks.

The absence of cortex on smaller flakes is useful for discriminating advanced reduction flakes from small flakes that simply derived from small cores. Small flakes are abundant in level 3 (as will be shown later below in Figure 7-24) and means in non-normal distributions are sensitive to skewing. One may ask “is the sheer number of smaller flakes in level 3 from more advanced reduction activities, as demonstrated by the presence of broken bifaces in level 3 (discussed earlier), skewing the mean and lowering the mean length of flakes?"

The Pearson's r correlation coefficient between Length and the Percentage Cortex variables is strong on complete flakes from both level 3 and 4, but it is extremely strong in level 4. In level 3 there is a strong correlation between Length (X) and Percentage of Dorsal Cortex (Y) (r = .203, p = .001, Y = .79X + 19.06). In level 4 the correlation between Length (X) and Cortex (Y) is extremely strong (r = .330, p = <.0005, Y = 1.16X + 22.89). Evidently flakes got smaller in level 3 even when they contained significant dorsal cortex coverage, supporting the argument that larger cores were less available in level 3 than they were in preceding levels.

These changes in core morphology support earlier patterns that were observed in the distribution of retouched flakes and bifaces in levels 4 and 3 (see Figure 7-15). Recall that the retouched flakes that were prevalent in level 4 are largely replaced by bifaces in level 3 when smaller cores are dominant and procurement of large, tabular C2 cluster cores appears to be curtailed. These data from cores corroborate the data from bifaces and retouched flakes. Further evidence comes from a detailed examination of the last group of artifacts from the Q02-2u3 test unit to consider, the most well-represented group at the workshop: unretouched complete flakes.

Complete Flakes

Measures on 1063 complete obsidian flakes from the obsidian workshop test unit provides evidence of changing activities through time that support the observations made on cores and retouched artifacts. Flakes will be examined first through the mean values on their numeric attributes.

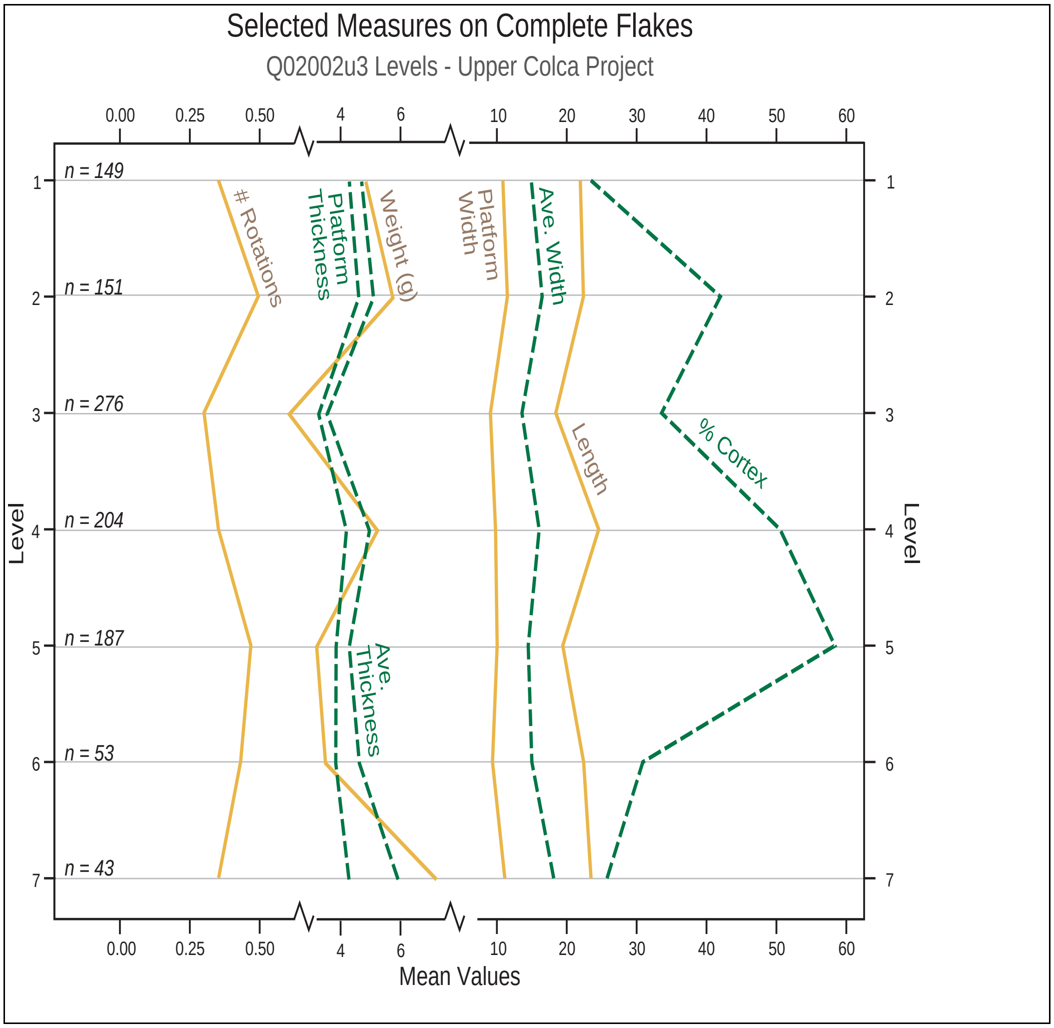


Figure 7-24. Q02-2u3: Graph showing means of measures on complete obsidian flakes.

The mean values of flake measures length, average width, average thickness, weight, platform width, platform thickness, percentage of dorsal cortex, and count of rotations were presented. The average width and average thickness variables were calculated by averaging the Proximal, Medial, and Distal measures for Width and Thickness on each flake.

Measure	df	F	Sigif.
Length (mm)	6	9.392	.000***
WidthAve (mm)	6	7.290	.000***
ThickAve (mm)	6	9.431	.000***
PlatWidth (mm)	6	2.344	.030*
PlatThickness (mm)	6	2.358	.029*
Weight (g)	6	7.707	.000***
% Cortex	6	18.819	.000***
# Rotations	6	2.914	.008***

Table 7-21. Q02-2u3: ANOVA on measures from complete flakes.

The observed differences in means are extremely significant ($p \leq .001$) except for the means of platform width and platform thickness, which are merely significant ($p < .05$). While mean values across levels are highly subject to skewing due to overrepresentation by the numerous small flake categories, the data in Figure 7-24 demonstrate that the large sizes associated with level 4 cores discussed previously are repeated in the flakes from level 4.

In Figure 7-24, the percent cortex variable shows a notable spike in level 5 but this variable should be considered in conjunction with the weight variable because by weight and size these highly cortical flakes are relatively small. Looking at the percent cortex in level 7, in contrast, one can see that there is little cortex and a mean weight of 8 grams indicating relative abundance and relatively wasteful reduction at the workshop. These large level 7 flakes appear to have come from large cores because they are comparably heavy, wide, and thick, and the flakes are not very cortical. This changes rapidly in level 6 as mean weight goes down despite a slight increase in corticality. The number of rotations similarly points to more efficient decortication in level 5 with thinner, shorter flakes that are relatively cortical. Level

3 rotations are low, although this is perhaps a product of the small overall size of these flakes hence rotations are less visible on the smaller surface.

Platform characteristics are important determinants of flake morphology (M. J. Shott et al. 2000; Dibble 1997; Dibble and Pelcin 1995) and can point to changing reduction strategies because platform attributes directly convey changes in knapping decisions in terms of point and angle of force. Platform characteristics show intriguing relationships with other flake characteristics, but the patterns are difficult to explore in the aggregate. As with multivariate analysis in cores above, the patterns discussed in flake morphology in the workshop test unit can be further explored using cluster analysis.

Cluster analysis on Complete Flakes

Cluster analysis of flakes from the Q02-2u3 pit elicits groupings from the numerical variables taken on complete flakes, and provides a way of reducing the dimensionality of the flake morphology dataset without the limitations of typological classification of flakes. Thirteen numerical measures were gathered on complete flakes and when these thirteen were included in the cluster analysis it was apparent that ten of the measures were related variables because they were measures that reflect overall flake size. As a consequence, the clustering solutions that emerged, regardless of the clustering method employed, tended to reflect the size groupings of smallest, medium, and largest measures in most attributes. A reduction of dimensionality was needed to collapse these correlated size measures into fewer variables so that a second order of variability in attributes that were not size dependent could emerge. Dimensionality can be reduced by conducting a Principal Components Analysis on the data prior to clustering, and then clustering the components with Eigenvalues of approximately 1 or higher.

Clustering the results of Principal Components Analysis (PCA) has precedence in archaeology going back to the 1970s (Ahler 1973; Redman 1973). In this study, the thirteen variables were first reduced to four PCA components and, subsequently, a Ward's Method clustering derived a 3 cluster solution from these 4 components. The numerical measures on complete flakes submitted to Principal Components Analysis include: weight, length, proximal width, medial width, distal width, proximal thickness, medial thickness, distal thickness, platform width, platform thickness, platform angle, percent cortex, and number of rotations. Mean values were substituted for empty values in the PCA. In this study, four PCA components with eigenvalues greater than 0.988 were clustered accounting for 75% of the variability in the dataset. Next, these four components were entered into a cluster analysis.

A variety of hierarchical clustering methods were explored and the most appropriate clustering solution appeared to be Ward's Method where three clusters were derived with a minimum of internal variance. In Ward's Method, cluster membership is assessed by calculating the total sum of squared deviations from the mean of the cluster. By maintaining the smallest possible values for the error sum of squares then intracluster variance is minimized and intercluster variance is maximized.

	Function	
	1	*2*
Plat Thickness	.571*	.094
Plat Width	.546*	.079
Width Prox	.528*	.202
Plat Angle	-.493*	.252
Thick Prox	.411*	.297
% Cortex	.297	.705*
Weight (g)	.208	.452*
Thick Med	.324	.451*
Thick Dist	.153	.424*
Length	.164	.394*
Width Med	.305	.345*
Width Dist	.107	.309*
Rotations	.006	-.060*
* Largest absolute correlation between each variable and any discriminant function		

Table 7-22. Canonical Discriminant Function Structure Matrix in order of size of correlation.

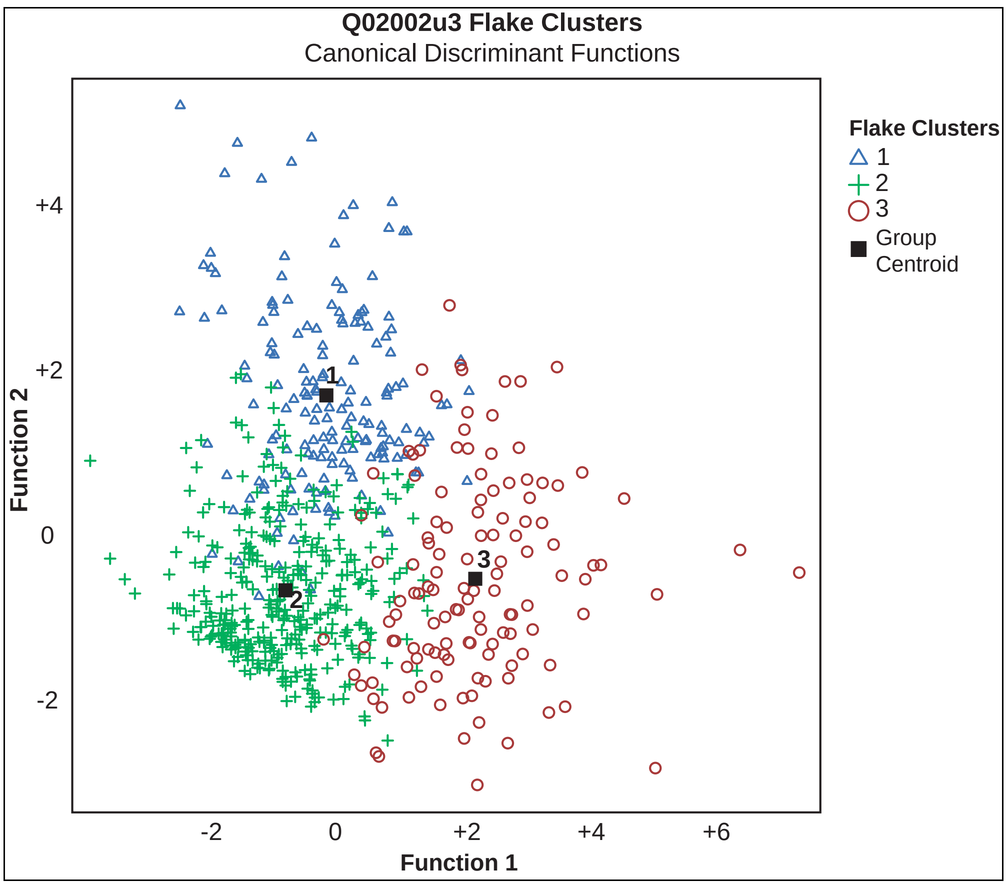


Figure 7-25. Canonical discriminant chart for complete flake clusters from Q02-2u3.

In Table 7-22, the contribution of each of the different measures taken on flakes to the two functions that emerge from cluster analysis are shown. Function 1 responds to platform characteristics, the morphology of the proximal parts of each flake, and flakes with tapering widths. Function 2 primarily responds to the variables that reflect the overall size, cortex, and rotations measures of each flake.

This clustering solution brings out the variability by excavation level among flakes in Q02-2u3 that were discussed above. Broadly speaking, the clusters discriminate large cortical flakes from small, non-cortical flakes, but a third group, differentiated primarily by its platform characteristics, also emerged from the analysis.

Characteristics of Three Flake Clusters from Q02-2-u3			
	F1 (n=265)	F2 (n=668)	F3 (n=130)
Size and Platform	Longest flake class, and slightly heavier than F3 class. Includes the greatest size variability.	Smallest flakes with the smallest platforms and moderate platform angle.	Moderately large flakes with very large platforms and very acute platform angles. Tapering significantly proximal to the distal. Slight tendency for faceting as a form of platform preparation.
Cortex, Rotations, Terminations	Significantly more cortex than other clusters but only slightly fewer rotations. Many plunge terminations, few hinge.	Significantly little cortex. Few rotations. The most hinge terminations, fewest plunge.	Moderate amounts of cortex, slightly more rotated than other clusters.
Ob1 vs Ob2	Some Ob2. (n=14), 5.3%	Few Ob2. (n=20), 3.0%	Few Ob2.(n=5), 3.8%.
Comments	Largest flake class. These flakes are conceivably serving as blanks.	Smallest class of flakes and advanced reduction flakes.	Possibly corner removal flakes on tabular obsidian nodules.

Table 7-23. Q02-2-u3: characteristics of 3 clusters of flakes based on numerical attributes.

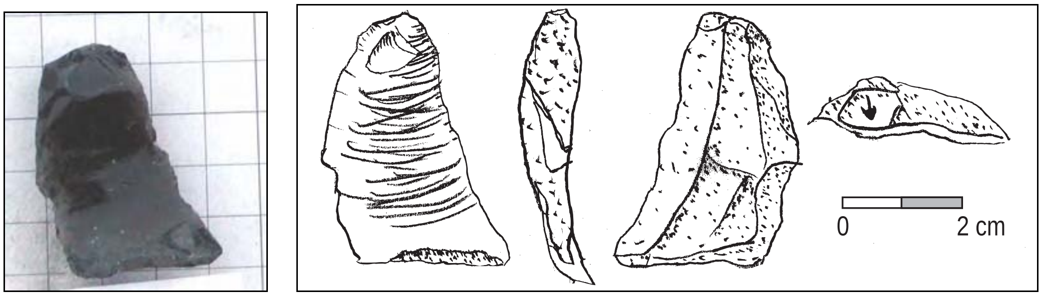


Figure 7-26. An example of a flake from the F1 cluster [L03-162.21].

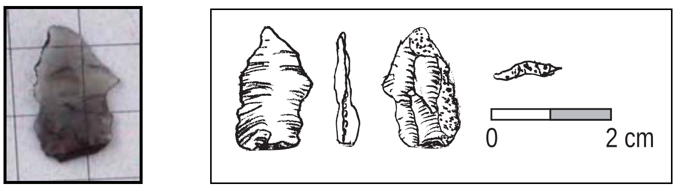


Figure 7-27. An example of a flake from the F2 cluster [L03-162.118].

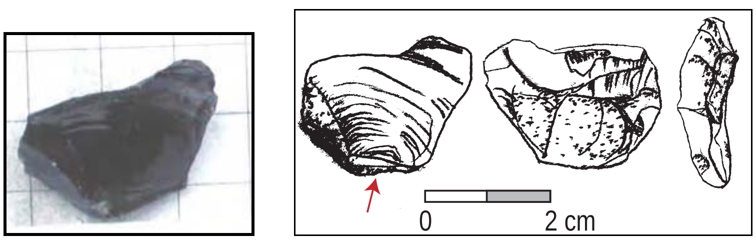


Figure 7-28. An example of a flake from the F3 cluster [L03-162.66].

These clusters capture much of the variability present in the flakes from Q02-2u3. Patterns among nominal attributes of these clusters are also worth examining. Non-numerical attributes could not be submitted to the PCA and clustering functions directly because only quantitative measures can be used with that procedure. Nominal attributes, such as flake termination, must be addressed using analyses measures of association such as Standard residuals and Cramer's V.

Flake Cluster		Termination			
		Feather	Hinge	Plunge	Step
1	*No.*	166	20	62	13
	Std. Residual	-.3	-4.0*	5.0*	1.0
2	*No.*	431	154	59	22
	Std. Residual	-.2	3.0*	-2.8*	-.6
3	*No.*	93	18	14	5
	Std. Residual	.9	-1.2	-.6	.0

Table 7-24. Q02-2u3: χ^2 showing types of terminations by flake cluster. On the whole, these relationships are not very strong (Cramer's V = .171).

In Table 7-24 standard residuals point to significant differences in the cluster 1 and 2 proportions of hinge and plunge terminations. In this table, a significant difference exists where ever the standard residual exceeds 1.96. However, on the whole, the table relationships are not very strong because the Cramer's V for the table is just 0.171. The proportions of hinge and plunge terminations are notably different between F1 and F2. The high number of plunges in F1 might be explained by these flakes serving as decortication flakes where plunging terminations can serve to clear off the bottom of the core to improve the chances of achieving feather terminations in subsequent blows. As a core maintenance strategy, plunging terminations can improve subsequent flaking events by increasing the striking angle. Furthermore, when the end of the core is non-cortical it increases the chance of feather terminations.

Other platform attributes of these flake clusters include an unusually high incidence of faceting on the platforms of F3 flakes. This kind of platform preparation is sometimes used to remove cortex or inconsistencies from the platform area. Furthermore, a χ^2 table showed that Platform Angle, the distinctively low attribute of

F3 flakes, is the variable with strongest association with the three cluster classification (Cramer's V = .457).

Interpretation with an Investigation of Flake clusters by Excavation Level

Investigating the proportions of these flake clusters by excavation level provides insight into the changing activities at the Maymeja workshop. A graph showing the proportions of these clusters by level will be shown and discussed in detail beginning with the oldest strata, the Terminal Archaic level 7 (2880-2650 BCE).

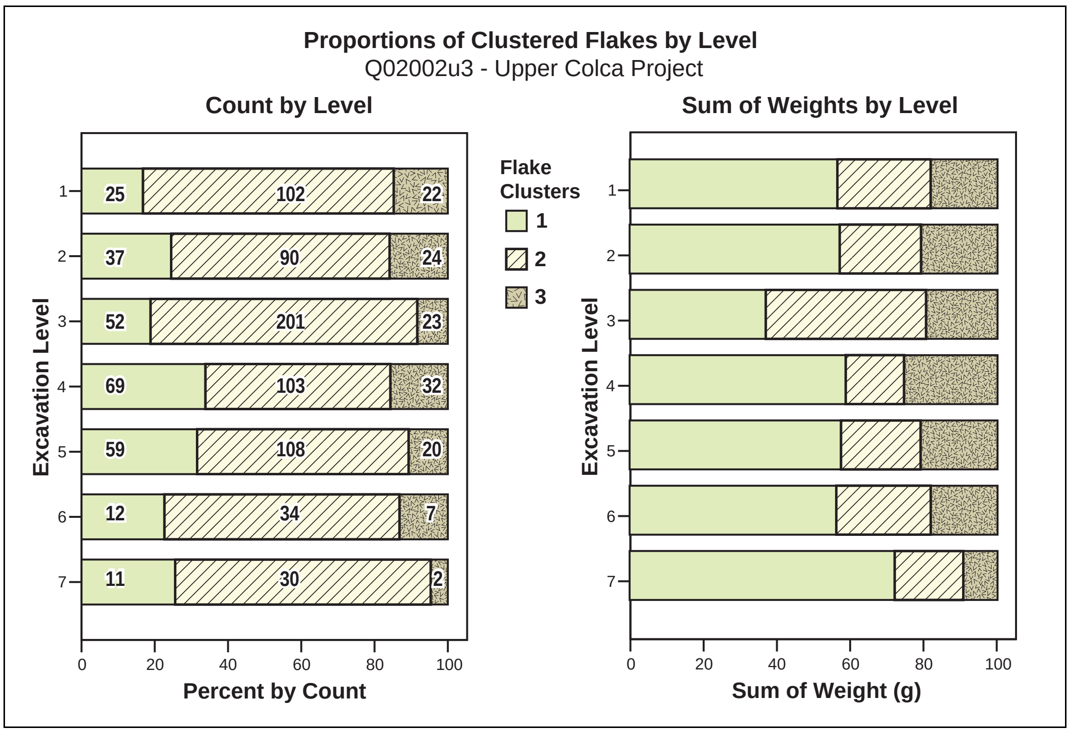


Figure 7-29. Graph showing Flake clusters by excavation level.

Level 7 ***– Basal level***

A high proportion of F1 flakes by weight was in keeping with expectations concerning early use of the workshop area. Early reduction of widely available large cores resulted in a large number of F1 flakes. The F3 flakes in this level had relatively acute platform angles.

Level 6 ***– Large Platformed Flakes (F3)***

An increase in F3 by count and weight in level 6 that persisted through later levels in the unit hints at a change in reduction strategy that produced these large platformed flakes. The defining characteristics of these flakes, are large platforms with very low dorsal platform angles, and these are very pronounced in this level within the F3 group. In reviewing the core clusters by level from Figure 7-22, there are few cores in this level and a relative prevalence of small cores, suggesting a decrease in availability of the large cores found in other levels. The production system that was dominant in level 7 had perhaps been altered by level 6 for lack of raw material in large nodules.

Level 5 – ***Core export level****.*

This level maintained roughly the same proportions of F1, F2, and F3 flakes, but the overall flake counts were much higher. In other words, a pattern that began in level 6 developed into full-fledged production strategy in level 5 because the proportions suggest that similar activities were being preformed but with higher production rates. The F2 flakes had significantly smaller platform thicknesses, a characteristic that fluctuated greatly between levels. The F2 flakes also had more rotations and they had much more cortex than F2 flakes did in higher, later levels. This suggests that smaller cores were being decorticated in level 5. Revisiting the core proportions from Figure 7-22, it is notable that large C3 cores dominated the assemblage of discarded cores in this level, despite the evidence from the flakes that small cores were in use. Hence, it appears that certain cores were decorticated and exported and therefore such cores appear in reduced frequency in this level.

A notable increase in the number of bifacially retouched flakes and broken bifaces is apparent in level 5, indicating that a pattern of some more advanced reduction activities was underway during these levels. There is also a slightly higher representation of Ob2 material among F3 flakes in this level.

Level 4 – ***Large flake blank production level***

In general, production patterns first witnessed in level 5 continued at a higher rate in level 4. A ^{14}C sample from this level had a radiocarbon date from the Early/Middle Formative transition (1500-1320 BCE). The large F1 flakes had significantly more rotations while F2 flakes had fewer rotations. F2 flakes also had thicker platforms in this level, particularly contrasting with thin platforms on F2 flakes in the surrounding levels 3 and 5. All cores had significantly more rotations than in preceding and succeeding levels (see Figure 7-23), and this was particularly true of the tabular C2 core cluster. There was a slight increase in C2 cores in this level. These data indicate that further rotations were being applied, and that large tabular C2 cores, which were heavily decorticated and thus must have been extremely large to start with, were being discarded in abundance in this level. The level 4 excavation strata was also unusually thick (13.9 cm), therefore proportions are comparable to other levels while the actual count are not directly comparable. One significant difference between level

5 and level 4 is the presence of large cortical flakes in level 4, as shown in Figure 7-23.

Level 3 – Advanced reduction

Level 3 was distinguished because it contained a far greater number of small flakes and cores than did previous and subsequent levels. It was mentioned above that evidence of advanced reduction in level 3 included the discard of 13 broken bifaces yet only 2 retouched flakes were discarded. The many small flakes in this excavation level resulted in much higher artifact densities. Among the F1 flakes the lengths and weights were lower, while among F2 flakes the lengths were significantly longer, and among the F3 flakes weight dropped significantly. Thus, flakes in all 3 clusters shifted towards the smaller ends of their size categories. There were twice as many F2 flakes in level 3 than in previous levels, and they had low platform thickness, few rotations, and had significantly less cortex than did previous levels.

Cores in level 3 primarily consisted of large C3 cores that essentially replaced the C2 cores in this level. The lack of C2 cores suggests that the cores were either being further knapped, or they were being transported away through export during this occupation level.

The evidence from level 3 is consistent with workshop activities that had shifted from initial reduction to more advanced stages of reduction. The absence of large cortical flakes and large tabular C2 cores suggests that the investment in procurement that was supplying the cores to the workshop had changed,and perhaps excavating at the quarry q02-2 had ceased. As this is a workshop area with a long history of use, scavenging could have continued for many years as relatively large cores and flakes were surely extant in the workshop area. It appears that the system was essentially well-stocked in the beginning of level 3 but it appears that by the end of level 3 the easily available, knappable obsidian was relatively depleted.

Level 2 – Returning to production

Cores and flakes in level 2 return to a larger size scale. There were relatively few broken bifaces compared to retouched flakes. There are additional rotations on both F1 and F2 flakes, and F2 flakes had very little cortex and high platform thickness values. A return to quarrying at the q02-2 quarry is one possible explanation for the higher availability of material in these levels. In level 1, the F1 flakes are significantly rotated and some of the obsidian has notable quantities of irregular cortex.

Connection to the quarry pit

An important question remains concerning the history of the Q02-2 quarry pit that lies 600m uphill to the east of the workshop. Due to a lack of datable materials or diagnostic artifacts in the quarry pit test unit Q02-2u2, it was not possible to directly link excavation levels at that unit with activities and excavation levels at the workshop test unit Q02-2u3 on a temporal basis.

If large nodules were being transported from the quarry to the site of A03-126 where they were being reduced, the morphology and visual characteristics of cortical flakes in Q02-2u3 may reflect this import of cores from the quarry pit up the hill.

These tables can be compared with data presented earlier in Table 7-9 and Table 7-11 from the quarry pit test unit.

	Material Quality			Color of obsidian					
Level	Ob1	Ob2	% Ob2	Brown-Banded	Black	Clear-Banded	Clear	Grey-Banded	Grey
1	215	7	3.15%	1	2	66	104	7	39
2	206	6	2.83%	2	3	42	115	28	20
3	349	18	4.90%		10	106	219	10	17
4	301	18	5.64%		25	68	126	33	60
5	250	9	3.47%		19	61	162	7	8
6	69	3	4.17%		2	26	27	2	10
7	65	6	8.45%		5	20	23	7	12
Total	1455	67	4.40%	3	66	389	776	94	166

Table 7-25. Q02-2u3: Obsidian type and color of artifacts by level.

	Length in mm						
	5-19		20-39		40-70		
Level	*No.*	*%*	*No.*	*%*	*No.*	*%*	Total
1	10	16.7	22	36.7	28	46.7	60
2	26	28.0	44	47.3	23	24.7	93
3	58	39.7	43	29.5	45	30.8	146
4	26	15.8	85	51.5	54	32.7	165
5	57	38.3	61	40.9	31	20.8	149
6	4	25.0	9	56.3	3	18.8	16
7	3	23.1	2	15.4	8	61.5	13
Total	184	28.7	266	41.4	192	29.9	642

Table 7-26. Q02-2u3: Length of complete flakes and cores with ≥50% cortex.

In comparing these data with the tables discussed earlier from the Q02-2u2 quarry test unit, no specific pattern is apparent that decisively links the quarry pit with the workshop downslope. An increase in Clear and Clear-Banded obsidian becomes visible in level 3 of the workshop (q02-2u3), in Table 7-10 shown above, that could reflect a sudden availability of this material from excavation at the quarry pit provided that the quarry pit is the sole source of this clear and clear banded obsidian. However as mentioned, the quarry pit is probably not the sole source of clear obsidian because it contains proportions of clear obsidian that reflect tool use over the entire region. There was concurrently a decrease in other colors of obsidian in level 3. No discrete pattern was observed in the Ob1 vs Ob2 material type linking the two pits. Finally, the length of cortical flakes indicates that dramatically more long flakes were deposited at the source from level 5 onwards, as discussed earlier, but there were also notably more medium and small cortical flakes in those levels as well.

7.4.3. Summary Interpretation of A03-126 Workshop

The evidence from the workshop area is being interpreted here through the following sequence of events. During the earliest phases of obsidian procurement the archaeological surface data (Ch. 6) suggest that the Maymeja area of the Chivay obsidian source was visited irregularly in an embedded procurement strategy that brought mobile foragers into the Maymeja area. Evidence for the use of the Maymeja area itself during the Middle Archaic comes from projectile points, but procurement in the Maymeja area probably only occurred in a context that was embedded in subsistence activities by local or near local residents.

In the middle of the Terminal Archaic Period, at approximately 2800 BCE and a time of increased intensification on the pastoralist economy, the Maymeja workshop area became occupied more consistently and debitage began to accumulate on the edges of the bofedal in this area. Flaked stone artifacts from these lower levels (levels 6-7) provide evidence of relatively advanced reduction because the cores found in the lowest level of the workshop test unit contained a high count of rotations and the cores had little cortex remaining on the exterior despite the fact that the cores were fairly large. The artifacts found in these levels suggest that the source area had a sufficient abundance of large obsidian nodules, and that relatively large cores were discarded readily when they did not provide sufficiently large flakes to suit the knapper.

Subsequently, the assemblage at the workshop changed and with the increased quantities and regularity of flake and core morphology at the workshop it appears that the quarrying activities at q02-2, a quarry pit 600 meters to the east, occurred during this time. The evidence (levels 4-5) points to an intensified processing of obsidian in the form of tabular obsidian nodules of primarily Ob1 obsidian material. The dramatic increase in production coincides with a peak in frequencies of Chivay obsidian at sites throughout the Titicaca Basin consumption zone to the east and the south of the Chivay source. Evidence from the workshop suggests that the obsidian was processed and exported in the form of flake blanks and bifacially reduced tabular cores.

Regularity in reduction strategies in these levels can be inferred from the morphology of discarded items. While the abundance of production in levels 5 and 4 is evident from high rates of discard and strata thickness, there is relatively low variability in artifact class and form. Very low levels of advanced reduction were occurring, but a persistent minor quantity of retouched flakes and bifaces was found. On the whole, however, the assemblage is dominated by large but heavily rotated cores, and the discard of large flakes. It can be inferred that in other levels large cores and flakes would have been rejuvenated or some how recovered, but in these levels of regularized production, such items that did not conform to the production aims of the workers were simply discarded. A small proportion of flakes in these levels were "Kombewa flakes" (Table 7-16), a technique that results from the flake-as-core technique of using large flakes as cores, and removing the percussion bulb with a perpendicular thinning strike.

Sometime after 1400 BCE (level 3 and higher) this intensified production activity for regional export ended and reduction activities at the workshop returned to local provisioning. The morphology of cores and flakes at this point shifts dramatically and more advanced and variable reduction occurred at the workshop. It appears that the surplus from an earlier stage of intensified obsidian production was exploited in this later time as the cores and other available materials were much further reduced. On top of this sequence is a final phase of lower intensity production from the Late Formative and onward that resembles the earliest phase at the workshop both in density of lithic debitage and in technical class variability.

In sum, changes over time at the workshop suggest a sequence beginning with local exploitation of the source. This was followed by an intensified period of production that corresponds with increased distribution and consumption regionally. It appears that large flake blanks and mid-sized cores were being exported in these levels. Finally with the collapse of this production system for regional export it appears that locals were taking advantage of surplus material that remains in the system for local reduction and provisioning. The upper most levels at the workshop indicate that lower intensity use of the area and variable reduction strategies dominated the activities at the workshop.

7.5. Block 2 Test Excavations at Pausa A02-39

7.5.1. A02-39, Test Unit 1 and 2

The local context of A02-39 is described in Section 6.4.2 and Figure 6-58. Two test units were placed along the perimeter of two separate oval features [A03-557 and A03-559] on the southern portion of A02-39 "Pausa". The Test Units 1 and 2 were essentially sterile. In TU2 non-diagnostic bone and charcoal were found in an ash layer that appeared level to the built-up oval wall just to the east of TU2. Some carbon samples were retrieved from TU2 level 4 (33cm below datum) and the carbon returned a date of 1586BP±35 (AD 400–570), an Early Tiwanaku period date following Stanish's (2003) date of AD 400 for the onset of the Tiwanaku period. This would be an Early Intermediate Period date following the Ica chronology.

Discussion

Evidence from TU2 [A02-39u2] suggests that this secondary rock oval structure [A03-557] to the south-west of the main Pausa ovals, was perhaps an overflow area. As the test unit was placed at the bottom-most portion of the oval (presumably a corral structure) much of the bone and charcoal that was encountered was perhaps fill that was swept to the lowest point in the corral by animal activity. It appears that during the Early Tiwanaku period the enclosed area was relatively level and charcoal and bone were swept to the bottom of the corral area.

7.5.2. A02-39, Test Units 3 and 4

Test Units 3 and 4 are adjacent 1x1m test units placed immediately outside of the northern edge of structural features A03-558 (see Figure 6-58 and Figure 7-32) where a curved alignment of rock slabs appears to delimit a residential structure.

Figure 7-30. A02-39u3 (upper unit in photo) and u4 (lower) at basal levels. Top of photo is east.

Figure 7-31. Circular hearth (F1) in A02-39u4, level 5. Top of photo is north, unit is 1m on a side.

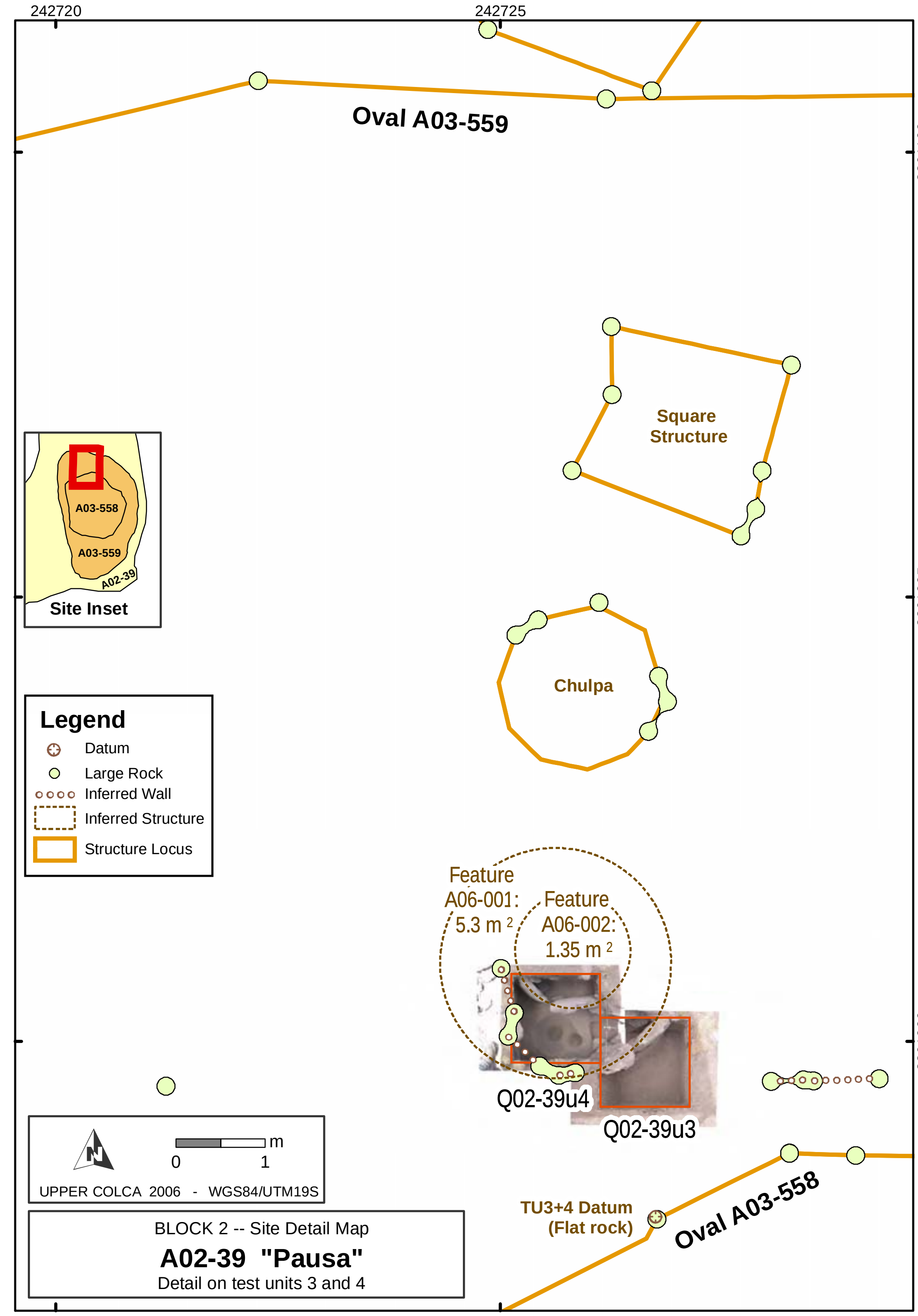


Figure 7-32. A02-39 "Pausa" – north, with Test Units 3 and 4, ovals, and inferred features. Compare with larger map showing ovals in Figure 6-58.

Excavations revealed that inside the curved wall feature [A06-001] was another wall consisting of two slab rocks [A06-002] floating above the depth of the six large rocks that make up A06-001. Circular features have been extrapolated from these two structures and they are shown in Figure 7-32. The circular inference of the smaller feature [A06-002] is more speculative, as only three large slab rocks were found and the rocks seem displaced.

Stratigraphy

The local test unit datum for both of these units was placed on a large, flat rock that is part of the A03-558 oval that lies just to the south of TU3. This mapping station, as well as the site datum north, are shown in Figure 7-32 in the positions where they were mapped with a total station in 2004.

Level	H.B.D.*	Contents	Soil	Photo #
1	5	Top surface. Roots	Fine sandy volcanic soil, roots from low brush	2638
2	12.5	F1: NW of rocks, 0a: matrix. Roots	V. Dk Grey/Brown 10YR3/2, fine grain, sub-angular,poorly sorted .7/.5	2641
3	17.5	F1, F2, 0a. Roots	Dark brown 7.5YR4/2, subangular blocky, med grain, poorly sorted, .7/.3	2646
4	32	F1: midden, indoor? F3: light, sterile Roots, lithics, ceramics	F1: V. Dk Grey/Brown 10YR3/2 Fine grain, subrounded, well-sorted, .9/.7; F3: Brown 7.5YR4/3, med grain, poorly sorted, .9/.5	2650-2651
5	44	F1	Dark brown 7.5YR4/2, subangular blocky, med grain, poorly sorted, .9/.5	2661-2663
6	56	F1a, F3 Lg chert flake lying flat, organic soil	F1a: Dark brown 7.5YR3/2, med grain, well sorted, .9/.7; F3: Brown 7.5YR4/3, med grain, poorly sorted, .9/.3	2664, 3035-3414
* HBD = mean height below datum in centimeters for the top of each level based on five depth measurements.				

Table 7-27. A02-39u3 test unit. Excavation levels, overview, and soil description.

Level	H.B.D	Contents	Soil	Photos
1	3	S1: Top surface Rocky soil, obsidian and non-diagnostic ceramics	Compacted, roots.	2649
2	14	S2: F1: N side; F2: S side Rocks and roots, fewer artifacts	F1: Dark brown 7.5YR3/2, silty sand,med grain, poorly sorted, .7/.5	2665
3	23	S3: F1, F2 Yellowish grey wall mortar. Black-on-red sherd in wall.	Dark brown 7.5YR3/2, silty sand, subangular blocky, med grain, poorly sorted, .9/.3	2680
4	32	S3: F1, F2 Small charcoal pieces. Greyish brown poss. Midden. ^{14}C: 1822±37 bp	F1: Alluvial, V. Dk Grey/Brown: 10YR3/2, silty sand, med grain, poorly-sorted,.9/.3. F2: Dk brown 7.5YR3/2, silt, subangular blocky, fine grain, poorly-sorted, .9/.3	3012
5	37	S4: F1,F2,F3 Less compact, carbon, ceramic, bone, charcoal, much obsidian.	F1: V. Dk Grey 7.5YR4/1, subangular blocky, coarse, poorly sorted, .9/.7	3016
6	49	S5: F1,F2,F3 Less compact, carbon, ceramic, bone, charcoal. ^{14}C: 1698±31 bp	Dark brown 7.5YR3/2, silty clay, subangular blocky, poorly sorted. F1: fine grain .9/.3, F2: coarse grain, .9/.3, F3: med grain, .9/.3	3033-3034. 3416-3417
7	58	S5: F4. Hearth only. Compact, fine clayey soils around hearth.	Dark brown 7.5YR3/2, silty clay, fine grain, subangular blocky, poorly sorted, .5/.5	3423
8	68	S5: F4. Hearth only. Compact, fine clayey soils around hearth. Torquoise.	Dark brown 7.5YR3/2, silty clay, fine grain, subangular blocky, poorly sorted, .5/.5	3424-3425
9	80	S5: F4. Hearth only. Compact, fine clayey soils around hearth.	Dark brown 7.5YR3/2, silty clay, fine grain, subangular blocky, poorly sorted, .5/.5	3426-3427
* HBD = mean height below datum in centimeters for the top of each level based on five depth measurements.				

Table 7-28. A02-39u4 test unit. Excavation levels, overview, and soil description.

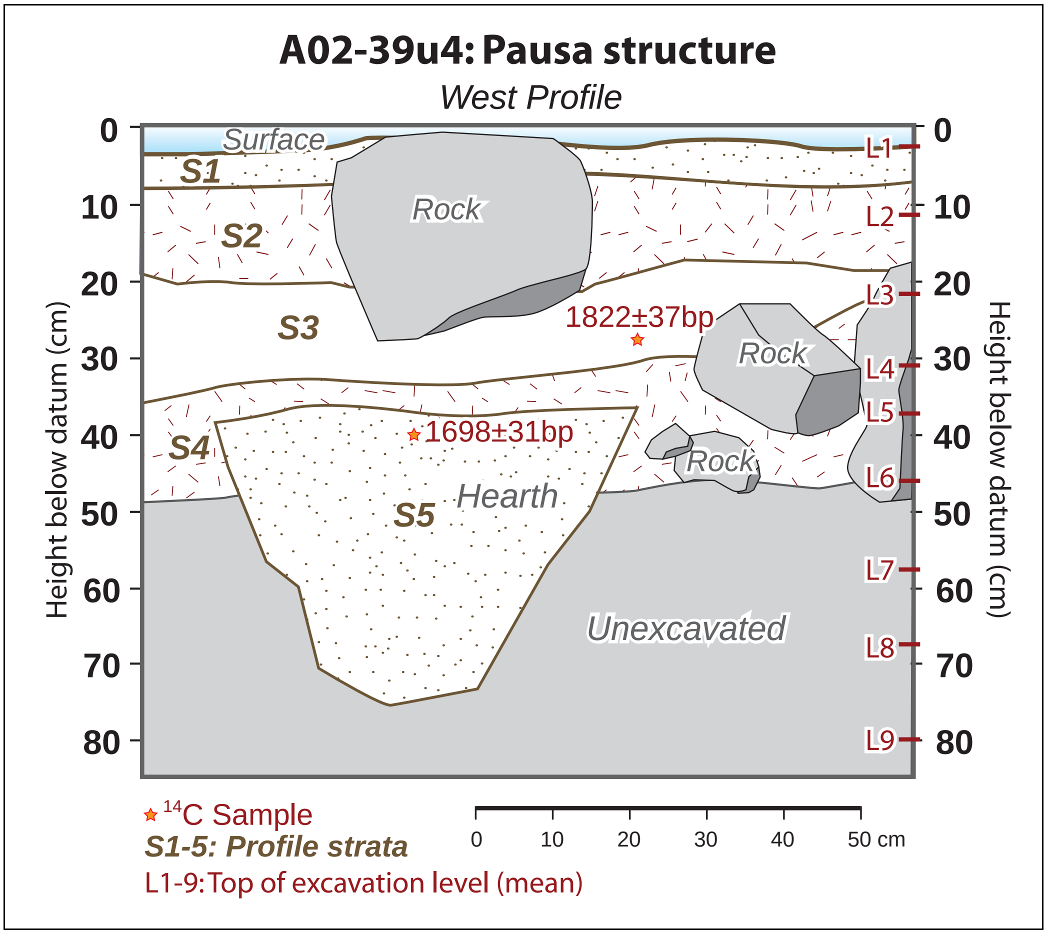


Figure 7-33. A02-39u4 Pausa test unit west profile diagram showing strata and levels.

Radiocarbon dates recovered from levels 3 and 5 of Unit 4 are temporally inverted, but they overlap in the 2-sigma error ranges. These dates place the later use of the hearth in the vicinity of AD200, or the Upper Formative. At units 3 and 4 at Pausa showed a relatively high percentage of obsidian by count throughout the sequence (83%), although by weight obsidian was somewhat less dominant (58%), while volcanics became more prominent (33%).

Artifacts by level

Level	Proj Points	Bifaces	Cores	Flakes	Flakes Retouched	Groundstone
1	7	2	2	90	1	
2	1			63	2	
3	4	1	1	67	2	
4	3			59	1	
5	2	3		134	3	
6	6	1	2	55		1
7	1			16		
8				2		
Total	24	7	5	486	9	1

Table 7-29. A03-39u3/u4 counts of lithics by level.

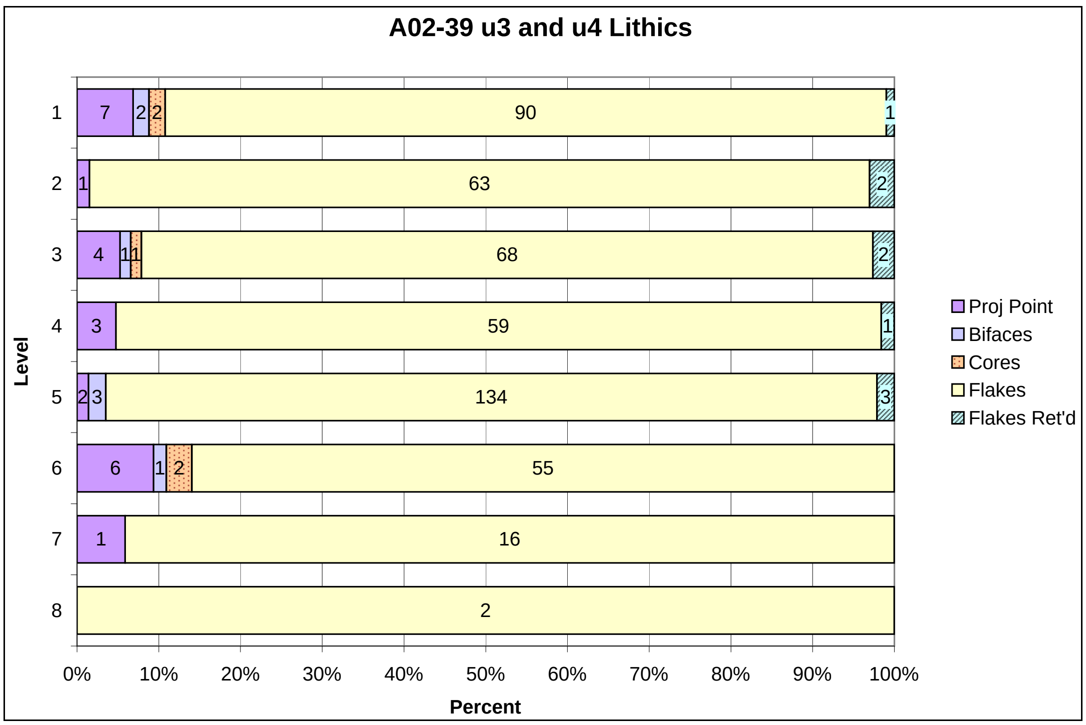


Figure 7-34. A02-39u3/u4 Bar graph showing counts of lithics classes by excavation level.

Classes of lithics from A02-39u3 and u4 show that demonstrable variability was occurring in activities in this area. All of the diagnostic projectile points were Series

5 points, all points were made from Ob1 obsidian except for one Ob2 point, and 80% of the points were broken. The complete points were found scattered in every level, and the series 5 types are consistent with the Late Formative dates from radiocarbon dating. Some of the points were extremely small, including one beautifully pressure flaked point [L03-60.3] that measured only 12.9mm long by 5.2mm wide, and 2.9mm thick weighing 0.1 g. The other points were all very small, with a mean weight of 0.6 grams, which suggests that the size of the projectile is not necessarily related to material abundance as obsidian was abundant at this location in the Late Formative and yet the projectile points were extremely small.

Level	Complete Flakes	Pressure	% Pressure by Row	Observed BTF	Calculated BTF	% Calculated BTF by Row
2	46	1	2.1	1	5	10.9%
3	45	2	4.3	1	8	17.8%
4	41		0	2	10	24.4%
5	97	1	1.0	3	18	18.6%
6	36		0		1	2.8%
7	6		0		2	33.3%
Total	271	4	-	7	44	-

Table 7-30. A02-39u3 and u4: Obsidian flake types by excavation level.

In level 5, between 50 and 60 cm depth and associated with the F1 hearth feature in south half of Unit 4, a distinct increase in obsidian reduction activity was encountered that suggests more advanced reduction activity was occurring in this period. Focusing only on complete obsidian flakes, reveals a much higher count of complete flakes per unit volume of dirt, a quantity that was more than double the number in other levels.

Leaving out level 1 due to surface contamination, the evidence from complete flakes suggests that while bifacial reduction was occurring in level 5, pressure flaking was relatively rare. Bifacial thinning flakes were noted by one of the analysts (Mackay) in the process of labwork (observed BTF column) but because other analysts were not making note of BTF during analysis, additional candidates for inclusion in the BTF category based on the BTF calculation model presented above appear in the column labeled "Calculated BTF". Both observed BTF and calculated BTF values suggest that during level 5 distinctive reduction activities occurred.

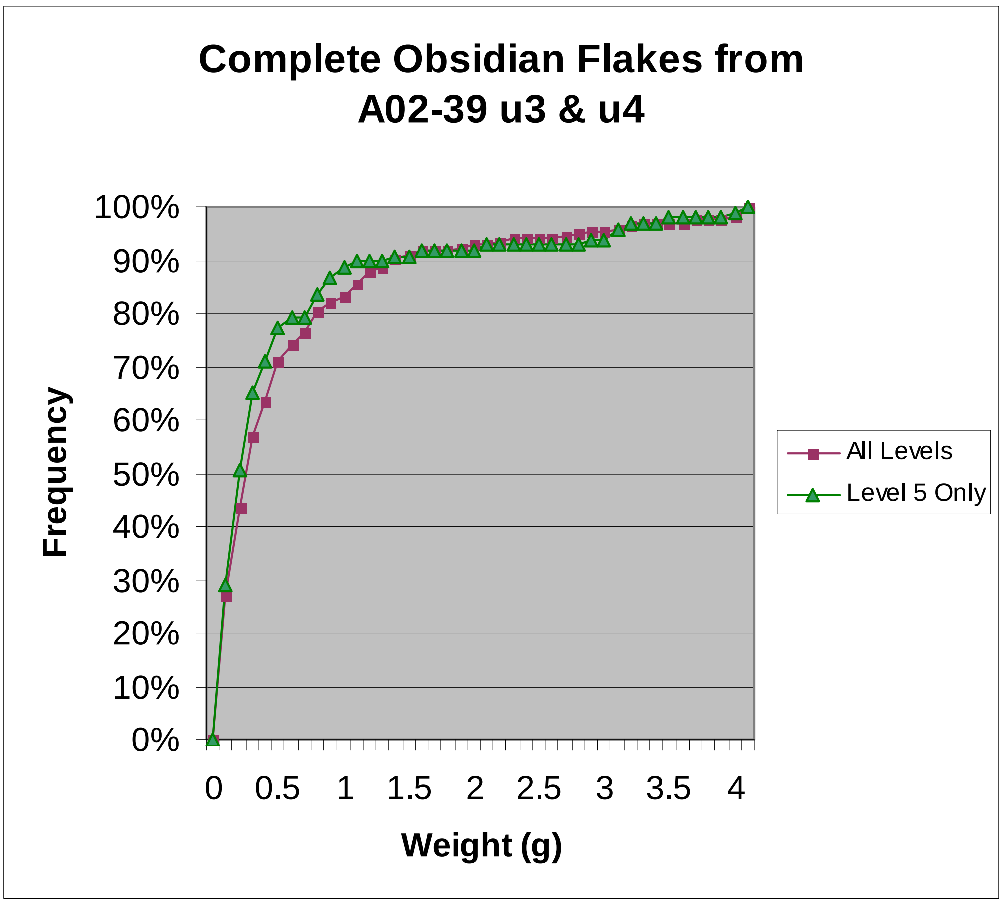


Figure 7-35. Cumulative Frequency of A02-39 u3 & u4 showing Level 5 reduction against reduction for all levels.

Figure 7-35 shows that there was a larger number of very small flakes in level 5, where over 75% of the complete flakes weighed less than 0.6 grams. Evidence of the conservation of material appears in levels 4 and 5, where complete flakes have a higher mean number of rotations and much smaller platform sizes. Finally, the mean coverage of dorsal cortex on flakes decreased from 6.9% in level 5 to 4.3% in level 4, while 6.4% is the mean for these units. In other words, there was a slightly greater range of reduction levels occurring in level 5 where there was more cortex but also a great many small flakes. By the next level, level 4, there was primarily decorticated material in use, and relatively little cortical obsidian.

Other artifacts include bone and ceramics throughout the sequence, and a few tiny pieces of turquoise in level 6 at the bottom of the hearth. Ceramics were found in every level in these excavation units, but few of them were diagnostic. Of the 38 sherds only four were rim sherds and two were handle pieces. One sherd found in level 5 had an incised line parallel to the rim, but was otherwise non-diagnostic. Five sherds from the lower levels (level 3, 5, and 7) resemble the “Chiquero” style described by Wernke (2003) with a brushed interior and no slip. Bone fragments were found in every level but none were diagnostic. Burned bone and charcoal in grey soil were found in particularly high density in hearth F1, along with a broken piece of groundstone and fire-cracked rock.

Discussion

Evidence from these test units suggest that the small hearth was built between windscreens and walls made of standing slab rocks. Based on the small size of the hearth and the structure size, the hearth seems to have been a residential feature.

Assuming the overall site configuration at Pausa involved two large ovals of rocks that may be observed today, the structure that was encountered in unit 3 and 4 pits would be immediately north of the internal oval. These ovals may have been herd control features, such as large corrals with well constructed wall bases on slightly raised mounds, and this residential structure would have been constructed against the north perimeter of the inner circular corral feature. Evidence from lithic reduction show that advanced stages of lithic reduction were occurring here, and while the evidence of bifacial production and pressure flaking absent from the Chivay workshop area, such activities appear to have been occurring with greater frequency in Block 2.

7.6. Block 3 Test Excavations at Taukamayo A02-26

7.6.1. A02-26, Test Unit 1

The site of Taukamayo contains archaeological materials in a variety locations on the site as described in Section 6.4.3, including the profile of a cut on the edge of a low-angle, creeping rainy-season landslide. In the cut profile carbon, lithics, bone, and ceramics were identified at approximately 45 cm below the ground surface. A test unit was placed on the undisturbed edge of the landslide

Stratigraphy

Inspection of the slope cut and the stratigraphy of the test unit confirmed that the site had not slid in the past and the stratigraphy was largely intact. There are signs of increasing angle of deposition through time. Sloping, colluviated soils gave way to level, well-sorted gravels near the bottom of the cultural levels. Radiocarbon dating indicated that the deposit is largely synchronic as the two sigma error of the radiocarbon samples overlap.

Figure 7-36. Test unit A02-26u1 is a 1x1m test unit placed on the edge of a creeping landslide with an irregular extension area (1x) on the south edge of the unit. Top of the photo is north.

The TU1 was placed immediately north of the cut slope, but because it was oriented to true north there was a small irregular, extra section to the south of the unit that dubbed A02-26u1*x*. As a cut profile was available it was possible to observe that the ~60cm of overburden above the charcoal, bone, lithic, and ceramic layer in the profile was virtually sterile. The overburden was excavated relatively expediently by only screening only one-quarter of the dirt through 1/16” screen, the rest went through 1/4” screen only. By level 3 (58cm below datum) everything was screened through 16” screen.

Level	H.B.D.*	Contents	Soil	Photo #
1	30 cm	S1: All: 1/4" screen, Quad D: 1/16" screen. Few artifacts.	Top of unit, grass, roots, light brown soil.	3528
2	47	S2: All: 1/4" screen, Quad D: 1/16" screen. Few artifacts.	Dark grey 7.5YR4/1. Compacted, organically rich, poorly-sorted, subangular .3/.9.	3529
3	58	S3: All quads through 16" screen from here downward. Few artifacts.	V. Dk Grey 7.5YR3/1, subangular blocky, med grain, poorly sorted, .7/.3	3532
4	65	S3, S4: 1, 0a (matrix). Rocks, roots, charcoal, bone, yellow clay blob. ^{14}C: 1265±31bp (AD660-830)	F1: Alluvial, V. Dk Grey/Brown: 10YR3/2, med grain, well-sorted,.5/.3. F2: 7.5YR3/1, med grain, well-sorted, .7/.3	3538-3541
5	75	S4: F1,F3. Bone, ceramics, many lithics, charcoal.	F1: V. Dk Grey 7.5YR4/1, subangular blocky, coarse, poorly sorted, .9/.7	3546
6	80	S4, S5: F1. Bone, ceramics, many lithics, charcoal. Top of hoe.	V. Dk Grey 7.5YR3/1, subangular blocky, med grain, poorly sorted, .7/.3	
7	88	S5: F1, F3. Much bone on west side of unit, lithics, andesite hoe	F1 and F3: V. Dk Grey 7.5YR3/1, coarse grain, poorly sorted, .7/.3	3573-3576
8	98	S5: F1, F4. Bone, ceramics, many lithics, charcoal, midden.	F1: Alluvial, V. Dk Grey/Brown: 10YR3/2, med grain, well-sorted,.5/.3. F2: 7.5YR3/1, med grain, well-sorted, .7/.3	3600
9	105	S5, S6: F1, F4. In F4 there was ochre and obsidian, but less bone. ^{14}C: 1313±36bp (AD650-780)	F1 and F3: V. Dk Grey 7.5YR3/1, coarse grain, poorly sorted, .7/.3	3666-3667
10	116	S6: F1,F5. Lithics, ceramics, bone	F1 and F5: V. Dk Grey 7.5YR3/1, coarse grain, poorly sorted, .7/.3	3673
11	124	S6, S7: Arbitrary div: 1a, 1b. Lithics, ceramics, bone	F1 and F5: V. Dk Grey 7.5YR3/1, coarse grain, poorly sorted, .7/.3	3675
12	130	S7: Arbitrary div: 1a, 1b,1x. Mixed midden, charcoal, lithics, 2 clay concentrations	Moist soils. V. Dk Grey 7.5YR4/1, subangular blocky, med. grain, med. sorted, .9/.7	3677
13	141	S7: Arbitrary div: 1a, 1b,1x Few lithics, 1 sherd, no bone	Very moist soils. V. Dk Grey 7.5YR4/1, subangular blocky, med. grain, med. sorted, .9/.7	3679
14	156		Compact soil	3684
** HBD = mean height below datum in centimeters for the top of each level based on five depth measurements.*				

Table 7-31. A02-26u1 test unit. Excavation levels, overview, and soil description.

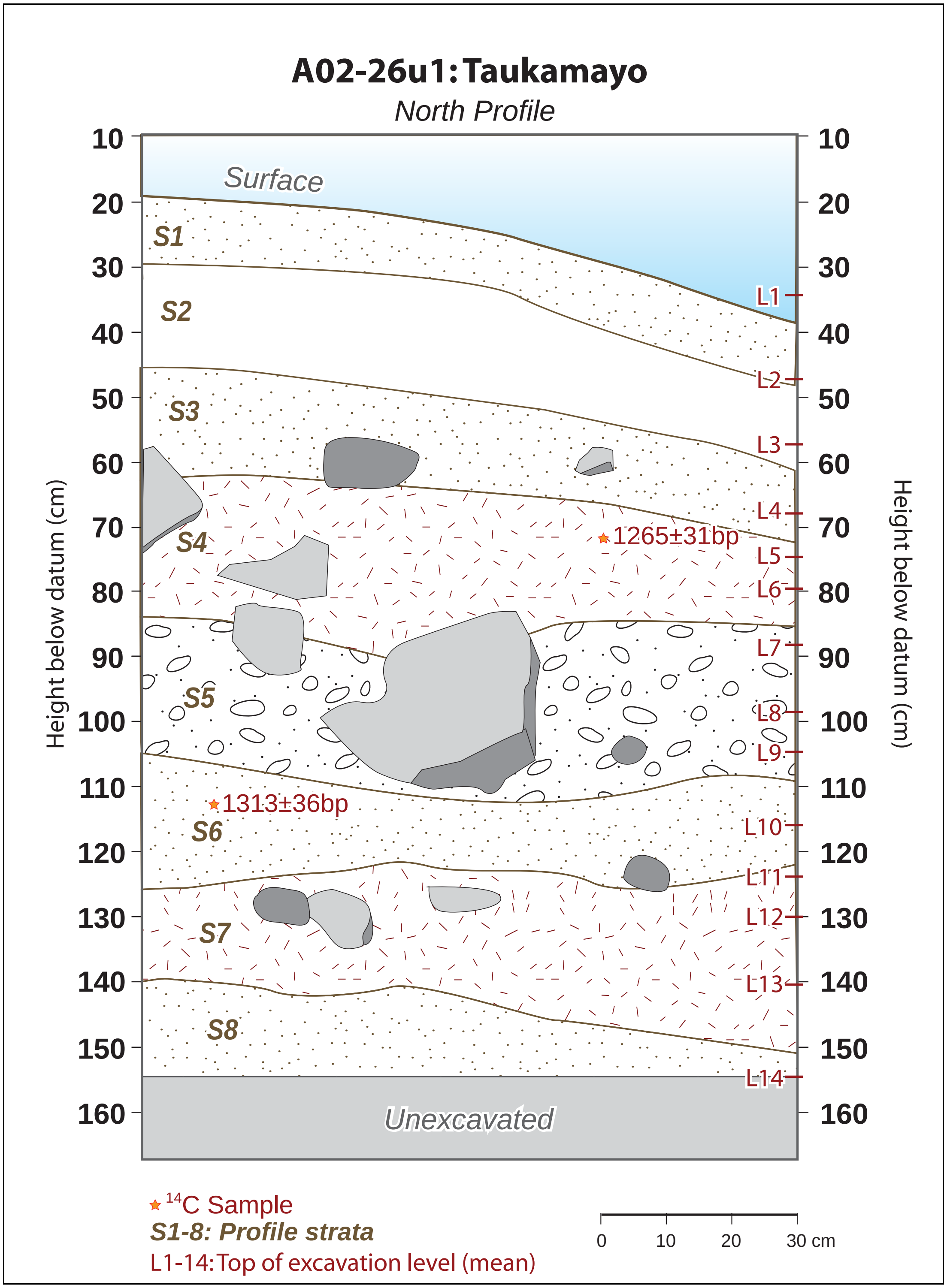


Figure 7-37. A02-26u1 Taukamayo test unit, north profile diagram showing strata and levels.

The stratigraphy at A02-26u1 revealed that the site was intact behind the profile as no obvious landslide had disturbed the soils. There was a distinct change in angle approximately 60-80cm below the surface where the strata are at a much lower angle. These strata contain a great deal of charcoal and bone, and the radiocarbon dates place the assemblage at approximately AD700. This is the middle of the Tiwanaku period and it represents the beginning of the Middle Horizon. The slope angle change that is suggested by the soil stratigraphy is likely related to changes in the position or altitude of the adjacent creek. Evidence of alluvial sorting and river smoothed stones were also found in strata below the S4 and S5 occupation, which suggest that these occupations are on top of an old river terrace. Today, Taukamayo creek is approximately 40m vertical below the site altitude, and denuded hillslopes around the creek suggest that erosion is severe in this tributary valley to the Colca. A preliminary assessment is that Taukamayo creek has significantly incised since the Late Formative and Middle Horizon when it flowed below the site of A02-26 which lay on a relatively flat T1 terrace. Increased incising of Taukamayo creek first caused soil deposition to assume steeper angles, as is apparent in the upper 60cm of the profile. However in the more recent past the creek has begun to undercut the T1 terrace on which the site rests and the southern part of Taukamayo has since slid, revealing the profile cut.

Artifacts by level

Obsidian arrives into the test unit area in conjunction with bones, both burned and unburned, that turned out to be primarily camelid bones. The lithic analysis evidence suggests that obsidian was brought into the area around level 8 where the mean flake size is considerably higher than average and obsidian goes from an average 55% of the lithic assemblage by level, to 80% of the assemblage in level 8 and then 70% of the assemblage in level 7.

		Obsidian			Non-obsidian		
Level	*Possible Bifacial Thinning*	*No.*	*Ave. Rotations*	*Ave. Cortex*	*No.*	*Ave Rotations*	*Ave Cortex*
2		5	0	0	5	0	18.0
3		6	0	0	4	0	17.5
4		17	0.4	1.2	24	0	7.9
5	6	51	0.6	1.6	39	0.2	4.9
6	2	53	0.3	1.5	27	0.4	9.6
7	7	79	0.3	1.8	32	0.1	3.4
8	1	38	0.3	4.7	10	0	7.0
9	1	9	0.3	0	4	0	2.5
10		8	0.1	0	14	0.2	7.1
11		10	0.3	6.0	27	0.3	12.2
12		6	0.5	8.3	20	0.2	15.0
13		5	0.2	2.0	20	0.2	15.5
Total	17	287	0.3	2.2	226	0.2	9.0

Table 7-32. A02-26u1: Artifact counts and averages for select measures.

	Proj Points	Bifaces	Cores	Retouched Flakes	Flakes	
Level	*No.*	*No.*	*No.*	*No.*	*No.*	Total
2					10	10
3					10	10
4		1			40	41
5	2	3	1	2	82	90
6		1	3	1	75	80
7	4	2	4	1	100	111
8	2	2	2		42	48
9					13	13
10					22	22
11			3	2	32	37
12			1		25	26
13			1		24	25
Total	8	9	15	6	475	513

Table 7-33. A02-26u1: Lithic Technical Classes by Level showing counts.

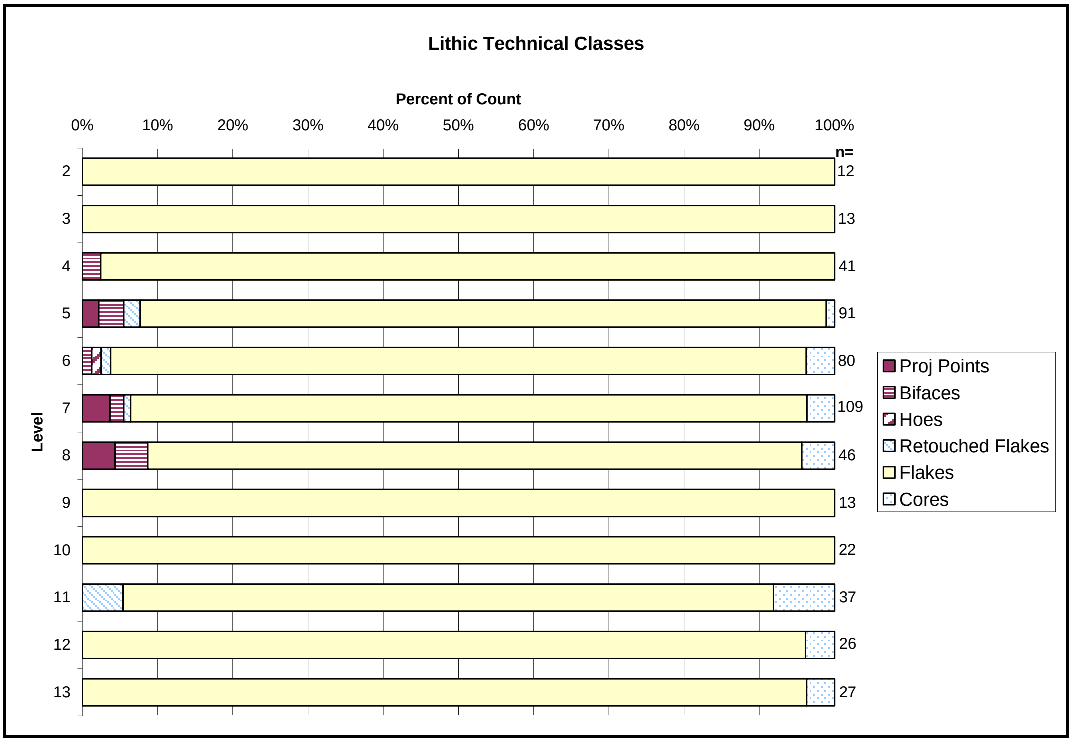


Figure 7-38. A02-26u1 Technical Class by Excavation Level.

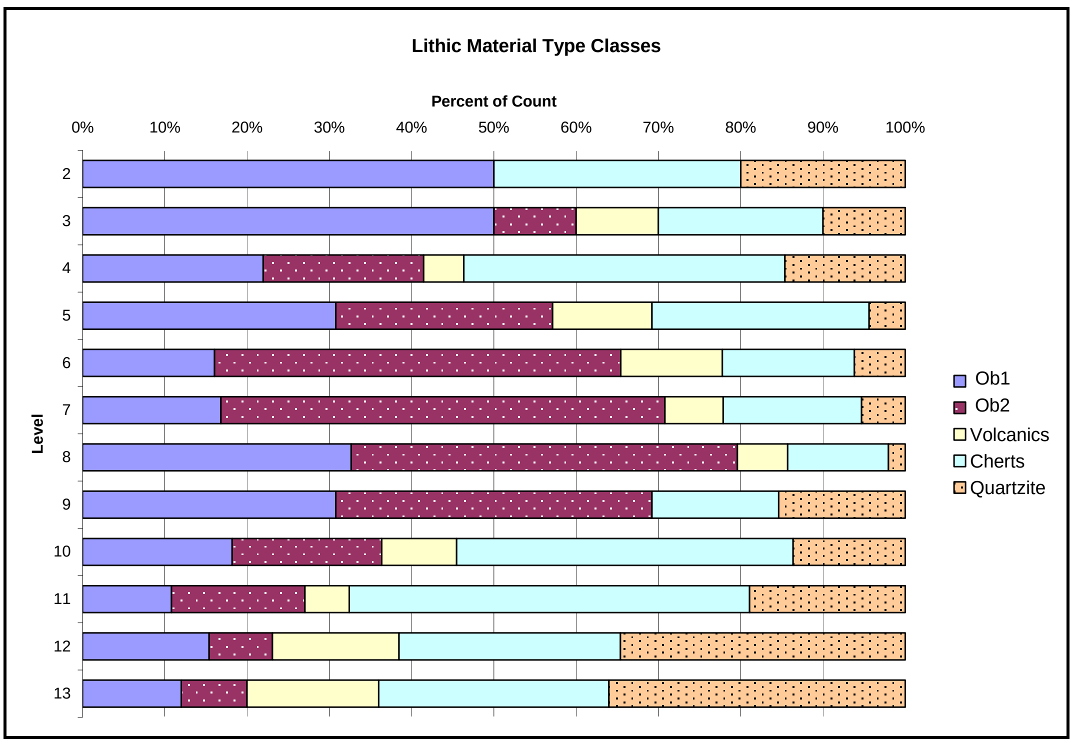


Figure 7-39. A02-26u1 Material Types by Excavation Level.

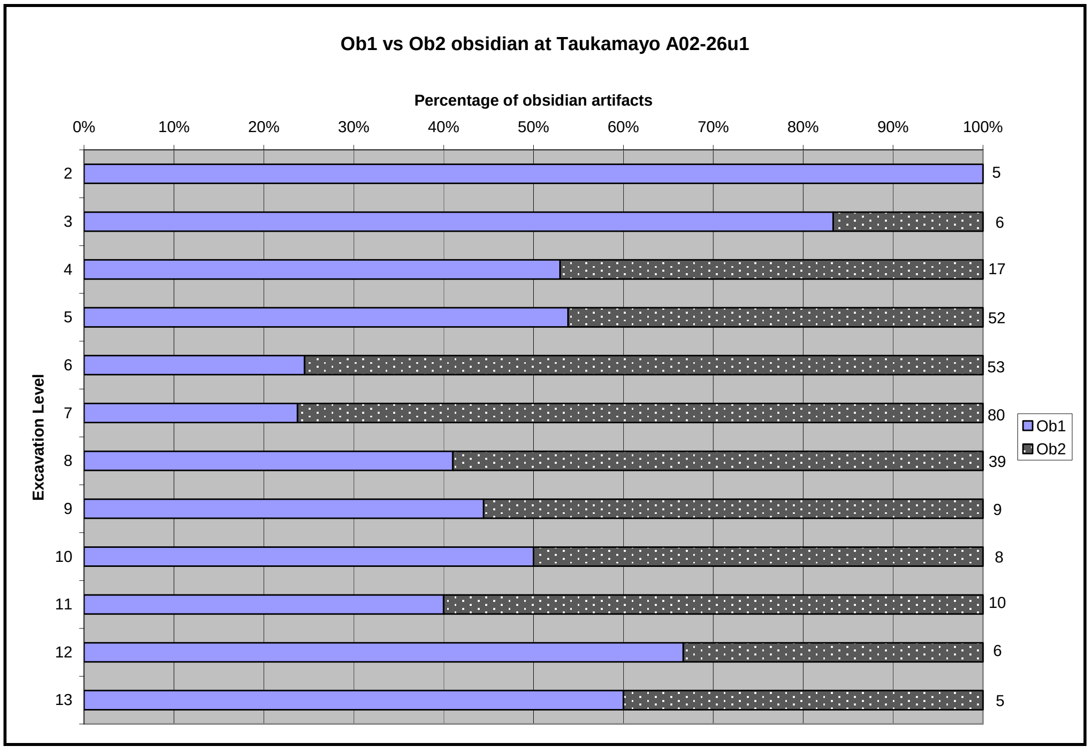


Figure 7-40. Obsidian at Taukamayo A02-26u1, Ob1 and Ob2 compared.

Material types at Taukamayo provide insights regarding the use of non-obsidian lithic material in the vicinity of the Chivay source. Chert is abundant in the Colca and the Llapa rivers, and in Taukamayo creek. Yet the reduction in imported obsidian appears to have occurred at a few distinct sites in the Upper Colca valley area, as if complementing the local chert use.

The use of Ob1 and Ob2 obsidian at Taukamayo is also informative. The influx of obsidian in levels 6-8 appears to have been from a source with Ob2 obsidian as both types of obsidian increase in these levels but the percentage of Ob2 obsidian is significantly greater than it was in previous and later levels. In the course of survey work, Ob2 obsidian was encountered outside of the Maymeja zone in Block 4, and also at a minor obsidian source in the Pulpera drainage called Condorquiña (Section 4.5.1). It is possible that the Ob2 obsidian was derived from one of these sources, and that this lower quality obsidian was generally not intended for projectile point production. In fact, projectile points are comparatively rare at Taukamayo, with only 8 obsidian projectile points and preforms coming from the TU1 pit, and of these only one point (in level 7) was Ob2 material. This evidence suggests that the focus on obsidian production in this area in the beginning of the Middle Horizon was on flake and biface production, and there was relatively little preference shown for Ob1 obsidian over Ob2 material.

In level 5, there appears to have been more advanced reduction of obsidian occurring. The BTF index suggests that bifacial thinning flakes are more prevalent than in other levels, and 3 broken bifaces (50% of total) were found in level 5, the average number of rotations went from 0.36 to 0.56 in level 5 implying that greater conservation of material was occurring in that level.

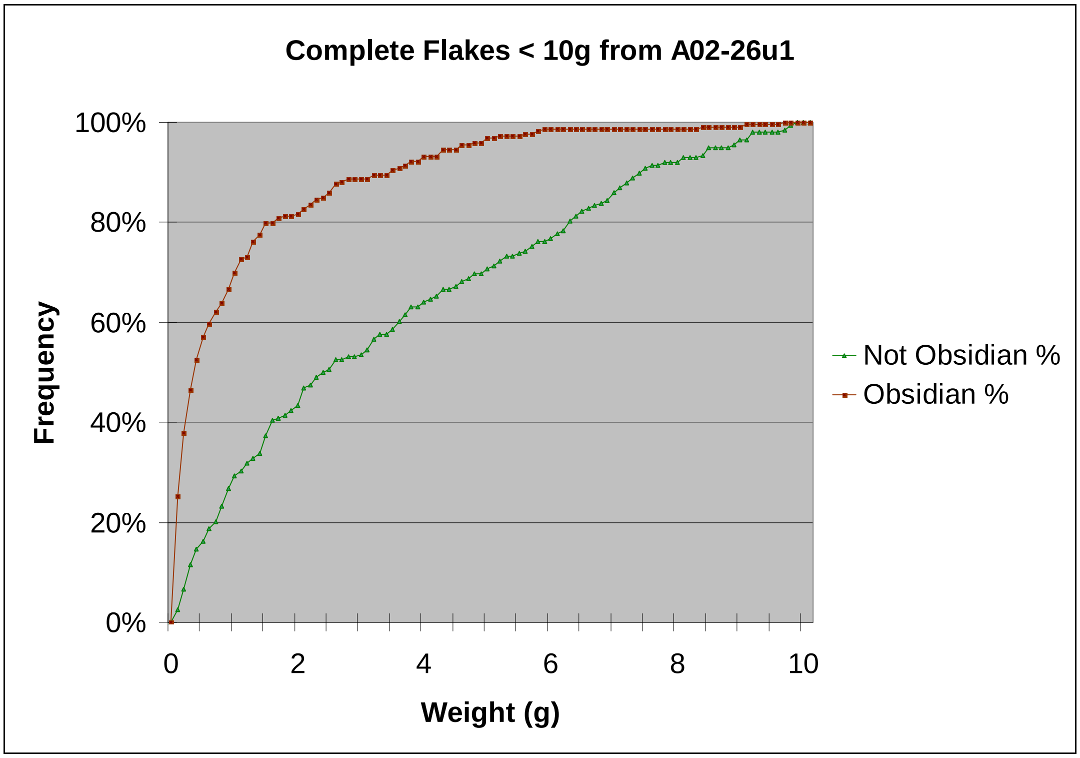


Figure 7-41. Cumulative frequency comparing obsidian and non-obsidian flakes.

Levels 5 and 6 also contained a high density of animal bone. Analysis of diagnostic faunal remains by Randi Gladwell revealed that the majority of the bones were camelid, and though some small mammal bones were encountered that may have been *cuy* (guinea pig) or *viscacha* bones. Comparing obsidian with non-obsidian overall, it is apparent that more advanced reduction occurred on obsidian. This contrast is expressed in Figure 7-41 where over 80% of obsidian flakes are under 1.7g in weight.

Comparing Material Types in A02-26u1 and Block 3 overall

The excavation unit A02-26u1 at Taukamayo presents lithic evidence, albeit synchronic to the Tiwanaku period, that is, in some ways, representative of the material use pattern in Block 3 overall. Distinct patterns emerge, however, with respect to the use of Ob2 obsidian, because as was noted Ob2 obsidian was rarely used outside of Block 3.

	A02-26u1 Excavation				Block 3 total surface collection			
	Ob1		Ob2		Ob1		Ob2	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Proj Points	7	87.5	1	12.5	24	96.0	1	4.0
Bifaces	2	25.0	6	75.0	16	69.6	7	30.4
Rt'd Flakes	1	33.3	2	66.7	9	52.9	8	47.1%
Flakes	101	38.7	160	61.3	32	49.2	33	50.8
Cores	3	33.3	6	66.7	15	88.2	2	11.8
Total	114	39.5	175	60.6	96	65.3	51	34.7

Table 7-34. A02-26u1 Excavation and Block 3 surface: Lithic Tech. Classes by Obsidian type.

Table 7-34 shows that Ob1 obsidian was primarily used for projectile point production, however bifaces from Ob2 were used to a much greater extent at A02-26u1. Retouched flakes of the two material types were used in similar proportions in the two contexts.

Discussion

This test unit appears to show several occasions of obsidian reduction in conjunction with camelid butchering and cooking during the earliest part of the Tiwanaku period at this site in the upper Colca. More advanced reduction was occurring on obsidian, but there appeared to have been little preference for Ob1 obsidian over the Ob2 material, and in fact in the production of bifaces it appears knappers used Ob2 preferentially, though both materials were available. The Uyo Uyo obsidian source is under 40 km downstream and there are irregularities in Uyo Uyo material that such that it falls in the Ob2 category.

As dates contemporary with Tiwanaku were derived from this unit, a regional consideration of this occupation should include the distributions of Chivay obsidian in this time period. Regional distributions indicate that during the Tiwanaku period Chivay obsidian was rarely used north of Chivay source area. Distributions tend strongly towards the south and east where the Lake Titicaca Basin consumption pattern is strongest. Yet it is curious that the highest density of obsidian in the Block 3 area north of the source is dated to the Tiwanaku period, which is in a northward direction and towards the Wari sphere. In concordance with regional obsidian distributions in this time period, it is notable that the heavy use of Ob2 obsidian, and the production of bifaces rather than projectile points, suggests that goods produced at this obsidian production area use were intended for modest local consumption.

7.6.2. Test Unit 2

Test unit two was a profile cleaned back 40 cm on the south side of A02-26 Taukamayo landslide. Bone and obsidian flakes were exposed in a landslide cut area in a location that mirrored the position of A02-26u1, but on the opposite edge of the landslide area and much closer to the drop to Taukamyo creek. This profile was cleaned back 25cm and bone as chipped stone, as well as three charcoal samples, were recovered. A preliminary review of these artifacts has been conducted but the charcoal ^{14}C samples have not yet been analyzed.

7.7. Comparisons between Blocks with surface and excavated data.

7.7.1. Size of flaked stone artifacts

Given the proximity of an obsidian source of regional importance, there is a distinctive absence of large flakes in the immediate consumption zones of Survey Blocks 2 and 3. An examination of surface and excavated data, reveals an upper limit on artifact dimensions that suggests that local people were not consuming the larger nodules available at the Chivay quarry. The length and mean thickness of cortical and non-cortical complete flakes from surface and excavated contexts are shown in Figure 7-42. Early stage reduction flakes, taken here to be those with more than 20% cortex, made up 5% of all obsidian flakes in Blocks 2 and 3.

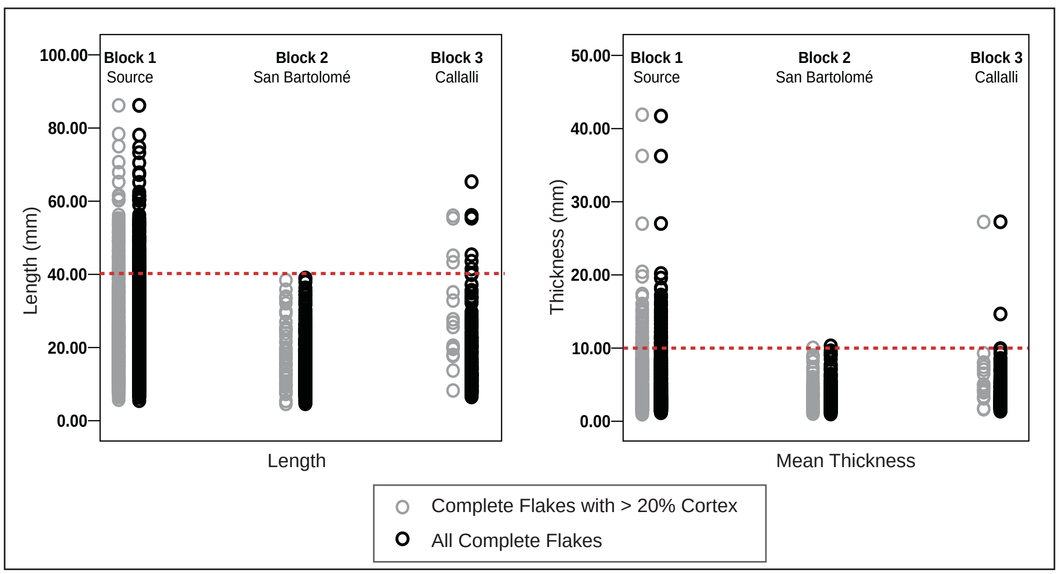


Figure 7-42. Flake metrics from Quarry area (Block 1) as compared with local consumption areas (Blocks 2 and 3). Red dashed line indicates upper size limits for B2 and majority of B3 evidence.

	Survey Block					
Length (mm)	1	2	3	4	5	Total
< 10	57	16	1		10	84
10 – 20	288	36	7	2	36	369
20 – 30	264	19	7	14	31	335
30 – 40	128	8	5	15	9	165
40 – 50	73		2	3	2	80
50 – 60	21		2		1	24
60 – 70	12					12
> 70	4		1	1		6
Total No.	847	79	25	35	89	1075

Table 7-35. Counts by length for all complete obsidian flakes with ≥20% dorsal cortex.

The presence alone of such flakes indicates that some obsidian cobbles were being transported from the source region and reduced in Blocks 2 and 3. There is a relatively clear distinction between the upper size limits of these early stage reduction flakes from Maymeja, and those appearing in Block 3, and, more strikingly, in Block 2 (Figure 7-42, dashed line). Cortical flakes over 40mm in length were common (9.7%) at the source workshop, but no cortical flakes at Block 2 were this length, and few cortical flakes in Block 3 exceeded 40mm in length (3.5%). Further, the large Block 3 early stage reduction flakes were predominantly Ob2 obsidian which is common in the Blocks 4 and 5 survey area. These data indicate that the reduction of large cobbles, such as those available in the Maymeja quarry, was *not* occurring in the puna and upper valley blocks of the survey.

One may extend this analysis to all complete obsidian flakes, in case initial reduction (and decortication) of larger cobbles was occurring elsewhere with only later processing present in Blocks 2 and 3. With all complete flakes included these same limits on flake size are reinforced (see Figure 7-42), again most markedly in Block 2. Thus, there are no flakes discarded in Blocks 2 or 3 that approach the flake size potential offered by the quarry source, even after initial decortication. This precludes distance decay as an explanation of this pattern for two reasons. The first is that the early stages of cobble reduction, as represented by cortical flakes, are present on site. Thus, complete or near-complete cobbles were being reduced locally, but the maximum size of flakes attainable from these cobbles had an upper limit (an absolute upper limit in the case of Block 2) of 40mm, substantially smaller than those produced in Block 1. The second is that in the reconnaissance of Blocks 4 and 5 there was a lack of significant intermediary consumption zones between the source and the puna and valley consumption zones.

7.8. Conclusion

Test excavation work illuminated several vital aspects of the Chivay obsidian production system that would have remained as major unknown factors without the testing program. The excavation work demonstrated that intensified obsidian procurement represents a very early example of concentrated production activity in the south-central Andean highlands. Further, ceramics distributions and architectural patterns were of limited use in documenting obsidian production activities, and the Preceramic dates (Terminal Archaic) for initial intensification explain, in part, why ceramics were absent in earlier stages of obsidian production at the Maymeja workshop. The data from excavation also corroborate regional consumption data from the site of Qillqatani and elsewhere that attest to wide circulation of obsidian in these relatively early dates. The documentation of regular changes in the assemblages at the workshop and at consumption sites in the immediate vicinity that offer comparative morphological data for archaeologists working with obsidian from consumption sites further from the Chivay source area. Finally, an investigation of the ways in which the visual characteristics of obsidian varied through time in the excavation sequences can be compared with the variability in space presented in the previous chapter.

The research and analysis at the source could have been improved in two principle ways. First, additional excavated data from the quarry workshop would strengthen the interpretations of the change over time, the spatial extent, and the rate of production at the source. The second major improvement could come from replication studies. As small triangular projectile points and, presumably, large flakes as slicing tools were the principal objective of most production at the workshop, replication would have provided an empirical basis for connecting assemblages from the workshop with the possible forms of the artifacts that were exported from the quarry. Further research will be discussed at the end of the next chapter. In the subsequent and final chapter of this dissertation will summarize and further discussion of the significance of these findings in the larger context of regional exchange.

– Chapter 8 –

Major Findings from the Upper Colca Project

8.1. Introduction

This chapter reviews the most significant findings of the Upper Colca Archaeological Research Project. The principal results will be summarized by time period, and then these larger findings of this research will be reviewed thematically by looking at the evidence with respect to specific issues such as quarrying, production, and modes of regional interaction. Subsequently this chapter will return to the four models for obsidian circulation in the Andes that were introduced earlier, in Section 3.7. This chapter concludes with a review of the theoretical implications of the research as well as a brief discussion of future directions in research at raw material sources in the Andes.

8.2. Review of major findings

Summarizing the results presented in Chapters 6 and 7, a number of changes in obsidian procurement at the Chivay source correspond to changes recognized regionally in south-central Andean development. While the activities at the Chivay source area did not exactly meet the expectations of the project that were implied by patterns of regional consumption data, these differences between the expectations and the results of the Upper Colca project are informative, and these differences will be highlighted in the text. The differences appear to be largely the result of a historical bias in research, in that there has been a predominant focus on the more socially complex, later episodes in Andean prehistory. For example, obsidian has been found in many ceremonial Tiwanaku contexts and in the Tiwanaku core area such that some investigators in the heartland area argue that the Chivay source was state-controlled (e.g., Giesso 2003). Yet, in numerous studies in the Colca region, and this study of the Chivay source in particular, archaeologists have yet to find definitively Tiwanaku artifacts in the Colca area. Contrasting with this lack of evidence from the Tiwanaku period, consider the evidence from earlier periods: the Terminal Archaic and Early Formative. While relatively few sites have been excavated that date to the Archaic / Formative transition in the south-central Andean highlands, the evidence from the Chivay source shows that obsidian production intensified during that time. Indeed, a review of the little evidence available from Terminal Archaic and Early Formative sites in the adjacent consumption zone indicates a spike in obsidian consumption during that time.

In other words, archaeologists in the south-central highlands have historically focused on late prehispanic complex polities, and today the legacy of data from excavations aimed at regional centers has biased the overall picture of obsidian consumption towards the later Prehispanic period. While there were major social and economic changes underway in the third millennium BC, the findings here reveal that obsidian was one of the earlier materials to show a distinct increase in production and circulation in the south-central Andes.

8.2.1. Archaic Foragers (10,000 – 3300 BCE)

During the lengthy Forager period there were a number of gradual changes that may be observed in obsidian procurement and circulation. Obsidian appears to have been procured directly from the Maymeja area since at least the Middle Archaic. Evidence from the dating of a glacial moraine, and from obsidian consumption at the distant site of Asana, suggests that the Maymeja area itself was glaciated until approximately 9000 cal BCE.

The Ob1 material (obsidian free of heterogeneities) appears to have been used preferentially for tool production over the Ob2 material (obsidian with heterogeneities) throughout the Forager period, as was true in later times. During the Late Archaic, obsidian use for projectile point production declined and points were chiefly made from fine-grained volcanic stone, such as the andesite material common in Block 2.

Establishing the degree of embeddedness of obsidian procurement during particular periods of the Archaic Forager time frame is not a straightforward task. If evidence of advanced reduction stages is taken as a sign of more embedded procurement, then the evidence for advanced reduction comes in several forms.

(1) There was a greater proportion of diagnostic points identified for series 1-4 points than series 5 points in Block 1.

(2) Most of the diagnostic points identified in the Block 1 area are incompletely flaked and were broken longitudinally as would occur during production.

(3) The bases of latitudinally snapped, non-obsidian projectile points were encountered that appeared to have been discarded in the Maymeja area. The implication is that as the hafts were reused for newly-made obsidian projectile points, the broken bases were discarded from hafts that were being retained.

Embedded procurement may have taken the form of blank production with later advanced reduction occurring in adjacent blocks, such as Block 2 that contains stronger evidence of Archaic residential occupation.

Elsewhere in the study region more distinct site size differences are apparent during the Archaic Foragers period. Operating within the confines of surface survey information, sites were differentiated into residential bases and small logistical sites based primarily on lithic artifact density and diversity, shelter opportunities, and other site features. Archaic occupation in the high puna area of Block 2 appears to have been more long-term. Dense scatters, and variability in lithic materials were encountered, along with identifiable series 1-4 projectile points at a various late stages of manufacture and use. The sites with an abundance of flakes of fine-grained volcanic stone all have a Late Archaic component, and given the predominance of fine-grained volcanic material in the production of Late Archaic point types, the presence of andesite and rhyolite flakes at sites in Block 2 appears to correlate most strongly to Late Archaic occupation. Archaic Forager sites with no pastoral component rarely had obsidian flakes, and obsidian use appears to have been relatively diminished. This lack of obsidian flaking debris in Forager sites is further supporting evidence for embedded procurement and source-area tool production during the Archaic Forager times.

Numerous projectile points diagnostic of the Archaic Forager period were found in Blocks 4 and 5, but the surface of these sites was dominated by evidence from later reoccupation and therefore it is difficult to isolate these lithic concentrations as belonging to the non-pastoral or pastoral period. Rock shelters in Block 5, like Mollepunku and Kakapunku, appear to have had high rates of reoccupation throughout prehistory.

The Block 3 area around Callalli has the lightest evidence of Archaic Forager period occupation. Chert production sites on river banks, and some small, isolated sites in sheltered areas, provide the bulk of the evidence in this region. Perhaps the paucity of the Archaic Forager component in Block 3 reflects the better hunting opportunities elsewhere, such as on the high puna, and better vegetation and gathering opportunities in the lower altitude Colca valley downstream. It appears that the Callalli area was relatively lightly occupied during the Archaic and perhaps the more specialized ecology of the puna above and the lush valley below were more conducive to Archaic Forager subsistence. The sites identified here appear to have been the result of short-term stays in the course of travel through the river valley.

8.2.2. Early Agropastoralist

Obsidian procurement in the Early Agropastoralist period took place in the context of sweeping changes in economic and political circumstances in the south-central Andes. A marked increase in interregional exchange was complemented by greater sedentism and possible circumscription, an increased reliance on food production, and early evidence of social ranking in the form of differences in supra-household architecture and grave goods. The social and economic integration of altiplano communities through networks of regular camelid caravans has been proposed as an important preliminary stage in early economic coalescence in south-central Andean highland communities prior to the emergence of regional polities of the Late Formative (Browman 1981a; Dillehay and Nuñez 1988). While an increased reliance on camelid pastoralism is evident from regional settlement patterns and faunal assemblages, the date of the onset of the system of regional caravan networks is difficult to establish.

The existing evidence from diagnostic ceramic distributions suggest that regional integration through regular caravan traffic occurred when particular styles became more widely distributed, such as Middle Formative Qaluyu pottery, or earlier with Early/Middle Formative fiber-tempered pottery in the southern Titicaca Basin. However, the regional styles of projectile points changed dramatically in a time period that is earlier still: the Terminal Archaic (3300 cal BCE). While changes in projectile point styles are likely connected to technological modification, such as the use of bow and arrow and differences in hafting, the widespread adoption of the series 5 projectile points throughout the central and south-central Andes from the Junin puna to northern Chile suggests that interregional contact was pervasive.

Evidence showing that quarrying and workshop activity at the Chivay source began during the latter part of the Terminal Archaic, suggests that the regional economy was already becoming relatively integrated and responsive to non-local demand. First, the evidence from this period shows that production targeted larger nodules that served to signal surplus and abundance, and would retain greater use-life with distance from the source. Second, the quarrying activity appeared to focus on obtaining the Ob1 obsidian nodules of clear or grey material. Finally, the date inferred for the construction of a swept path out of the Chivay source quarry area appears to coincide with production at the source; although the specific dating of the construction of the road is tenuous. Changes in the regional demand, the responsiveness of procurement, and the ability to transport obsidian, are part of a larger suite of changes during the Terminal Archaic and Early Formative, and this production system will be discussed below in the context of regional integration during that time period.

The Early Agropastoralist period in Block 2 shows evidence of growing pastoral herds and the construction of a variety of well-established animal control structures. These Block 2 facilities, many of which are abandoned today, are notable in that a variety of ceramics and lithic artifact styles are scattered on the surface of these sites. These pastoral structures may be interpreted as corrals, or some other animal control structure but with additional ritual functions. For example, at the site of Pausa, three large ovals varying in size from 20m in diameter to 50m in diameter were examined. These structures are delimited by solidly placed large rocks between 30-100cm across and the ovals have several curious attributes: (1) the ovals, regardless of size, all have 26 to 28 large rocks, (2) niches along the east side of the largest oval suggest that this structure was more than merely a corral, (3) the quantity of obsidian and ceramics at the site of Pausa far exceeds similar configurations elsewhere in Block 2, suggesting a particularly important function for this site. The 2003 testing at two of the Pausa structures revealed what appears to have been a domestic hearth dating to the Late Formative, around AD200, and the construction of a secondary structure and platform at the end of the Late Formative around AD400. The evidence from surface ceramics distributions suggest that these Late Formative dates are linked to a number of those corral mounds. Advanced-stage obsidian reduction is found in abundance at these mound structures, which implies that the people pasturing the expanding herds of camelids in Block 2 were involved in obsidian tool manufacture, but the presence of exclusively small, advanced stage flakes (never greater than 4 cm) implies that these people were not responsible for the initial quarrying of large nodules since the evidence shows that they never discarded large flakes or cores in Block 2.

In the upper Colca drainage in Block 3, the Early Agropastoralist evidence is less defined than was the occupation in the Block 2 puna area. The quality of pasture is known to be considerably better, particularly for alpacas, above 4200 masl. Several sherds of non-local ceramics with similarities to Middle Formative (Qaluyu) and Late Formative (Pukara) in the Lake Titicaca Basin were encountered in the course of work in this area which suggests that the Callalli area was a major cross-roads and thoroughfare, as it is today. Obsidian was found primarily in the form of finished bifacial tools, but some obsidian production was encountered in Terminal Archaic contexts at the rock shelter of Quelkata, and at the open air site of Taukamayo. While the test unit at Taukamayo produced Tiwanaku period dates (circa AD 650), many of the ceramics that were observed in the landslide debris appear to date to the Formative.

8.2.3. Late Prehispanic

Evidence from regional consumption patterns indicate that while Chivay obsidian was in wide circulation within the Tiwanaku economic sphere, the regional distribution and quantity consumed declined during the subsequent LIP and Late Horizon. As one of the research questions motivating this study at the Chivay source, evidence was specifically sought to explain the economic circumstances around obsidian production in Late Prehispanic contexts. New evidence will be reviewed that was acquired from fieldwork in 2003, and later in this chapter contrasting models of production will be explored in more detail.

Tiwanaku

No direct evidence of Tiwanaku was encountered at the Chivay source or in the immediate vicinity during fieldwork in 2003. A single obsidian preform was encountered that appears to have been an early stage of a type 4E (Tiwanaku stemmed) projectile point in Block 2, but the identification is not definitive. Titicaca Basin materials were encountered deriving from particular time periods in the form of non-local decorated ceramics, such as sherds of possible Qaluyu and Pukara (Formative) styles, and Colla and Chucuito (LIP and Late Horizon) ceramic styles, but no Tiwanaku pottery was encountered any where in the Upper Colca research area. In Block 3, a calibrated radiocarbon date of A.D. 650 – A.D. 780 (Figure 7-3) from Taukamayo places the occupation in the Tiwanaku period, but no Tiwanaku or Wari evidence was found at the site. Rather, pottery akin to the local Chiquero material was encountered that is diagnostic to the Formative in the main Colca valley (Wernke, 2003). The asymmetrical relationship between Chivay obsidian consumption in the Tiwanaku economic sphere, and the lack of Tiwanaku diagnostic materials in the Chivay source area will be discussed in more detail below.

Local Middle Horizon patterns are of particular interest because regional distributions of these ceramics may shed light on the nature of the frontier relationship between Tiwanaku and Wari that appears to have been occurring in the upper Colca valley during the latter half of the first millennium AD. Ceramics in the local Middle Horizon style (as per Wernke 2003: 466-478) were encountered in Block 2, but these sherds were confined to the northern half of Block 2. Middle Horizon pottery was found scattered throughout Block 3. A single local Middle Horizon sherd was found mid-way between the Chivay source and the town of Chivay, and one sherd was found in Block 6 upstream of Tuti. In short, the Colca Middle Horizon type defined by Wernke was encountered throughout the Upper Colca study area although, as discussed in Chapter 6, there is a distinct zone in Block 2 south of which the local MH pottery is not found.

Late Intermediate Period

Ceramics of the local Collagua style dominate the decorated ceramics found throughout the Upper Colca survey area. Pastoral facilities are rich in decorated ceramics resembling the main Colca Valley styles described by Wernke and others and underscoring the close links between Collagua polity in the Colca valley, and their expanding herding sector on the adjacent puna. Sherds of the Colla type, the Lake Titicaca Basin LIP style, were found in the northern part of Block 2 and also along the trail leading from Block 2 towards Block 1 and the Colca valley. Relatively close economic and cultural links are expected between LIP groups in the Colca and the Titicaca Basin as these groups shared a number of traits including the Aymara language, *chulpa* mortuary architecture, and the defensive *pukara* hilltop settlements. Yet, interestingly, no Colla sherds were encountered in Block 3, the upper Colca valley, although the ceramics and architectural evidence shows that the Collagua presence was relatively strong in this area. This may be explained in terms of ecological complementarity, as one might expect the Colla to have been actively trading with the lower Colca valley agriculturalists, but the upper Colca valley is at the same elevation as the Titicaca Basin and thus it had relatively little to complement the goods available in the Titicaca Basin.

The LIP occupation of Block 3 appears to have been focused around agricultural plots and pastoralism in the adjacent high puna. Evidence of abandoned agricultural plots was noted both upstream and downstream of Callalli (3,900 masl) with furrowed areas that were likely planted in frost resistant crops like quinoa or tubers.

Late Horizon

During the Late Horizon the reorganization that took place under Inka rule is evident in settlement pattern changes and ceramics distributions. At the Chivay obsidian source, the highest quantity of diagnostic ceramics were those in Late Horizon styles. These ceramics may be derived from the mortuary structures that were encountered in the Maymeja source area, or the LH ceramics may be a reflection of the increased investment in water control projects and expanded herding. A possible extension to the Huarancante canal capturing water from Quebrada de los Molinos would have had its origins precisely at the Maymeja workshop at the Chivay source.

Elsewhere in the survey area the Inka period introduced a number of changes including distinctive differences in long-distance interaction. In Block 2, the Late Horizon component appears to have been consolidated around a few larger sites. The presence of Titicaca Basin pottery is notably lower in the Late Horizon in Block 2, and Cusco Inka styles are introduced in that area. Fourteen sherds of Colla style pottery (Titicaca Basin LIP) were found in Block 2, and these were primarily scattered in the northern half of the block. By the subsequent Late Horizon only two Chucuito style sherds (Titicaca Basin LH) were found in Block 2. The most common decorated pottery was the local LH Collagua-Inka and the Collagua-3 style. In Block 3, settlement became concentrated at agricultural plots along natural river terraces near the confluence of the Río Colca and Río Llapa in an area known as Callalli Antiguo. A concentration of structures with non-local Inka pottery along the principal road system on the south side of the Colca suggests that this site may have had administrative functions in the Late Horizon settlement pattern.

8.2.4. Discussion

This review of the major findings from research in 2003 shows that it was regional forces that dominated the changes that were observed in obsidian procurement through time. Raw material for use in the local economy was relatively steady, with local cherts dominating Block 3 assemblages in most time periods, and local fine-grained volcanics prevalent in Block 2 during the Late Archaic. However, changes on the regional scale in long-distance interaction and in demand for obsidian beginning in the Terminal Archaic introduced distinct intensification in procurement of obsidian. The later changes that occurred in the Early Pastoralists and Late Prehispanic times reflected the growing intensification in both agricultural and pastoral economies in the Colca. In contrast, the procurement and circulation of Chivay obsidian is relatively sustained and is not subject to this expanded production in later times.

8.3. Production and interaction

The Upper Colca project research in the Chivay source area provides new evidence of lithic procurement and organization in the vicinity a raw material source of regional significance. In this section, specific themes will be discussed concerning Chivay obsidian procurement and production based on research in the vicinity of the Chivay source.

8.3.1. Lithic raw material use in the vicinity of the Chivay source

Within the larger survey area, the radial attenuation pattern of obsidian artifacts around the Chivay obsidian source is a common characteristic of single-point raw material sources. This attenuation resembles a distance-decay pattern, but on a local scale. Obsidian artifacts dominate the assemblages in Survey Blocks 1, 4, and 5; the ones that are adjacent to Chivay source, while locally available chert and quartzite are well-represented in assemblages in Block 3, the upper Colca river valley. The impetus for quarrying in the Maymeja area appears to have been driven by a demand for larger obsidian nodules, and for obsidian material with few heterogeneities. Complete artifacts with > 30% cortex, including tools, flakes, and cores, were considerably larger in Block 1 than in other blocks. In surface assemblages in Block

2, which lies the same distance from the Chivay source as Block 3, obsidian dominates the lithic artifacts and andesite and other fine-grained volcanics are also present. On the surface of Blocks 1, 4, and 5, close to the Chivay source, obsidian cores and cortical flakes are more common, and in Blocks 1 and 5 bifacial thinning flakes (BTF) were relatively common with the highest fraction of BTF being located at the site of A03-910 in Block 5.

Variability in the use of Ob1 and Ob2 material

Earlier it was noted that there was variability in obsidian knapping quality both in original geological exposures and in artifact materials. Obsidian containing heterogeneities such as air bubbles, ash particles, fractures, and occasionally inclusions, were observed in different areas of the Chivay source. While the majority of tools were produced on homogeneous glass (referred to here as “Ob1”), a substantial fraction of flakes and cores, and some tools, were observed in the “Ob2” material containing heterogeneities. When the Ob2 heterogeneities are very small, the knapping quality of the material appears to have not been compromised albeit the material is visibly less pure. A large percentage of the flakes in Block 3 were Ob2 obsidian, while all of the projectile points made from Ob2 obsidian were found in Block 2 in the high puna.

Visual characteristics of Chivay obsidian vary across the source area as well. Colors recorded for artifacts during the phase II lithics analysis included black, grey, transparent (clear), and dark banding was visible in grey and transparent obsidian. Banding resulting from concentrations of tiny magnetite crystals is common in light grey and transparent material. High numbers of transparent flakes were encountered in Block 1 and Block 2, which is along the direct route from the Chivay source to the Lake Titicaca Basin where obsidian from the Colca is known as the “transparent type” (Giesso 2003). Obsidian color and translucence was difficult to quantify during lab analysis, and it is possible that the distinction between grey and clear obsidian may be connected to flake thickness where thinner flakes appear to be less grey due to greater quantity of light passing through.

8.3.2. Quarrying for non-local consumption

Evidence from 2003 Upper Colca project excavation and survey work suggest that the large nodules excavated from the quarry pit in Maymeja were not being used by local consumers in Blocks 2 and 3. While cortical flakes larger than 4 cm were relatively common in Maymeja, the cortical flakes (≥ 20% dorsal cortex) in Block 2 never exceeded 4 cm in length, and in Block 3 rarely so, which implies that the starting nodule size is far smaller in these consumption areas. When all obsidian flakes are considered, including those with no cortex in case all early stage decortication was occurring in the Maymeja area, the above pattern is reinforced.

It appears that large nodules, perhaps in excess of 30cm on a side, were quarried and at least some of the nodules were processed in the immediate area of the quarry, yet only 15 km from this location none of the obsidian flakes measure over 4cm in size. It is conceivable that this is a case of extremely accelerated distance decay where, despite an abundance of small obsidian flakes in excavated or surface contexts, large flakes were never being discarded under any circumstances based on the evidence from 2003. However, excavated assemblages from Qillqatani 200km to the south-east disproves this idea of accelerated reduction. The evidence from Qillqatani in the Terminal Archaic and Early Formative (see Section 3.4.2 and Figure 3-7), show that precisely when there is a wealth of obsidian at the Chivay source workshop, some of the largest flakes of obsidian were being discarded at Qillqatani. Sourcing studies and visual characteristics of these artifacts indicate that assemblages from these levels at Qillqatani were entirely Chivay type obsidian (Table 3-5).

How was the obsidian quarried at Maymeja? The quarrying may have been conducted with local cobbles of rhyolite and andesite, in a manner akin to what is described by Burton (1984) at the Tuman metamorphic hornfels quarry in New Guinea, however no evidence of hammerstones or digging sticks were encountered as quarrying tools in the 2003 excavation unit at the quarry.

> The men worked with simple tools. Hammerstones of up to 2 kg were made from waste rock at the quarry and were pounded against the weak planes of the rock face until these could be forced open and a part of the face brought down. The hammers were hand held. Fire was never used at the Tuman quarries, as it was elsewhere; it was an unsuitable technique for the conditions. Wooden stakes or wedges would have been the only other mechanical tools (Burton 1984: 241).

Digging sticks made of wood or bone may have been used at Chivay, but if the wood staves were abandoned on the surface they were likely to have been recovered and possibly burned by local pastoralists as this area short of fuel-wood. The lack of hammerstones at Chivay is puzzling. Rademaker et al. (2004) report finding digging sticks and hammerstones at quarry pits in the vicinity of the Alca source. Fire does not appear to have been used at the Chivay source quarry pit as has been reported at non-obsidian quarries (Holmes 1919; Purdy 1984) as neither carbon nor fire-affected obsidian (J. M. Lloyd et al. 2002) were observed in test units.

8.3.3. Site visibility at Maymeja and warfare in the Colca area

A pattern that was noted in the distribution of knapping locations in the Maymeja area of the Chivay source is for nodules to have been transported small distances (less than one km) to promontories and overlooks for processing. While LIP and LH pottery are sometimes found near these scatters, the association with the Late Prehispanic time block is not secure because is likely that these high visibility overlooks were reused, and that the scatters belong to multicomponent sites.

Figure 8-1. View westward from obsidian production area A03-210 towards main Colca valley, settlements on north bank of Río Colca near Coporaque are visible. Ignimbrites and tuff outcrops in the lower Maymeja area are in the foreground in this photo.

On a local scale, this evidence probably reflects a pattern where herder would establish themselves on overlooks and knap obsidian while monitoring the herd. In several instances, however, extensive scatters were observed on large-scale promontories that over look the entire Quebrada de los Molinos (e.g., the sites A03-570 and A03-578) and beyond. One relatively large scatter, A03-209 “Maymeja 7”, was found 700m west of the Maymeja workshop area, far from other resources. The principal attribute of this location was its commanding view of the main Colca valley including terrain well beyond the town of Yanque, as well as the approach to Maymeja via Quebrada de los Molinos.

Was obsidian projectile point manufacture associated with provisioning for warfare? If conflict were occurring in the Colca valley, one possible explanation for this pattern is that local groups who were familiar with the obsidian source were conducting initial reduction while simultaneously monitoring events in the main valley. Some features associated with conflict would have been visible from the obsidian source including communication such as smoke signals. Stanish (2003: 219-220) and Arkush (2005: 162-163) discuss ethnohistoric (Garcilaso 1960 [1609]: Bk. 6, Ch. 7) and twentieth-century evidence for the use of smoke signals in Late Prehispanic Titicaca Basin contexts. Other evidence of conflict visible from afar might include the movement of large number of people and animals, associated dust columns, and smoke from burning houses or fields. While advanced reduction stage artifacts, such bifacial thinning flakes and broken preforms, were not found in unusually high densities in these high visibility locations, medium stage reduction debris was evident.

Conversely, there also exists evidence that contradicts connections between obsidian and warfare in the Andes. Relatively few pieces of direct evidence link obsidian points with lethal injuries in human remains (but see Engel 1966: 212; Ravines 1967). Analysis of 144 individuals from coastal Chinchorro burials (circa 2500 BCE, Terminal Archaic) in what is now Arica, Chile on the Peruvian border, found that 1/3 of all adults showed trauma from interpersonal violence and that males were three times more likely than females to have skull trauma from percussive force such as clubs and sling stones. Most of the later LIP and LH evidence of conflict also involves percussion weapons like slings and maces, although writing in the sixteenth century, Cobo reports that bow and arrow were important in warfare (1990 [1653]: 216-217).

Despite the indeterminate evidence for obsidian use in warfare in the highlands, the link between reduction and high visibility in these locations is strong. The high visibility and environmental exposure of these positions along the west rim of Maymeja, as compared with *Average* visibility in Block 1, was calculated using the GIS Visibility index layer. The construction of the Visibility index GIS layer is described in Section 5.9.2 (see also Tripcevich 2002).

Feature	Visibility Index
Mean for sites in Block 1	18.5
A03-209 “Maymeja 7”	31
A03-571 “Valdivia 1”	40.6
A03-578 “Valdivia 8”	39

Table 8-1. Visibility index values of high visibility production locations.

Site A03-209 offers particularly sweeping views of the main Colca valley including Pampa Finaya and pukaras on the north side of the Río Colca, while A03-571 and A03-578 provide high visibility of the Quebrada de los Molinos approach to the obsidian source.

8.3.4. Quarry pit and associated workshop activities

The evidence of obsidian production activities on the south side of Maymeja at the Chivay source remains some of the strongest evidence of production in the region. The evidence from this sector of Maymeja demonstrate that obsidian production was intensified on this area of the source. While the Maymeja workshop is very small when compared on a global or even on a regional scale, the 2003 test unit Q02-2u3, that was 1x1m across and 72cm deep, produced approximately 750 kg of culturally derived flaked stone artifacts. It is difficult to estimate the area over which these depths and densities continue, but a 3x4m area at ~70 cm depth can be advanced as a conservative estimate. The 2003 survey showed that while obsidian reduction zones were numerous in the Maymeja area, none compared with this workshop site [A03-126] in terms of density or stratification. As will be discussed below, the evidence from this area of the source provided the most significant contributions in the form of: (1) temporal control, (2) evidence of intensified production, and (3) links to the pastoral economy.

Temporal control

Temporal evidence in this area came principally from three radiocarbon dates acquired from the workshop test unit [Q02-2u3] that placed activities in the workshop area between the Terminal Archaic and the Middle Formative. These dates are important because they are earlier than evidence of discrete production activity has been found elsewhere in the region, and furthermore it serves to explain the dearth of ceramics in the workshop area because the activities begin during the Preceramic period.

Unfortunately, quarrying at the Q02-2 quarry pit itself was not able to be directly dated because no datable organic materials were encountered in the Q02-2u2 test unit. Inference from three possible lines of evidence suggests that the excavation of this quarry pit occurred during the Early Formative Period (2000 – 1300 cal BCE). These lines of evidence include:

(1) Analysis of the workshop Q02-2u3 test unit, 600m downslope of the quarry pit in question, shows evidence of the arrival of larger cores and intensification of production in a distinct event during the Early Formative.

(2) The total lack of ceramics associated with the quarry pit itself, the aceramic ancient road "Camino Hornillo" [A03-268] leading away from the quarry, and the sites in the immediate vicinity of the quarry are consistent with the early dates of activity at the workshop as ceramics should not be expected.

(3) The only diagnostic artifact found along Camino Hornillo [A03-268] was an obsidian projectile point in the 4f style that is diagnostic to the Terminal Archaic.

It is possible that obsidian hydration dating may provide evidence linking obsidian flakes excavated from the quarry pit Q02-2u2 with obsidian from dated layers in the workshop Q02-2u3 unit through relative dating. Brooks (1998: 447-451) ran obsidian hydration on ten samples with Glascock from MURR on obsidian from Juscallacta, but the resulting dates were far older than expected, confirming a general skepticism among archaeologists regarding hydration dating as an absolute dating method. An application of hydration dating at the Maymeja quarry would have to overcome two principal obstacles. First, hydration dating has been shown to be unreliable in areas with large temperature fluctuations and particularly in places where there are diurnal temperature changes (Anovitz et al. 1999) as is certainly the case in the Chivay source area. Second, the samples from the two contexts may not be comparable because the obsidian flakes from the workshop unit Q02-2u3 are often in saturated soils as they are adjacent to a bofedal, while in contrast the obsidian at the quarry pit Q02-2u2 is in very dry sandy ash, and therefore environmental moisture is much greater in one circumstance than in another. Obsidian hydration rates are sensitive to the amount of moisture in the vicinity of the obsidian sample.

Intensified obsidian production

Episodes of intensified production were apparent in test excavation units at both the quarry pit and the workshop. At the quarry pit, the upper most levels (2 and 3) of the test unit showed evidence of concentrated activity, and because this test unit was in a debris pile, the strata are reversed so that levels 2 and 3 are the result of some of the deepest quarrying work at the quarry pit. In level 2a a number of discarded obsidian nodules were encountered measuring approximately 7 cm in length, and the thickness and angle of these strata indicated that quarrying was active and was resulting in a build-up in the discard zone. The low quantities of bifacial retouch or culturally-flaked stone of any kind in these upper levels at Q02-2u2 suggests that during the final episodes of excavation at the quarry it was purely whole nodules that were being extracted and transported away.

At the Q02-2u3 workshop, down the slope, intensified production was most apparent in levels 5 and 4 with evidence of the availability of larger cores taking the form of the discard of large cores and cortical flakes. These levels are interpreted as representing greater regularity in reduction strategies because they were thicker levels and production was more abundant, yet artifact morphology and variability was consistently low. In level 5, evidence was encountered that suggests that some proportion of cores were being transported away while others, even relatively large cores, were discarded at the workshop. In level 4, a similar strategy was in place, where it appears that medium and large cores with certain desirable characteristics were exported after some reduction, and some large flake blanks were also exported, but a fairly large percentage of cores and large flakes were discarded, suggesting that there was an abundance of material. Level 4 was thicker than other natural levels and it showed distinct evidence of abundance in large nodules, and relatively wasteful production, with large cores being sampled and discarded, along with the discard of large flakes. The presence of Kombewa flakes in levels 4 and 5, a flake-as-core technique, suggests that some variability in knapping strategies was practiced.

These characteristics changed dramatically in level 3 when discarded cores and flakes became much smaller and more advanced reduction seemed to have been occurring. The number of retouched flakes drops significantly, but concurrently the number of broken bifaces increased to thirteen, indicating that some advanced reduction was occurring. Activities in level 3 are distinct from all other levels and difficult to characterize because they seem contradictory. On the one hand, reduction strategies were more variable as some advanced reduction was occurring and heavy rotation and conservation of cores was taking place; while on the other hand, there were relatively large cores (cluster #3 type cores) being discarded as well as some cortical flakes in the level 3 assemblage. The peculiar pattern detected in level 3 may be due to a combination of a return to more local and variable production, combined with scavenging from the richness of the discarded material in the previous occupation level. By the ensuing level, level 2, the assemblage appears to have continued the pattern of variable reduction strategies but with lessened access to large nodules. In sum, the evidence from intensification at the quarry and the workshop suggests that workshop reduction began in the Terminal Archaic, quarry excavation and workshop production intensified and became more regular during the Early Formative, and ultimately during the final levels workshop activities returned to more haphazard localized production.

Links to the pastoral economy

The final pattern evident in the intensified obsidian production that was documented in the southern part of Maymeja is the correlation between pastoralism and obsidian production. There is the simple fact that it is physically easier for pastoralists to access and circulate obsidian. Burger and Asaro (1977: 41) note that tool-quality obsidian is found on geologically young volcanoes which, in the Andes, are from the Late Miocene and are typically found above 4000 masl where pastoralists reside. Furthermore, herders have the cargo animals to transport nodules. Based on the 2003 survey of the Chivay source, obsidian is available in a number of locations between 4950 and 5000 masl on the flanks of Cerro Hornillo. Obsidian lag gravels, often material with heterogeneities, blanket the Maymeja area and occur on a wide range of slopes on the eastern flanks of Hornillo. Obsidian is also eroding from a gully on the north side of Maymeja in an exposure labeled Q02-1. While there is reason to believe quality obsidian nodules lie underneath the tephra rich soils in a number of areas around Hornillo, it is surely no coincidence that the most high volume and persistent source of water in the region is adjacent to the Maymeja workshop, and the quarry pit is upslope to the east, as close to the workshop as possible along the 4970 masl contour.

Three principal patterns link obsidian production with pastoralism in this area:

(1) Maymeja production. The Maymeja workshop is adjacent to a water source and a rich grazing area, and a maintained, but relatively clean and unoccupied, corral [A03-127] sits adjacent to the Maymeja workshop. Construction in this area follows the margin of the rich bofedal, small circular structures and eroded terraces were evident here, and obsidian flakes litter the area. The second highest densities of flaked obsidian were found in the lower, northwestern portions of Maymeja close to the modern estancia [A03-570]. It is possible that these two zones were occupied simultaneously, as each residential sector adjoins a separate, large bofedal.

(2) Local Scale. Throughout the highland portion of the 2003 survey, especially in Block 2, concentrations of obsidian flakes were almost always associated with pastoralist site features. A road leads away from the quarry pit that suggests that loaded caravans departed to the south from the Chivay source along a route referred to as Camino Hornillo. This route is in an unsurprising location, as the road climbs out of Maymeja along the least-steep possible route, and following this road caravans could soon join the regional trail network near Lagunas Lecceta, just a few kilometers to the south.

(3) Regional Scale. The consumption of Chivay obsidian is largely associated with pastoralist sites. It expands on a regional scale in the Terminal Archaic with

pastoralism, and on the western foothills of the Andes both obsidian and herding corrals are rare below an altitude of 1200 masl.

The simple association of obsidian with pastoral activities of shearing and butchering appears plausible on one level and such applications of obsidian probably facilitated its widespread distribution (Section 3.6). Despite this functionalist association between obsidian and pastoralism, several particulars of obsidian consumption patterns run contrary to this view. First, high-quality cherts with excellent fracture properties are available throughout the Titicaca Basin and given the quantity and size of Titicaca Basin herds, particularly in the Late Formative and onwards, one would expect much greater quantities of obsidian consumption as herd sizes grew. In fact, obsidian consumption appears to have been relatively reduced as populations and herds grew during Late Prehispanic times. Second, in the Chivay obsidian consumption zone sufficiently large flakes for shearing and butchering (for example, 2 cm or larger) are relatively rare in both surface and excavated contexts. Curation of obsidian in tool form does not appear to have been a priority except for in the production of projectile points.

The links between pastoralism and obsidian circulation appear to have more indirect than the functional connection would suppose. The development of regional caravan exchange, including long-distance circuits and the relative ease of transporting weight, served to move stone into regions where such materials were rare. The second probable connection is the social and symbolic link that obsidian provides between consumers, non-local trade networks, and representation of alliance and affiliation. Obsidian possession was one of a number of ways of differentiating ones self. Evidence of access to non-local raw materials, mediated through camelid caravans and pastoral economy, was one possible way to demonstrate social connections and access to goods and knowledge in other forms. Additional aspects of the social and symbolic links with obsidian exchange will be discussed below.

8.3.5. Pottery and lithic production

Few correlations were noted between pottery distributions in the 2003 Upper Colca survey and obsidian production and circulation. Pottery is scarce in the Maymeja area of the Chivay source. Most of the diagnostic Prehispanic ceramics in the Maymeja area belong to the LIP and Late Horizon, and this occupation probably reflects the presence of resources like pasture and water, and the construction of mortuary structures in the Maymeja area. Pottery resembling the "Chiquero" style described by Wernke (2003) as Formative was not encountered at all in the obsidian source area, or even in the Blocks 4 and 5 vicinity of the source. Pottery resembling the Chiquero style was common in Block 2 on the puna, but the only site in Block 3 with this pottery was Taukamayo [A02-26], a site that is interpreted here as a stop for non-local caravans passing through the upper Colca valley. Another factor linking Taukamayo with Block 2 was that Taukamayo contained the highest density of obsidian debris in Block 3, where obsidian was abundant.

While there are spatial associations between Chiquero and Formative Period sites in the main Colca valley, as documented by Wernke (2003), testing at Taukamayo revealed that this style of pottery persisted into later levels. These sherds were found in A02-26u1 test unit in levels dating to AD650–780, over 250 years into the Tiwanaku period used by Stanish in the Titicaca Basin, and corresponding with Williams' (2001) dates for the first Wari occupation of Cerro Baúl. In the main Colca valley, Wernke notes that Chiquero pottery is replaced by the red-slipped Colca "Middle Horizon" style that includes Wari influences in characteristics such decoration and the constricted, cumbrous bowl form (Malpass and De la Vera Cruz 1986; Wernke 2003: 468-469). One possible explanation for the continued use of Chiquero-like pottery in the seventh century AD in the upper Colca near Callalli, while the diagnostic Middle Horizon ware began to be used in the main Colca valley, is that Wari influences arrived in the principal agricultural sector of Colca valley from adjacent Wari-influenced agricultural regions as part of a suite of agriculture related technologies. Developments in the Colca such as expanded terracing, irrigation, and other agricultural methods supposedly appear during the Middle Horizon in the Colca. In terms of the geographic origins of the Colca Middle Horizon style, Wernke (2003: 470) notes that these ceramics have stylistic similarities both with the low-lying areas like Chuquibamba and Majes, as well as with Wari-influenced ceramics in highland Cusco, but significantly the Middle Horizon and LIP styles in the Colca show no relation to Tiwanaku-related ceramics traditions.

8.3.6. Projectile Points

The major insights provided by projectile points from this research are as follows. First, projectile points were a principal diagnostic artifact type and points were analyzed according to Klink and Aldenderfer's (2005) point typology in order to assign temporal control to surface materials in the survey area. According to the point typology, styles from the Terminal Archaic and later that were encountered (principally, series 5b and 5d), are not particularly time sensitive because the styles continued in use throughout the ceramic period (see Figure 3-10). As obsidian production intensified during the Terminal Archaic there is a strong correlation between obsidian and 5b and 5d point styles in the region, however the point typology could not be used to further study changes in obsidian production because the typology is not time-sensitive during the Terminal Archaic to Late Horizon time block.

Diagnostic projectile points recovered in the course of this research show that the Chivay source area was occupied since the early Holocene. Obsidian is used for the majority of projectile point manufacture in the Upper Colca project area except during the Late Archaic when heavy, stemmed points are used throughout the south-central Andes, and andesites dominate projectile point materials even close to the Chivay source.

Projectile point styles diagnostic to the Terminal Archaic and later are overwhelmingly made of obsidian. This pattern holds in the regional consumption zone as well, supporting the assertion that it is during the Terminal Archaic that obsidian becomes more widely known, and that the Chivay source area acquires new significance in the geography of prehispanic Andean peoples. Evidence from consumption contexts shows that projectile points were the principal formal artifact made from obsidian, and as most obsidian was procured during the time period associated with Series 5 point styles, the formal tools produced from the material were predominantly small, triangular points. It is interesting, therefore, that this research encountered evidence that ancient peoples appear to have targeted larger nodules and the maximizing of obsidian quality and nodule size because the objective pieces were quite small.

The small size of series 5d projectile points provides examples that sometimes defy the expectations of distance-decay. In the excavation work in Block 2, in the A02-39u4 test unit in a level dated to the Late Formative extremely small 5d point was encountered. This complete point [L03-60.3] was delicately pressure flaked; it measured just 1.3 cm in length, and it weighed less than 0.1g. This remarkably small point was noticed in the fine 1/16" screen. However, 29 complete obsidian projectile points were identified in the Block 2 area that weighed less than 1g, all series 5 points, and it is clear that small, light projectiles were the intended product in this type of obsidian production. Yet, these sites were just one day's travel from the obsidian source and obsidian is relatively abundant in Block 2 and these points beg the question: "why economize with material by knapping such miniscule projectile points?" As was observed by Close (1999) with North African bladelets, artifact forms can trump the expectations of distance decay and very small artifacts may be produced in areas that are rich in raw material. Production at the Chivay obsidian source area in certain periods in prehistory appears to have been one such context.

If the production of types 5b and 5d projectile points, with a mean length of 3–4 cm, was the objective then why excavate for 15–20 cm long nodules at Maymeja? First, the utility of freshly struck obsidian flakes for a variety of cutting and shearing tasks is widely recognized as a principal appeal of this material. Therefore a large nodule represents the potential for producing formal tools, but a large obsidian nodule also represents a transportable and exchangeable source of sharp flakes. Second, in the distance-decay context of single source raw materials like obsidian, large nodules contain greater potential both in terms of prestige for the owner, because evidently the owner is closer to the source of these desired goods, but also in terms of exchangeability and possible tool forms. Thus, even if tiny projectile points were the ultimate tool form for obsidian, the acquisition of large nodules that were then conveyed directly to distant consumers with the aid of pack animals probably represented the largest return in terms of both symbolic and material wealth for the procurer.

8.3.7. Regional caravans and local interaction

Ethnohistoric and ethnographic accounts attest to the prominence of the Colca in regional trade networks both in terms of the size and capability of pastoralists in the upper Colca area to launch long-distance caravans, and for the draw created by the Colca valley agricultural sector on regional caravans. While archaeological evidence of passing camelid caravans is often subtle, in the course of survey work in 2003 a number of features were encountered that are potentially linked to caravan mobility.

Pastoral bases and caravan stops

The most extensive pastoral features in the Upper Colca survey area lie in the dense Block 2 occupation along the eastern toe of the Huarancante lava flow. The area has been occupied fairly consistently since the Early Archaic and a distinctive land use pattern was documented in 2003 related to pastoral occupations, including corrals and associated residential structures, along the margins of the lava flow. As is characteristic of pastoral occupations, the structure of these sites is blurred by multiple non-contemporaneous occupations, refuse disposal is shallow, and stone corral walls and rock shelters serve as the few permanent feature types that persist through time from previous pastoral occupations (Nielsen 2000: 480-483). The Block 2 survey revealed that many of the larger estancias contain multicomponent sites, indeed most of these choice locations are occupied to this day in some capacity. However, the small and mid-sized pastoral bases in the area show more variability, as ceramic distributions suggest that some sectors were settled while others were abandoned at times in prehistory. The number of active corrals and the herd size potential in a given time period is difficult to estimate due to this pattern of shifting locations for small and mid-sized pastoral bases.

Based on systematic survey work in 2003 it appears that a number of the animal control features in Block 2 exceed the local capacity for seasonal grazing and were perhaps linked to short-term stays by passing caravans. These large animal control structures primarily take the form of vestiges of corrals that appear as bases of stone enclosures on top of low mounds rising from surrounding pampa. While it is difficult to estimate animal numbers due to shifting pastoral occupation, seasonal changes in land use, and the brevity of the 2003 observational period, the conditions in Block 2 appear to be the “Caravan rest areas” that were first discussed in Section 3.2.5.

Caravan rest areas

Larger sites that are the result of repeated occupation as rest areas are well documented in ethnoarchaeological accounts of camelid caravans (Nielsen 2000:

461-462, 500-504; Lecoq 1988: 185-186; T. L. West 1981a: 70). According to these accounts, in the course of a multi-week caravan journey the team will rest periodically, usually for two or three nights, in order to allow for recovery by the animals and for conducting routine maintenance tasks by the caravan drivers such as repairing cargo panniers and stitching up the shoes made for the llamas' feet. Typically, these rest areas are situated adjacent to a rich grazing area with plentiful water and little competition for pasture access. The rest stops commonly are located immediately before or after a strenuous section of trail.

The Block 2 area is something of a natural bottleneck at the transition zone between the Colca valley and the puna, and it also contains the largest bofedal in the study area. The Block 2 puna is situated just outside of the rugged volcanic terrain that rings the Colca valley. It is the first extensive area of prime grazing encountered after caravans have crested the ascent out of the Colca, and the ascending animals would have presumably been loaded with agricultural cargo. It is therefore unsurprising that large corral facilities were encountered in this location.

The lithic and ceramic artifacts associated with these abandoned corral features are also telling. While local LIP and LH sherds are common in Block 2, the unslipped Chiquero-style pottery of Formative production, are also widespread in Block 2. Obsidian flakes are extremely common in the vicinity of these mounds. As demonstrated in the testing work at A03-39, small hearths and obsidian knapping at medium and advanced reduction stages occurred on the margins of these corral structures.

Obsidian knapping at rest areas

One plausible scenario for the quantity of obsidian in the Block 2 area would have caravan drivers resting for several days after the arduous climb from the Colca valley and knapping obsidian in the Block 2 area while their herds recover from the climb. Perhaps caravans would periodically venture into the Maymeja area of the Chivay source and recover larger nodules. Local herders also use the Block 2 puna and perhaps they were involved in obsidian procurement. Local herders, arguably more familiar with the obsidian source itself, could have brought obsidian to this area and passing caravans resting in the area may have traded for nodules and this would have contributed more obsidian to the Block 2 area.

The evidence from Block 2, however, is overwhelmingly of advanced stage obsidian reduction, and therefore if whole nodules were being exported from the Chivay source in whole form then they were not being knapped at Block 2. This evidence suggests that nodules were being reduced at the Maymeja workshop over in Block 1, or being exported from the region in whole form. Primary reduction and the use of large obsidian artifacts was not occurring in Block 2. As mentioned above, 10% of the flakes in Block 2 were over 4cm in length and neither cortical, nor non-cortical, flakes approach this size potential in Block 2. The absence of large flakes in this area, a zone rich in small obsidian flakes, is curious and it suggests that non-local caravans were responsible for the quarrying activity in Block 1. The larger (15–20 cm long), Ob1 nodules would have had to have been quarried, and some fraction of them knapped, in the Maymeja zone and then transported from the region without further processing in areas such as Block 2.

Was there multiethnic access at the Chivay source?

A principal question concerning the Chivay obsidian source area, when it was finally located in the 1990s, was whether cultural materials showing Titicaca Basin stylistic affiliation would be found at the source area. The lack of known Pukara or Tiwanaku materials in the vicinity of the source, as confirmed by the Upper Colca research project, suggests that access to the source was not physically restricted, and that perhaps neighboring groups were granted access as needed. Other plausible explanations are that, even in the Middle Horizon, material moved through down-the-line trade and no diagnostic, non-perishable materials were reciprocated back to the source area. Alternately, a freelance trading entity was responsible for transporting the material towards Titicaca, but this group traded exclusively with Titicaca Basin polities and curiously none of the material found its way into the Wari sphere despite the proximity of Wari-influenced sites in the lower valley. Given Tiwanaku's demonstrated strategy of placing colonies, sometimes integrated multiethnic, directly adjacent to resources of interest (P. S. Goldstein 1989), it seemed possible that a site with a Tiwanaku component would be found adjacent to the Chivay source.

> The obsidian data do not appear to conform to the expected pattern of postulated multiethnic "artisan islands" within the vertical archipelago model proposed by John Murra (1972, pp. 442–443) in which rare or restricted resources such as metal ores, or here different obsidian types, are shared by different groups; in this case, each group (Huari and Tiahuanaco) would have had colonies to acquire the resource for the distant homeland (Burger et al. 2000: 342).

A central goal of the 2003 research at the Chivay source was to examine the source area for evidence of such "artisan island" sites, but no such sites were encountered.

Circuits, caravans and exotic goods

The circuit mobility model of Nuñez and Dillehay (1995 [1979]; Dillehay and Nuñez 1988) depicts the regional integration between "axis settlements" as articulated by circuits of caravan traffic (Section 3.2.6). Some of these circuits grew to become the dominant exchange routes in a region. Despite the historical and adaptational focus of the circuit mobility model, the model's emphasis on the integrating role of camelid caravan networks linking dispersed communities in the altiplano highlights the importance of regional context in the emergence of political power in the transegalitarian milieu of the Titicaca Basin Formative.

The dynamic and decentralized Nunez and Dillehay model is compelling for understanding regional obsidian distributions in two ways. First, this model emphasizes the regular interaction that linked dispersed communities, often second-tier communities, across broad spaces. Obsidian appears to have had some social and symbolic significance, but it was only moderately rare and therefore it appears to have circulated relatively widely and continually between regional centers and also within second-tier and smaller communities. Thus the significance of obsidian is not principally as a "wealth item" like precious metals that served to differentiate elites in a type of network strategy (sensu Blanton et al. 1996). Rather, obsidian circulation, and the parties responsible for procuring and circulating it, depicts the subsistence level economic and cultural links upon which early aggrandizers likely constructed their political strategy.

During earlier time periods, such as during the Terminal Archaic when obsidian was first being intensified, it could be argued that obsidian was a rare "prestige technology" (Hayden 1998) that would confer advantages on the owner and would otherwise serve to differentiate people. Helms (1992: 159) describes how those conveying exotic materials were "long-distance travelers or contact agents as politico-religious specialists" in contact with the mysterious and distant (see discussion in Section 2.2.5). Such associations would arguably have been more likely during the earlier, emergent stages of regular caravan networks (e.g., the Terminal Archaic) under the assumption that sustained contact and diminished scarcity of a non-local material like obsidian would have probably reduced the social or symbolic power of such goods. Nevertheless, obsidian appears to have retained symbolically exotic associations that persisted in some form given the Late Prehispanic contexts: concentrations of obsidian in ritual mounds at Tiwanaku, and unmodified Chivay nodules at the gates of Machu Picchu (Section 3.5.3). However, given its abundance in the Early and Middle Formative sites, and the occurrence of obsidian in both commoner and elite contexts in the Late Formative, it would be difficult to argue that obsidian was status-conferring due simply to its non-local origin in that time period.

8.3.8. Models of regional obsidian circulation

The models developed here are evaluated against the evidence from the Chivay source acquired in the course of the Upper Colca project. This section, aims to address the models that were introduced in Section 3.7 with the new data acquired in 2003.

Model A: Direct acquisition

The Direct acquisition model describes personal visits to source areas by members of consumption households and it specifically excludes exchange of these goods between households. As per this model one should expect high variability in procurement methods, reduction strategies, and architectural and perhaps ceramics styles. Obsidian is found in both surface contexts and through quarrying, and presumably quarrying began to be practiced as the obsidian available from surface collection became more depleted. Thus, there is evidence in variability in procurement methods and in reduction strategies, however it is difficult to ascertain whether this variability results from procurement differences from non-local visitation, or from diachronic changes in available material.

It was previously suggested (Section 3.7.1) that during the Formative Period non-local visitors from the Lake Titicaca Basin, a known consumption zone for Chivay obsidian, may have left evidence of their presence during personal procurement. In the southern Titicaca Basin a distinct fiber-tempered early pottery tradition was used, but in both the north Titicaca Basin and the Colca area the contemporary pottery was grid tempered. One form of evidence of non-local personal procurement from the southern Titicaca Basin might take the form of sherds of fiber-tempered pottery from utilitarian vessels, although it may be difficult to differentiate from the evidence of fiber-tempered pottery the acquisition of obsidian through personal procurement from trade-item reciprocation. However, very little pottery, local or non-local, was identified in the Maymeja zone of the obsidian source and it is therefore difficult to use pottery to evaluate any of the procurement models. In the adjacent Block 2 survey area, obsidian scatters were often spatially coterminous with “Chiquero” pottery described by Wernke (2003) as a Formative style in the main Colca valley. As the Formative ceramics chronology in the Colca is still being defined, and there may have been differences in ceramic styles by altitudinal and ecological zone as well, it is difficult to definitively state whether all the pottery that appeared to belong to the Formative in the Chivay source area was indeed of local production.

Architecture at the Chivay source was also difficult to connect with the question of local versus non-local acquisition. Several circular structures approximately 2.5m in diameter were encountered in the area of the Maymeja workshop, but as the construction was eroded and appeared to have been expediently built, the association between these buildings and specific architectural traditions in the Colca valley or elsewhere is indeterminate. Wernke (2003) found that circular buildings were prevalent in the higher altitude portions of his survey. Further excavation in the workshop area may expose house floors or ceramics that indicate local or non-local cultural affiliation.

Direct acquisition certainly changed through prehistory from the earliest mobile foragers to the locals who procured material for household needs throughout the prehispanic past. Colca area residents probably procured obsidian for their needs from the Chivay source directly during visits to the high country that were embedded in hunting trips for *viscacha*, deer, and *vicuña*. Indeed, it was a local hunter from Chivay, Pedro Huaracha, that guided Sarah Brooks to the obsidian source in 1994 (Brooks 1998: 433-438). When non-local residents, such as residents of the Titicaca Basin, visited the Chivay source as they followed the Escalera-Lecceta route, it was perhaps for personal procurement but more likely it was in the context of caravan-mode circulation, either independent or administered, as described below.

Model B: Multiple reciprocal exchanges (down the line)

According to this exchange model, local upper Colca communities procured a sufficient excess of obsidian from the Chivay source to supply material into the exchange system for regional circulation. Two principal material expectations were described for this mode: first, the Chivay source area would contain local artifact styles and relatively low variability in procurement; second, that assemblages from the local Upper Colca communities would have some fraction of large obsidian flakes and perhaps cores consistent with the large nodules found in the Maymeja area.

As mentioned, ceramics and architectural evidence are in short supply at the Chivay source itself. There is spatial consistency in the procurement of obsidian, as the quarry pit and the workshop appear to have been repeatedly occupied over the years, but evidence from the both stratified test units show that quarrying and production was episodic. The earliest and the latest (upper-most) levels of the workshop test unit showed intermediate reduction events and some advanced reduction that may have been the result of irregular local visits to the source area.

One could argue that the intensified and regular production observed in the middle levels of the quarry pit test unit and the workshop test unit were the result of locals mining their adjacent obsidian source to meet the demands of the non-local reciprocal exchange network. However, two pieces of evidence contradict this proposal. First, as was described in Section 7.6, if locals were quarrying and producing quantities of obsidian at Maymeja one would expect some fraction of the large nodules to be represented in assemblages from local communities either in Block 2 or Block 3. In fact, very few flakes, cortical or non-cortical, over 4 cm in length were found in Blocks 2 and 3, while over 10% of flakes from the Block 1 Maymeja workshop were in that category. Second, the spatial evidence of intensification that was observed in production in the quarry and workshop was not reflected in evidence of intensified or concentrated obsidian deposits in the Block 2 and 3 areas. In Block 2, concentrations of obsidian flakes were found associated with corrals, but these were consistently small flakes. The question is if locals were responsible for intensified production at the Maymeja quarry, then which locals were conducting this work and why did they not use any of the large nodules in their local economy? The evidence suggests that locals were not involved in intensified obsidian quarrying and production in the Maymeja, but this does not preclude local residents guiding foreign caravans to the source area, or low intensity local procurement activity for local consumption and down-the-line exchange. Indeed, the concentrated obsidian deposits at Taukamayo in Block 3, although consisting of Ob2 material and relatively small flakes, may have been the result of local communities articulating with non-local caravans near the site of modern-day Callalli.

On the regional scale, down-the-line exchange is probably implicated in larger distributions of obsidian, particularly during the Archaic Period prior to the advent of caravan based mobility. A combination of direct, personal procurement and down-the-line exchange may have been the source of obsidian at sites like Asana and Qillqatani during the preceramic. There is evidence to suggest that during the Late

Archaic these down-the-line networks may have become more segmentary and isolated. It is during the Late Archaic that Asana no longer contained Chivay obsidian, and projectile point styles during the Late Archaic became increasingly localized. Subsequently, in a dramatic change, during the Terminal Archaic and Early Formative regional exchange became far-reaching, the series 5 projectile point style appears with relatively little variation throughout the central and south-central Andes, and the knowledge of food production and other technologies became widespread. The evidence presented here suggests that exchange patterns, including obsidian procurement through down-the-line and direct acquisition, were relatively reduced during the Late Archaic. During the ensuing Terminal Archaic, with the initiation of regional caravans, major changes include an expansion of regular exchange and temporal consistency in obsidian supply at places like Qillqatani maintained through long-distance relationships as is described by Model C.

Model C: Independent caravans

The Independent Caravans model entails household level organization of long-distance caravans for the acquisition of specific goods from another region, or for moving goods between a number of communities in a loop and bartering for goods at various locations along the route. The material expectations of this type of obsidian circulation in the Chivay source area include episodic but intense procurement while a caravan was stopped at the obsidian source, and prompt transport of obsidian southward from the Maymeja source area to a principal thoroughfare that connects the Colca with regional travel routes.

The 2003 Upper Colca project results support an interpretation of obsidian production at the Maymeja quarry and the workshop through procurement and circulation by independent llama caravanners, with this mode occurring from the Terminal Archaic through at least the Early Formative. The 2003 results support this interpretation at a number of scales.

(1) Dates. The ^{14}C samples collected from the workshop test unit show that intensified production occurred between 2880 and 1260 cal BCE. Based on the evidence of intensity of production, levels 2 through 4 at the quarry pit test unit [Q02-2u2] are tentatively linked with levels 4 and 5 at the workshop [Q02-2u3].

(2) Camelid pastoralist emphasis. Why was obsidian from the quarry pit not reduced at the quarry pit? Instead it appears to have been transported down slope 600m to a site adjacent to water and to a lush grazing area. There are a number of links between pastoralism and obsidian production at the source area that have been explored in detail above.

(3) Transport. It does not appear that locals participating in down-the-line exchange networks were responsible for quarrying and then processing obsidian at the Chivay source workshop because obsidian flakes and cores in the local consumption sites were much smaller than one would expect if local pastoralists were quarrying for large nodules.

(4) Regional consumption. The temporality of consumption in distant sites like Qillqatani suggests that regular, caravan-based exchange was the mode of transport between the source and the consumption zone. It seems more like that caravan traffic, rather than Direct Procurement and Down-the-line exchange, would have resulted in Chivay obsidian consistently representing 10% to 20% of the lithics assemblage at Qillqatani for a period of several thousand years.

That is not to imply that procurement and production for other modes of transport, including personal acquisition and down-the-line exchange, did not occur in Maymeja; only that the intensified production associated with quarrying work and concentrated reduction activities appear to have been linked to caravan-based export. While the pastoral link and the intensified production seem irrefutable, the challenge remains to differentiate independent from administered caravans.

Model D: Elite-sponsored caravans

Caravans organized and administered by elites are described in colonial documents from the Lake Titicaca Basin. According to these passages, Titicaca Basin herders could pay part of their annual labor obligations by contributing their labor and their caravan llamas to elite-organized long-distance caravan ventures that procured non-local goods that were, in turn, redistributed to the Titicaca Basin community in the form of feasts. Material expectations at the Chivay source for obsidian procurement and circulation under elite-sponsored caravans were discussed in Section 3.7.4. It could be relatively difficult to differentiate independent from elite-sponsored caravans from archaeological evidence because the actual caravanners in either case are commoners from altiplano herding communities.

Evidence of elite-organized obsidian procurement was not found, nor were walls or other defensive structures encountered that would have been protecting the obsidian source for some kind of access monopoly. Social mechanisms for monitoring and control of the source area are a possibility in prehistory but evidence of the use of distinctive artifact styles as a signal of “ownership” of the source area were not encountered in 2003. This is consistent with other obsidian sources in the Andes, such as Alca and Quispisisa (Burger et al. 1998b; Burger and Glascock 2002; Jennings and Glascock 2002), where quarrying remains and workshops rarely contain discrete evidence of hierarchy at the source, or even cultural affiliation from specific groups known to have used those sources, such as the Wari. In North America, in an examination of Mississippian chiefdom hoe production and consumption, Cobb (2000: 195) found no evidence of hierarchy at the Mill Creek quarries over the course of four centuries of quarrying. Cobb compares this with ethnographically documented quarrying in New Guinea for ceremonial axe blades, and similarly at this quarry no evidence was found of hierarchy in production in a tribal society, despite the fact that the blades were often finished at the quarry site (Burton 1984).

The geography of the Chivay source area presents natural defensive features, such as restricted entrances to the Maymeja area that are only available along a half-dozen routes that are not cliff faces. None of the access routes showed evidence of defensive fortification or restriction. In fact, these routes were generally improved with a roadway on one exit [A03-268] and a short portion of stairway on another egress. The consumption patterns of obsidian from the Late Formative until the Inka period do not suggest that evidence of elite-sponsored quarrying would be encountered (Section 3.5.3) Assemblages at Tiwanaku suggest to Giesso (2003) that the state controlled the acquisition of obsidian from Chivay (Cotallalli) and basalt from Querimita, however there are a number of articulation points between the

Chivay source and the Tiwanaku core 300 km to the south-east where the state could exercise control of the obsidian entering the core region. Recent perspectives on the probable ethnic diversity subsumed by the corporate strategies of the Tiwanaku state (P. S. Goldstein 2005; Janusek 2004a; Stanish 2002) highlight the variability that might be expected in the nature of relationships between Tiwanaku elites and communities in its periphery. If the internal ethnic constituency of the Tiwanaku state, and the polities that preceded Tiwanaku in the Titicaca Basin, were more diverse than previously thought, then it is possible that many of the corporate themes were a reflection of the need to centralize the political economy because the population was relatively heterogeneous.

In the Chivay source area, the only distinctive evidence of non-local, state-affiliated materials were sherds and architecture in styles belonging to the imperial Inka. These sherds and structures are almost certainly mortuary facilities, although it is also possible that they are shrines associated with water emerging from the spring in Maymeja. Given the reduced importance of obsidian in the Inka sphere, it seems unlikely that the Inka presence in the Maymeja area was related to administered obsidian production.

Discussion

The above obsidian procurement and circulation models are not mutually exclusive, and the implications can be considered synthetically in light of previously discussed exchange models in the Andes. The evidence just presented suggests that while obsidian procurement and initial production at the Chivay source was predominantly direct procurement, and transport via direct and down-the-line models of circulation, there was an important period of intensified procurement of obsidian that occurred during the Terminal Archaic through the Early and Middle Formative Periods. Obsidian is available on the surface surrounding Cerro Hornillo and the many small scatters on the ridges and in shelters in this area suggest that informal production occurred at various times in prehistory. These scattered reduction sites were complemented by evidence of intensive production that occurred in the southern portion of Maymeja where it appears that the principal goal was acquiring larger nodules of obsidian.

Models that attribute the origins of long-distance trade caravans to administered trade based on elite strategies (e.g., Stanish 2003: 69) have similarities to the models that limit the inducement to long-distance exchange to elite competition (Berdan 1989: 99; Brumfiel and Earle 1987b). Following this perspective, in a context of down-the-line exchange it was elite demands and finance for procuring non-local goods that prompted the development of regular, long-distance caravan exchange, and then trade expanded to accommodate the needs of the wider population. As discussed by Smith (1999: 113), these perspectives place multifaceted processes like exchange into dichotomous terms. Differentiating elite from commoner demands, and defining prestige and utilitarian goods across the wide prehistoric variability in time and space is especially difficult. In the Andes, if "virtually all trade in the Andes conforms to what Polyani referred to as 'administered trade'" (Stanish 2003: 69) then how does one explain the consistently high percentages of non-local lithics due to long distance trade, as documented in primarily Formative levels at Qillqatani? It is argued here that these percentages are in excess, in both quantity and regularity, of the sporadic incidence of obsidian one might expect from down-the-line exchange over 200 km of largely homogeneous puna. If this regular consumption of non-local goods is indeed the product of independent caravans that began in the Terminal Archaic then it demonstrates an upswing in long-distance interaction that was founded on camelid domestication but it predates evidence of social ranking.

8.4. Theoretical implications from obsidian procurement evidence

According to John Clark (2003: 34), the key concept in trade models is that "Trade has social evolutionary consequences. Without this foundational postulate nothing else matters". While obsidian studies in the Andes can also provide important insights on historical subjects such as the early peopling of the Andean highlands, and the changes in long distance interaction due to camelid caravans, the study of ancient exchange in the south-central Andes has direct bearing on exploring the basis and development of social and political power. Beginning from the assumption that long-distance exchange of products like obsidian in Late Archaic foraging contexts was based primarily on down-the-line exchange mechanisms, it is possible to develop inferences about the contexts of early caravan transport. Drawing on earlier discussions in chapters 2 and 3, the theoretical implications of early long-distance caravan exchange will be considered in terms of three principal variables: (1) herd size and status, (2) the scale of interaction, and (3) competitive behavior and exchange.

8.4.1. Herder status and herd size

The domestication of camelids is not sufficient cause for the development of long-distance caravan traditions. Ethnographic evidence suggests that caravans are organized by herders with sufficiently large herds and the economic stability to depart on a caravan journey for weeks or months. Herders have high labor productivity and scheduling that permits important members of the household to depart on long voyages (Section 3.2.3). Households that conduct long-distance caravans often have a herd that is large enough to contain a viable number of caravan animals, or they will lease animals from others in order to have sufficient camelids to make a journey worthwhile (Browman 1990: 400; Nielsen 2000: 387-388).

Pastoral wealth is primarily manifested in larger herd sizes, where wealthy herders in modern contexts will own hundreds or thousands of animals in the south-central Andes. While an ethos against accumulation may have existed in some contexts, for example among egalitarian foragers, pastoralists worldwide display a similar logic of accumulation with respect to herd size. “In pastoral societies, having more animals is better than having fewer. Because the pastoral economy is based on a continuous demand for successful animal reproduction to replace losses due to predation, disease and use, the accumulation per se of more animals is a socially sanctioned and desirable end in itself.” (Aldenderfer 2001: 25). In a human behavior ecology framework, Aldenderfer (2006) suggests that the origins of pastoralism may have its roots in the costly-signaling value of the possession of large herds. Thus, herd size is linked to status and it represents one of the factors contributing to the ability of caravan drivers to organize long distance caravans, and, in turn, to acquire non-local goods as part of caravan activities.

8.4.2. The changing scale of regular interaction

While long-distance interaction through reciprocity networks and high mobility foraging had long existed, it is likely that, along with the development of long-distance caravan traditions commenced a period of unprecedented regularity in interaction over distance. Building on the argument that due to the importance of exotic goods, those who possess such goods, and the ability to transcend regional boundaries as discussed in Section 2.2.2 (Appadurai 1986: 33; Helms 1992: 159), caravan drivers may have been among the early agents able to traverse regional boundaries in a context of increased circumscription. From the perspective of "social distance" using Sahlins' (1972) terms, regular caravan traffic represents a change in the scale of integration extending the "tribal sector" (balanced reciprocity), as well as augmenting the interaction with the "intertribal sector" (balanced or negative reciprocity). Changes are also expected in distance-dependent formulas such as Hayden's (1998) "prestige technology" where goods that were formerly laborious to transport in quantity became increasingly available resulting, over the long term, in a decline in the exotic associations for goods like obsidian.

There is little detailed evidence with which to evaluate the social position of early caravan drivers, but one should consider the socially integrating role of caravans over the larger region (Dillehay and Nuñez 1988), as well as the status and influence that may be accorded such caravan drivers. Itinerant peddlers, roaming herbalists, and other travelers are also common in the south-central Andes, and these persons could have transported goods widely. Furthermore human bearers are well documented in the Andes and in contexts with tight and perhaps exploitative control of labor, human porters can be organized into extremely efficient transport teams. Regular caravan transport is, however, a distinctive development because caravans represent a relatively low-cost mode of transport that is associated with staples and bulk items (Nielsen 2000: 514) and to the extent that caravan transport became linked to key economic cycles like agricultural production, caravans became recurrent and perhaps anticipated along these regular routes.

Changes in the scale of interaction were linked to larger economic transformations that included small-scale food production and the creation of surpluses, widespread technological change, early social inequalities, and greater sedentism; all processes that potentially contributed to the importance of caravan linkages. The integrating role of early caravans, and the position and status accorded to caravan drivers in this process, deserves further consideration.

8.4.3. Aggrandizing behavior

Evidence of early social differentiation in the south-central Andean highlands take the form of public architecture and ritual features that occur in the latter part of the Late Archaic at Asana during the Qhuna Phase, 3800–3300 BCE (Aldenderfer 1998b: 243-261) and exotic grave goods by the Terminal Archaic (circa 2900 BCE) at Jiskairumoko (Craig 2005: 570). While long-distance exchange of singular items, such as a finely knapped projectile tip of non-local material, are well-documented during the Archaic Forager period, these are arguably examples of ‘tokens’ used to reinforce social relationships across space through buffering and mutualism (Aldenderfer 1998b: 301-302; Brown 1985; Spielmann 1986). At the end of the Late Archaic and into the Terminal Archaic there is evidence of a greater emphasis on creating surpluses and perhaps the first evidence of simultaneous or sequential hierarchy (G. A. Johnson 1982). The process of increasing complexity was not necessarily linear as, for example, at Asana in the Awati phase (the Terminal Archaic) where there appears to have been simpler social organization at the site focused on herding (Aldenderfer 1998b: 275; Kuznar 1990).

What prompted this emergence of competitive behavior discussed above that perhaps lies at the root of the obsidian intensification witnessed at the Chivay source in the Terminal Archaic? These changes could have roots in gradual processes through the Late Archaic that include domestication, low-level food production, and regional packing resulting from population growth. The frictions that develop from circumscription and reduced mobility are argued to have prompted the emergence of more complex social forms. Alternately, highland complexity could have been prompted by the development of complex behaviors on the coast. On the Pacific littoral, albeit 700 to 1000 km north of what is now the Department of Lima, monumental mound building is documented for the period described here as the Terminal Archaic that is argued to be based on surpluses generated from the bounty of the sea, combined with the production of cotton for nets (Moseley 1975). Research in the Norte Chico area shows that during the third millennia BCE monumental construction at coastal sites like Aspero shifted to inland complexes (Haas et al.

2004; Shady Solis et al. 2001), perhaps reflecting the growing importance of inland cotton production for the construction of anchovy nets and also for textile trade. Coastal complexity based on cotton surplus may have stimulated highland trade in the production of a surplus in woolen textiles (Aldenderfer 1999a: 218-219), as there is evidence for other highland and Amazon basin goods, such as tropical feathers, at preceramic sites on the central coast of Peru (Quilter 1991). While preservation problems in the highlands destroy evidence of preceramic textiles, the consumption of highland and Amazonian products is documented in coastal sites as far south as the Chinchorro III (2500 – 600 BCE) period in northern Chile (M. Rivera 1991: 15). Cultigens are also shared over a broad region, suggesting that interregional exchange was extensive during the Early and Middle Formative.

Was the intensified production that was observed at the Chivay source, and the regular consumption of obsidian at Qillqatani, a reflection of aggrandizing behaviors? The timing of the increased production and circulation of obsidian would suggest that it was, above all, a *surplus production* enterprise that was a reflection of the changing social and economic context of the Terminal Archaic and Early Formative. The evidence from this research shows that the quarrying at the Q02-2 pit was best correlated with consistent acquisition of large obsidian nodules that were probably in excess of 15cm long, yet the finished tools produced during the Terminal Archaic and onward were very small projectile points, often less than 3 cm in length. Thus, the acquisition of large nodules was not out of necessity based on intended tool forms, but probably for some other signaling value which highlights the relevance of the abundance concept. The perception of surplus would have been enhanced through supply lines as large nodules were consumed. The willingness to excavate for obsidian when there was an abundance of smaller nodules available on the surface, underscores the importance of large nodules to ancient obsidian consumers.

The possession of non-local goods are well documented attributes of aggrandizing behaviors in transegalitarian contexts (Clark and Blake 1994; Hayden 1998), yet it is not necessarily an overt expression of status that one should expect in early stages of social differentiation. Instead, the possession and use of irregularly distributed material, which includes obsidian but also might include salt, herbs, and other semi-rare goods, is a visible testament to the regional integration afforded by emerging caravan networks. Thus, while most individual obsidian artifacts may not have been "wealth items" the regular possession of a surplus of scarce "ordinary goods" of cultural value (M. L. Smith 1999) had the effect of imparting prestige on the caravan drivers who amassed and circulated these goods. As these exchange networks matured, the availability of non-local goods probably changed dramatically and, as noted above, the scale of what was considered "exotic" probably diminished as well. In that sense, obsidian production and circulation was a reflection of a transegalitarian socio-political context where an individual's successful participation in the regional economy reflected well upon him or her, and that success likely included acquisition of non-local products and manipulation of surpluses.

8.5. Future research

Research at prehispanic obsidian sources offer great potential for contributing to the reconstruction of ancient patterns in interaction and production. While all archaeological research is cumulative, quarry research is especially so because every artifact that is sourced contributes to a better understanding of the entire configuration of production and interaction. Therefore one can expect increasing focus upon, and more significant results from research into raw material source areas as archaeological knowledge accumulates. One should also anticipate rapid improvements in the sourcing and knowledge of particular raw materials as technical equipment become more affordable.

8.5.1. Other Andean sources

Other obsidian sources in the Andes are in need detailed research. In the Andean highlands, studies of the Quispisisa obsidian source (Burger and Glascock 2000, 2002) is particularly important as this source has had a long history of use with regional significance extending far beyond the Ayacucho province. Recent work at the high altitude of the Alca source by Rademaker et al. (2004) indicates that extensive obsidian production was occurring on the north slopes of Nevado Firura between 4400 and 4800 masl, above the quarrying work documented by Jennings (2002; Jennings and Glascock 2002). Studies of these production areas will also require detailed examination through excavation because diagnostic materials on the surface of most quarries are slim. Two lithic sources in western Bolivia, the Sora Sora obsidian source and the Querimita basalt source (Giesso 2000, 2003; M. D. Glascock and Giesso 1994; Márquez Ostria et al. 1975; Ponce Sanginés 1970), were examined by Giesso (2000) and as these materials occurred with frequency in the Tiwanaku core region, the source areas offer potential for providing further insights into Titicaca Basin prehistory that complement those provided here from the Chivay obsidian source.

8.5.2. Technological improvements

Innovations in chemical sourcing equipment are making raw material source studies all the more important with passing years. Improvements and reduced costs for portable XRF machines will make raw material sourcing a routine part of lab work. These technologies will have a substantial impact in archaeology because many raw materials that include volcanic rocks, ceramics, ochre, and metals can be sourced, and the maintenance of spatial databases of proveniencing evidence will become a vital task in its own right.

Improvements in remote sensing technologies will probably contribute to identifying raw material sources in coming years. The reflectance properties of high silica materials like obsidian present distinctive spectral values in the thermal bands that can be isolated using techniques like spectral mixture analysis (Lillesand et al. 2004). Furthermore, disturbed soils are often distinctive in remote sensing imagery, offering another potential venue for differentiating ancient quarries (Carr and Turner 1996). While remote sensing appears to provide a more effective way to locate obsidian sources, there are two major limitations to this approach: (1) thermal band (TIR) imagery tends to be very coarse (e.g., 90m pixels from the ASTER sensor), (2) obsidian is relatively abundant in many regions but distinguishing *tool-quality* obsidian from imagery is unlikely. Such technologies can, at minimum, save time by identifying most of the major obsidian sources in a given region and then these sources can be visited individually.

8.6. Conclusion

This research project was an effort to integrate an investigation of regional and theoretical relevance with innovative methodological approaches. The methodological contribution comes primarily in the form of a digital research structure with regional studies, fieldwork planning, data organization, lab analysis, and presentation having taken place entirely in a digital medium. The geographical theme of obsidian procurement and circulation, combined with the methodological needs of surface survey record-keeping, created a necessity for an accurate and systematic geographical data structure, a demand that was met here using GIS software.

The theoretical and regional contribution from this research project returns to a few major themes regarding obsidian procurement and circulation. This research has showed that the chronology of obsidian procurement and use has been expanded, based on diagnostic artifact types collected during a 33 km^2 surface survey and on eight ^{14}C dates selected from five out of eight test excavation units. The economic focus of those who intensified on obsidian production appears to have been pastoral, as the nearness of the workshop to rich grazing and perennial water was apparently more important than proximity to the obsidian quarry. The temporality of obsidian circulation suggests that the regularized contact, probably in the form of camelid caravans, linked long distance trade partners in sustained and perhaps seasonal exchange millennia before it is anticipated in evolutionary models. The emphasis in obsidian procurement appears to have been on large nodules of clear glass, despite fact that the dominant obsidian formal tool morphology the latter part of the prehispanic period was on tiny triangular points. This emphasis on large nodules was perhaps part of a status building competition among early leaders, because in the Titicaca Basin obsidian consumption perhaps represented linkages to the western polities and large nodules were possibly seen as evidence of sustained and direct exchange with outside groups along the western margins of the puna.

– Appendix A –

Arch ID and Lot ID Registry

A.1. All Arch ID (Centroids) values

This is a registry of Arch ID A03- numbers used during the course of the 2003 research program. The ArchID numbers are hyperlinks to web references.

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
10	0	12	6	Ichocollo1	lithic_p	8283794	228821	3961
11	0	12	6	Ichocollo1	lithic_p	8283828	228811	3962
12	0	12	6	Ichocollo1	site_a	8283814	228815	3960
13	0	13	6	Ichocollo2	site_a	8283690	228880	3960
14	0	0	6	Ichocollo2	lithic_a	8283699	228880	3960
15	14	13	6	Ichocollo2	lithic_p	8283696	228879	3964
16	0	13	6	Ichocollo2	lithic_p	8283685	228877	3964
17	0	17	6	Ichocollo2	ceram_p	8283510	228851	3963
18	18	0	6		struct_a	8283454	228827	3964
19	19	0	6		struct_a	8283405	228814	3965
20	20	0	6		struct_a	8282989	228715	3945
21	21	0	6		struct_a	8282939	228742	3945
22	0	22	6	Ichocollo3	site_a	8283858	228896	3964
23	0	0	6	Ichocollo3	lithic_a	8283849	228899	3968
24	0	0	6	Ichocollo3	lithic_a	8283857	228904	3968
25	24	22	6	Ichocollo3	lithic_p	8283861	228905	3974
26	0	0	6	Ichocollo3	lithic_a	8283864	228881	3964
27	24	22	6	Ichocollo3	lithic_p	8283851	228904	3970
28	24	22	6	Ichocollo3	lithic_p	8283852	228906	3974
29	0	29	6	Tuti4	site_a	8283870	228931	3970
30	0	0	6	Tuti4	lithic_a	8283869	228933	3974
31	30	29	6	Tuti4	lithic_p	8283865	228931	3974
32	0	32	6	Ichocollo5	site_a	8283911	228916	3970
33	0	0	6	Ichocollo5	lithic_a	8283887	228919	3974
34	0	32	6	Ichocollo5	lithic_p	8283881	228912	3974
35	0	0	6	Ichocollo5	lithic_a	8283906	228919	3974
36	0	32	6	Ichocollo5	lithic_p	8283899	228917	3974
37	0	32	6	Ichocollo5	ceram_p	8283897	228921	3974
38	0	32	6	Ichocollo5	lithic_p	8283895	228918	3974
39	0	0	6	Ichocollo5	lithic_a	8283926	228915	3972

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
40	43	32	6	Ichocollo5	lithic_p	8283931	228917	3972
41	43	32	6	Ichocollo5	lithic_p	8283924	228916	3972
42	0	32	6	Ichocollo5	lithic_p	8283895	228901	3970
43	0	0	6	Ichocollo5	lithic_a	8283929	228916	3972
44	0	44	6	Ichocollo6	site_a	8283951	228886	3969
45	0	0	6	Ichocollo6	lithic_a	8283951	228898	3970
46	0	0	6	Ichocollo6	lithic_a	8283950	228901	3970
47	0	0	6	Ichocollo6	lithic_a	8283942	228893	3970
48	0	44	6	Ichocollo6	lithic_p	8283953	228896	3970
49	0	44	6	Ichocollo6	lithic_p	8283945	228893	3970
50	51	44	6	Ichocollo6	lithic_p	8283955	228893	3970
51	0	0	6	Ichocollo6	lithic_a	8283953	228889	3970
52	0	44	6	Ichocollo6	lithic_p	8283942	228874	3969
53	0	44	6	Ichocollo6	lithic_p	8283945	228868	3969
54	0	0	6	Ichocollo6	ceram_p	8283924	228851	3968
55	55	44	6	Ichocollo6	ceram_a	8283943	228883	3969
56	0	0	6	Ichocollo6	lithic_a	8283967	228875	3969
57	0	44	6	Ichocollo6	lithic_p	8283962	228878	3970
58	56	44	6	Ichocollo6	lithic_p	8283965	228874	3970
59	0	44	6	Ichocollo6	lithic_p	8283968	228867	3970
60	56	44	6	Ichocollo6	lithic_p	0	0	3970
61	0	61	6	Ichocollo7	site_a	8284003	228874	3970
62	0	0	6	Ichocollo7	lithic_a	8283988	228876	3970
63	0	61	6	Ichocollo7	lithic_p	8283983	228873	3970
64	0	61	6	Ichocollo7	lithic_p	8283984	228873	3970
65	62	61	6	Ichocollo7	lithic_p	8283984	228874	3970
66	0	61	6	Ichocollo7	lithic_p	8283984	228880	3971
67	0	61	6	Ichocollo7	lithic_p	8283986	228877	3971
68	62	61	6	Ichocollo7	lithic_p	8283985	228875	3971
69	0	61	6	Ichocollo7	lithic_p	8283985	228872	3970
70	62	61	6	Ichocollo6	lithic_p	8283950	228889	3970
70	62	61	6	Ichocollo7	lithic_p	8283950	228889	3970
71	0	61	6	Ichocollo7	lithic_p	8283989	228873	3970
72	62	61	6	Ichocollo7	lithic_p	8283990	228875	3971
73	76	61	6	Ichocollo7	lithic_p	8283996	228875	3971
74	76	61	6	Ichocollo7	ceram_p	8283997	228878	3972
75	62	61	6	Ichocollo7	lithic_p	8283992	228878	3971
76	0	0	6	Ichocollo7	lithic_a	8284005	228881	3970
77	0	61	6	Ichocollo7	ceram_p	8283994	228879	3972
78	76	61	6	Ichocollo7	ceram_p	8283998	228879	3971
79	76	61	6	Ichocollo7	lithic_p	8283998	228880	3971

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
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82	83	61	6	Ichocollo7	lithic_p	8284000	228882	3971
83	0	0	6	Ichocollo7	lithic_a	8284003	228882	3970
84	0	0	6	Ichocollo7	lithic_a	8284014	228887	3971
85	83	61	6	Ichocollo7	lithic_p	8284003	228882	3971
86	76	61	6	Ichocollo7	lithic_p	8284001	228881	3971
87	83	61	6	Ichocollo7	lithic_p	8284001	228881	3971
88	76	61	6	Ichocollo7	lithic_p	8284008	228880	3971
89	76	61	6	Ichocollo7	lithic_p	8284009	228883	3971
90	84	61	6	Ichocollo7	lithic_p	8284009	228886	3971
91	0	61	6	Ichocollo7	lithic_p	8284006	228887	3971
92	0	61	6	Ichocollo7	lithic_p	8284008	228886	3971
93	84	61	6	Ichocollo7	lithic_p	8284009	228885	3971
94	76	61	6	Ichocollo7	lithic_p	8284011	228888	3971
95	0	61	6	Ichocollo7	lithic_p	8283995	228877	3971
96	0	61	6	Ichocollo7	lithic_p	8283987	228872	3970
97	0	61	6	Ichocollo7	lithic_p	8283987	228847	3970
98	0	98	4	Condorpaccha1	site_a	8264621	225453	4428
99	0	0	4	Condorpaccha1	lithic_a	8264616	225458	4428
100	0	100	4	Condorpaccha2	site_a	8264643	224802	4348
103	0	102	4		lithic_p	0	0	4487
107	0	0	4		lithic_p	0	0	4428
108	0	108	4	Rusocane1	site_a	8264501	224567	4319
109	109	108	4	Rusocane1	lithic_p	0	0	4312
110	110	108	4	Rusocane1	lithic_p	0	0	4312
111	111	108	4	Rusocane1	lithic_p	0	0	4312
112	0	0	4	Condorpaccha2	lithic_p	8265074	225816	4593
113	0	113	4	Condorpaccha3	site_a	8264543	225683	4569
115	0	115	4	Condorpaccha7	site_a	8264638	226246	4706
116	116	115	4	Condorpaccha7	ceram_a	8264634	226249	4707
117	0	115	4	Condorpaccha7	lithic_p	8264638	226233	4706
118	0	0	4		ceram_p	8264692	226681	4777
118	0	0	4	Condorpaccha2	lithic_p	8265113	225707	4518
119	0	0	1	Camino Hornillo	struct_p	8269147	228375	4999
122	0	0	1	Mayemeja1	lithic_p	8268685	227806	4931
123	0	0	1	Mayemeja5	lithic_p	8268503	227600	4923
124	0	0	1	Mayemeja4	lithic_p	8268186	227582	4979
126	0	126	1	Mayemeja1	site_a	8268683	227712	4904

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
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127	127	126	1	Mayemeja1	struct_a	8268677	227652	4894
128	0	126	1	Mayemeja1	lithic_p	8268674	227656	4901
129	0	126	1	Mayemeja1	lithic_p	8268676	227656	4901
130	0	126	1	Mayemeja1	lithic_p	8268676	227657	4901
131	0	126	1	Mayemeja1	lithic_p	8268678	227657	4901
132	0	126	1	Mayemeja1	lithic_p	8268677	227654	4901
133	0	126	1	Mayemeja1	lithic_p	8268678	227654	4901
134	0	126	1	Mayemeja1	lithic_p	8268678	227653	4901
135	0	126	1	Mayemeja1	lithic_p	8268678	227653	4901
136	0	126	1	Mayemeja1	lithic_p	8268675	227653	4901
137	0	126	1	Mayemeja1	lithic_p	8268677	227652	4901
138	0	126	1	Mayemeja1	lithic_p	8268678	227651	4901
139	0	0	1	Mayemeja1	lithic_p	8268677	227652	4901
140	0	126	1	Mayemeja1	lithic_p	8268678	227650	4901
141	0	126	1	Mayemeja1	lithic_p	8268678	227650	4901
142	0	126	1	Mayemeja1	lithic_p	8268679	227650	4901
143	0	126	1	Mayemeja1	lithic_p	8268678	227649	4901
144	0	126	1	Mayemeja1	lithic_p	8268677	227649	4901
145	0	126	1	Mayemeja1	lithic_p	8268676	227649	4901
146	0	126	1	Mayemeja1	lithic_p	8268674	227652	4901
147	0	126	1	Mayemeja1	lithic_p	8268675	227650	4901
148	0	126	1	Mayemeja1	lithic_p	8268676	227649	4901
149	0	126	1	Mayemeja1	lithic_p	8268675	227649	4901
150	0	126	1	Mayemeja1	lithic_p	8268675	227649	4901
151	0	126	1	Mayemeja1	lithic_p	8268673	227650	4901
152	0	126	1	Mayemeja1	lithic_p	8268673	227649	4901
153	0	126	1	Mayemeja1	lithic_p	8268671	227648	4901
154	0	126	1	Mayemeja1	lithic_p	8268671	227648	4901
155	127	126	1	Mayemeja1	ceram_p	8268678	227656	4895
156	127	126	1	Mayemeja1	ceram_p	8268678	227656	4895
157	127	126	1	Mayemeja1	ceram_p	8268682	227655	4895
158	127	126	1	Mayemeja1	ceram_p	8268680	227652	4895
159	127	126	1	Mayemeja1	ceram_p	8268681	227652	4895
160	127	126	1	Mayemeja1	ceram_p	8268681	227656	4901
161	127	126	1	Mayemeja1	lithic_p	8268674	227653	4901
162	0	163	1	Mayemeja4	site_a	8268167	227608	4932
163	0	163	1	Ancachita2	site_a	8269431	227649	4932
164	0	164	1	Ancachita3	site_a	8269404	227715	4938
165	0	164	1	Ancachita3	lithic_p	8269407	227730	4942
166	0	0	1	Ancachita3	lithic_a	8269408	227724	4942

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
167	0	164	1	Ancachita3	lithic_p	8269403	227730	4942
168	166	164	1	Ancachita3	lithic_p	8269411	227724	4942
170	0	170	1	Ancachita1	site_a	8269904	227333	4924
171	0	0	1	Ancachita1	lithic_a	8269906	227336	4926
172	0	172	1	Ancachita4	site_a	8269764	227534	4926
173	173	172	1	Ancachita4	struct_a	8269773	227533	4926
174	0	174	1	Ancachita5	site_a	8269668	227507	4924
175	0	0	1	Ancachita5	lithic_a	8269674	227511	4926
176	0	176	1	Ancachita6	site_a	8269641	227604	4926
177	0	0	1	Ancachita6	lithic_a	8269638	227606	4926
179	0	179	1	Valdevia1	site_a	8269076	226993	4834
180	0	0	1	Valdevia1	lithic_a	8269058	227007	4840
181	0	0	1	Valdevia1	lithic_a	8269088	226990	4834
183	0	183	1	Valdevia2	site_a	8269047	226923	4828
184	0	186	1	Valdevia3	lithic_p	8269083	226918	4824
185	0	0	1	Valdevia2	lithic_a	0	0	4825
186	0	186	1	Valdevia3	site_a	8269095	226916	4820
187	0	187	1	Valdevia4	site_a	8268984	226886	4813
188	0	188	1	Valdevia4	site_a	8269010	226853	4813
189	0	0	1	Valdevia5	site_a	8268997	226718	4782
190	0	190	1	Vilcahuaman2	site_a	8268774	226748	4783
191	0	0	1	Vilcahuaman2	lithic_a	8268766	226770	4785
192	0	0	1	Vilcahuaman2	lithic_a	8268787	226742	4783
193	0	0	1	Vilcahuaman2	lithic_a	8268792	226752	4786
194	0	194	1	Valdevia6	site_a	8268846	226916	4819
195	0	0	1	Valdevia6	lithic_a	8268848	226916	4824
196	0	196	1	Valdevia7	site_a	8269054	227198	4855
197	0	0	1	Valdevia7	lithic_a	8269060	227191	4855
198	0	0	1	Valdevia7	lithic_a	8269060	227195	4855
199	0	0	1	Valdevia7	lithic_a	8269063	227193	4855
200	0	0	1	Valdevia7	lithic_a	8269053	227212	4861
201	0	201	1	Saylluta2	site_a	8269481	226709	4814
201	0	201	1	Saylluta2	site_p	8269479	226713	4814
202	0	201	1	Saylluta2	site_p	8269478	226715	4814
203	0	201	1	Saylluta2	site_p	8269482	226712	4814
204	0	201	1	Saylluta2	ceram_p	8269481	226707	4815
205	0	201	1	Saylluta2	ceram_p	8269483	226710	4815
206	0	201	1	Saylluta2	ceram_p	8269483	226710	4815
207	0	201	1	Saylluta2	ceram_p	8269485	226711	4812
208	0	201	1	Saylluta2	lithic_p	8269488	226713	4814

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
209	0	209	1	Mayemeja7	site_a	8268408	227399	4896
210	0	209	1	Mayemeja7	struct_p	8268394	227405	4896
211	0	0	1	Mayemeja7	lithic_a	8268405	227395	4905
212	0	0	1	Mayemeja7	lithic_a	8268403	227398	4905
213	0	0	1	Mayemeja7	lithic_a	8268409	227417	4912
214	0	214	1	Saylluta1	site_a	8269533	226764	4817
215	215	214	1	Saylluta1	struct_a	8269531	226756	4817
216	0	201	1	Saylluta2	site_p	8269480	226714	4814
217	0	201	1	Saylluta2	site_p	8269482	226713	4814
218	0	0	1	Saylluta2	lithic_a	8269475	226724	4811
219	0	219	1	Cantera	site_a	8269005	228164	4972
219	0	219	1	Cantera	site_p	8269004	228169	4974
219	0	219	1	Cantera	site_p	8269006	228163	4974
219	0	219	1	Cantera	site_p	8269004	228163	4974
220	0	219	1	Cantera	site_p	8269003	228170	4974
221	0	219	1	Cantera	site_p	8269006	228160	4974
223	0	223	4	Llallahue2	site_a	8266298	229069	4959
224	0	223	4	Llallahue2	lithic_p	8266297	229063	4960
225	0	225	4	Llallahue1	site_a	8265247	229321	4930
226	226	225	4	Llallahue1	ceram_a	8265245	229321	4930
227	0	0	4		lithic_p	8264570	231394	4947
228	0	228	4	puma1	site_a	8263213	231989	4964
229	0	229	4	puma2	site_a	8263309	231931	4961
230	0	229	1	puma2	struct_p	8263293	231913	4961
230	0	229	1	Saylluta2	lithic_a	8269475	226724	4811
231	0	0	4	puma2	lithic_a	8263309	231932	4958
232	232	229	4	puma2	ceram_a	8263305	231923	4955
233	0	233	4	Puma5	site_a	8265043	233320	4907
234	0	233	4	Puma5	struct_p	8265071	233305	4906
235	235	233	1	Puma5	ceram_a	8265065	233314	4905
235	235	233	1	Saylluta2	lithic_a	8269475	226724	4811
236	0	0	4	Puma5	lithic_a	8265040	233326	4909
237	236	233	4	Puma5	lithic_p	8265040	233317	4906
238	238	233	4	Puma5	ceram_a	8265031	233316	4906
239	0	0	4	Puma5	lithic_p	8265115	233376	4901
240	0	240	1	Molinos1	site_a	8268406	223918	4146
241	240	240	1	Molinos1	lithic_p	8268404	223865	4136
242	0	0	1	Molinos1	lithic_a	8268422	223902	4139
243	0	0	1	Molinos1	lithic_a	8268394	223955	4146
244	244	240	1	Molinos1	struct_a	8268392	223968	4146

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
245	0	245	1	Saylluta3	site_a	8269367	227016	4838
246	0	0	1	Saylluta3	lithic_a	8269378	227028	4841
247	0	0	1	Valdevia1	lithic_a	8269086	226993	4838
247	0	0	1	Saylluta3	lithic_a	8269369	227022	4838
248	0	0	1	Saylluta3	lithic_a	8269354	226998	4838
249	0	249	1	Saylluta4	site_a	8269433	226850	4815
250	0	250	1	Saylluta5	site_a	8269333	226643	4809
251	0	251	1	Saylluta6	site_a	8269274	226699	4801
252	0	0	1	Saylluta6	lithic_a	8269270	226663	4801
253	0	0	1	Saylluta6	lithic_a	8269268	226663	4801
254	0	0	1	Mayemeja3	ceram_p	8267925	227628	5034
255	0	255	1	Mayemeja3	site_a	8267807	227610	5053
256	0	255	1	Mayemeja3	lithic_p	8267836	227601	5041
257	0	255	1	Mayemeja3	lithic_p	8267839	227592	5041
258	0	255	1	Mayemeja3	ceram_p	8267769	227635	5053
259	0	0	1	Mayemeja3	lithic_a	8267779	227619	5058
260	0	255	1	Mayemeja3	lithic_p	8267746	227634	5058
261	0	255	1	Mayemeja3	ceram_p	8267745	227645	5058
262	0	255	1	Mayemeja3	ceram_p	8267740	227660	5066
263	0	263	1	Mayemeja2	site_a	8267570	227800	5064
264	0	0	1	Mayemeja2	lithic_a	8267596	227796	5064
265	0	265	1	Hornillo1	site_a	8267683	228045	5075
266	0	265	1	Hornillo1	lithic_p	8267681	228042	5074
267	0	267	1	Hornillo7	site_a	8267881	228007	5069
268	0	268	1	Camino Hornillo	site_a	8268311	228224	5087
269	0	269	1	Hornillo3	site_a	8268027	228144	5067
270	0	270	1	Hornillo2	site_a	8267971	228119	5069
271	0	0	1	Camino Hornillo	struct_p	8268423	228117	5057
272	0	272	1	Hornillo4	site_p	8268265	228039	5055
273	0	273	1	Hornillo4	site_a	8268288	228125	5058
274	0	274	1	Saylluta2	site_p	8269461	226684	4814
275	0	275	1	Mayemeja5	site_a	8268548	227486	4880
276	276	275	1	Mayemeja5	struct_a	8268645	227609	4893
277	277	275	1	Mayemeja5	struct_a	8268614	227569	4884
278	278	275	1	Mayemeja5	struct_a	8268584	227533	4881
279	279	275	1	Mayemeja5	struct_a	8268556	227496	4880
280	280	275	1	Mayemeja5	struct_a	8268487	227408	4877
281	0	281	1	Hornillo6	site_a	8268530	228240	5067
282	0	126	1	Maymeja1	site_p	8268688	227673	4901
283	0	126	1	Maymeja1	site_p	8268687	227674	4901

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
283	0	126	1	Maymeja1	site_p	8268684	227675	4901
284	0	126	1	Maymeja1	site_p	8268688	227667	4900
284	0	126	1	Maymeja1	site_p	8268689	227667	4900
284	0	126	1	Maymeja1	site_p	8268688	227668	4900
284	0	126	1	Maymeja1	site_p	8268689	227668	4900
285	285	126	1	Maymeja1	ceram_a	8268683	227670	4901
286	286	126	1	Maymeja1	ceram_a	8268688	227665	4901
287	0	126	1	Maymeja1	lithic_p	8268689	227665	4901
288	0	288	1	Hornillo7	site_a	8268672	228052	5025
289	0	289	1	Hornillo8	site_a	8268672	228123	5054
290	0	290	1	Hornillo5	site_a	8268443	228242	5079
291	0	291	1	Hornillo9	site_a	8268780	228325	5040
292	0	291	1	Hornillo9	lithic_p	8268795	228307	5033
293	0	0	1	Hornillo9	lithic_a	8268775	228335	5038
294	0	0	1	Hornillo9	lithic_a	8268768	228339	5040
295	0	295	1	Hornillo10	site_a	8268827	228382	5033
296	0	0	1	Hornillo10	lithic_a	8268841	228359	5030
297	0	0	1	Hornillo10	lithic_a	8268834	228399	5035
298	0	0	1	Camino Hornillo	struct_p	8268980	228520	5036
299	0	299	4	Mamacocha7	site_a	8269462	229430	5007
300	0	0	4	Mamacocha7	lithic_a	8269464	229423	5014
301	301	299	4	Mamacocha7	ceram_a	8269463	229444	5006
302	300	299	4	Mamacocha7	lithic_p	8269466	229420	5006
304	300	299	4	Mamacocha7	lithic_p	8269454	229420	5006
305	0	0	1	Cantera	lithic_p	8268970	228090	4959
308	308	308	1	Hornillo11	struct_l	8268880	228083	4966
308	308	308	1	Hornillo11	site_a	8268887	228084	4971
308	308	308	1	Hornillo11	struct_a	8268889	228087	4966
309	0	309	1	Mayemeja6	site_a	8268872	227977	4946
310	0	0	1	Mayemeja6	lithic_a	8268882	228011	4952
311	311	309	1	Mayemeja6	struct_l	8268878	228018	4945
313	0	309	1	Mayemeja6	struct_p	8268871	227978	4941
315	0	309	1	Mayemeja6	struct_p	8268863	227963	4947
316	0	309	1	Mayemeja6	struct_p	8268869	227971	4941
317	0	0	1	Mayemeja6	lithic_a	8268866	227946	4940
318	0	0	1	Mayemeja1	struct_p	8268751	227785	4914
319	0	126	1	Mmja1 Q02-2	lithic_p	8268679	227700	4904
320	0	126	1	Mmja1 Q02-2	lithic_p	8268696	227744	4910
321	0	126	1	Mmja1 Q02-2	ceram_p	8268681	227707	4908
322	0	126	1	Mmja1 Q02-2	lithic_p	8268678	227701	4904

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
323	324	126	1	Mmja1 Q02-2	lithic_p	8268683	227692	4904
324	0	0	1	Mayemeja1	lithic_a	8268688	227695	4904
325	0	0	1	Mayemeja1	lithic_a	8268679	227701	4908
326	0	0	1	Mayemeja1	lithic_a	8268660	227711	4908
327	0	0	1	Mayemeja1	lithic_a	8268673	227703	4908
328	0	0	1	Mayemeja1	lithic_a	8268685	227693	4904
329	0	0	1	Mayemeja1	lithic_a	8268687	227665	4901
330	0	0	1	Mayemeja1	lithic_a	8268688	227664	4901
331	330	126	1	Mmja1 Q02-2	lithic_p	8268686	227665	4901
332	329	126	1	Mmja1 Q02-2	lithic_p	8268684	227676	4904
333	0	0	1	Mayemeja1	lithic_a	8268696	227736	4908
334	334	126	1	Mmja1 Q02-2	struct_a	8268679	227714	4904
335	335	126	1	Mmja1 Q02-2	struct_a	8268672	227699	4904
336	336	126	1	Mmja1 Q02-2	struct_a	8268677	227701	4904
337	337	126	1	Mmja1 Q02-2	struct_a	8268673	227701	4904
338	0	126	1	Mmja1 Q02-2	struct_p	8268693	227694	4902
339	276	275	1	Mayemeja5	struct_p	8268643	227615	4893
339	276	275	1	Mayemeja5	site_p	8268643	227615	4893
340	0	340	2	Amarani1	site_a	8259601	242175	4372
341	341	340	2	Amarani1	struct_p	8259697	242101	4382
342	0	0	2	Amarani1	lithic_a	8259450	242194	4368
343	0	0	2	Amarani1	lithic_a	8259463	242209	4372
344	342	340	2	Amarani1	lithic_p	8259462	242213	4368
345	0	0	2	Amarani1	lithic_a	8259418	242197	4371
346	342	340	2	Amarani1	lithic_p	8259483	242187	4367
347	347	340	2	Amarani1	ceram_a	8259674	242132	4378
348	347	340	2	Amarani1	ceram_p	8259697	242136	4378
349	349	340	2	Amarani1	ceram_a	8259685	242125	4378
350	347	340	2	Amarani1	lithic_p	8259673	242130	4378
352	352	340	2	Amarani1	struct_a	8259668	242186	4372
353	353	340	2	Amarani1	struct_a	8259602	242169	4372
354	353	340	2	Amarani1	lithic_p	8259624	242129	4377
355	0	340	2	Amarani1	lithic_p	8259619	242127	4377
356	0	340	2	Amarani1	lithic_p	8259623	242165	4372
357	357	340	2	Amarani1	struct_a	8259613	242176	4375
358	0	0	2	Amarani1	lithic_a	8259641	242198	4372
359	0	0	2	Amarani1	lithic_a	8259625	242175	4372
360	359	340	2	Amarani1	lithic_p	8259626	242193	4372
361	0	0	2	Amarani1	lithic_a	8259674	242214	4371
362	361	340	2	Amarani1	lithic_p	8259681	242225	4371

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
363	360	340	2	Amarani1	lithic_p	8259694	242178	4372
364	0	340	2	Amarani1	lithic_p	8259729	242172	4373
365	366	340	2	Amarani1	ceram_p	8259638	242156	4375
366	366	340	2	Amarani1	struct_l	8259636	242164	4373
366	366	340	2	Amarani1	struct_l	8259635	242166	4373
366	366	340	2	Amarani1	struct_l	8259631	242170	4373
366	366	340	2	Amarani1	struct_l	8259627	242170	4373
366	366	340	2	Amarani1	struct_l	8259631	242182	4373
366	366	340	2	Amarani1	struct_l	8259637	242159	4373
366	366	340	2	Amarani1	struct_a	8259635	242161	4375
366	366	340	2	Amarani1	struct_a	8259633	242172	4375
367	367	340	2	Amarani1	ceram_a	8259664	242191	4372
368	368	340	2	Amarani1	ceram_a	8259631	242167	4375
369	366	340	2	Amarani1	lithic_p	8259623	242149	4375
370	0	340	2	Amarani1	lithic_p	8259564	242103	4376
371	0	371	2	Amarani2	site_a	8259225	241750	4400
372	0	372	2	Amarani3	site_a	8259188	241873	4379
373	373	371	2	Amarani2	struct_p	8259226	241751	4407
374	0	374	2	Amarani4	site_a	8259092	241772	4378
375	375	374	2	Amarani4	struct_p	8259110	241731	4385
376	376	374	2	Amarani4	struct_a	8259106	241744	4385
377	0	0	2	Amarani4	lithic_a	8259097	241795	4378
378	0	0	2	Amarani4	lithic_a	8259091	241765	4378
379	378	374	2	Amarani4	lithic_p	8259091	241768	4378
380	378	374	2	Amarani4	lithic_p	8259091	241762	4378
381	0	374	2	Amarani4	lithic_p	8259109	241734	4385
382	0	374	2	Amarani4	lithic_p	8259124	241744	4385
383	0	374	2	Amarani4	lithic_p	8259131	241771	4383
384	0	374	2	Amarani4	lithic_p	8259123	241778	4378
385	0	374	2	Amarani4	lithic_p	8259108	241773	4379
386	377	374	2	Amarani4	lithic_p	8259102	241786	4378
387	377	374	2	Amarani4	lithic_p	8259102	241796	4378
388	377	374	2	Amarani4	lithic_p	8259090	241794	4378
389	0	389	2	Jocca	site_a	8258864	241079	4460
390	0	389	2	Jocca	lithic_p	8258863	241063	4473
391	0	389	2	Jocca	lithic_p	8258867	241083	4473
392	392	392	2		struct_l	8258563	241265	4409
392	392	392	2	Alcahuito1	site_a	8258066	241704	4380
393	0	393	2	Amarani6	lithic_p	8258902	241759	4382
393	0	393	2	Alcahuito2	site_a	8257922	241841	4371

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
394	0	0	2	Alcahuito2	lithic_p	8257888	241917	4374
395	0	0	2	Alcahuito2	lithic_p	8257871	241892	4374
396	0	396	2	Alcahuito4	site_a	8257720	242050	4380
397	0	396	2	Alcahuito4	lithic_p	8257699	242044	4380
398	0	0	2	Alcahuito4	lithic_p	8257692	241991	4381
399	0	405	2	Alcahuito3	lithic_p	8257648	242082	4377
400	0	396	2	Alcahuito4	lithic_p	8257693	242042	4380
401	0	396	2	Alcahuito4	ceram_p	8257690	242014	4381
402	0	396	2	Alcahuito4	lithic_p	8257707	242049	4379
403	0	396	2	Alcahuito4	lithic_p	8257715	242049	4379
404	0	0	2	Alcahuito4	lithic_a	8257703	242045	4380
405	0	405	2	Alcahuito3	site_a	8257616	242076	4377
406	0	406	2	Huancane5	site_a	8257390	241870	4379
407	0	406	2	Huancane5	lithic_p	8257402	241863	4379
408	0	406	2	Huancane5	lithic_p	8257387	241871	4379
409	0	409	2	Huancane6	site_a	8257374	241806	4384
410	0	0	2	Huancane6	lithic_a	8257389	241809	4384
411	410	409	2	Huancane6	lithic_p	8257394	241813	4382
412	0	409	2	Huancane6	lithic_p	8257418	241790	4391
413	410	409	2	Huancane6	lithic_p	8257394	241802	4387
414	410	409	2	Huancane6	lithic_p	8257391	241806	4382
415	410	409	2	Huancane6	lithic_p	8257388	241803	4387
416	0	409	2	Huancane6	lithic_p	8257410	241790	4387
417	0	409	2	Huancane6	lithic_p	8257381	241784	4384
418	410	409	2	Huancane6	lithic_p	8257385	241801	4387
419	0	419	2	Huancane7	site_a	8257402	241687	4406
420	0	419	2	Huancane7	lithic_p	8257391	241717	4397
421	0	419	2	Huancane7	lithic_p	8257382	241694	4398
422	422	419	2	Huancane7	struct_a	8257420	241669	4412
423	422	419	2	Huancane7	ceram_p	8257421	241663	4406
424	0	424	2	Huancane3	site_a	8257117	241633	4381
425	0	424	2	Huancane3	ceram_p	8257085	241601	4381
426	0	424	2	Huancane3	ceram_p	8257100	241598	4381
427	0	424	2	Huancane3	ceram_p	8257104	241602	4381
428	0	424	2	Huancane3	ceram_p	8257108	241637	4381
429	0	424	2	Huancane3	ceram_p	8257105	241646	4380
430	0	424	2	Huancane3	ceram_p	8257108	241621	4381
431	0	0	2	Huancane3	lithic_a	8257118	241640	4380
432	432	424	2	Huancane3	struct_a	8257119	241605	4381
433	0	424	2	Huancane3	ceram_p	8257129	241655	4381

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
434	0	434	2	Huancane2	site_a	8257026	241593	4382
435	0	0	2	Huancane2	lithic_a	8257021	241585	4382
436	435	434	2	Huancane2	ceram_p	8257040	241597	4382
437	0	437	2	Huancane4	site_a	8257163	241708	4380
438	0	0	2	Huancane4	lithic_p	8257167	241730	4378
439	0	0	2	Alcahuito3	lithic_p	8257542	242083	4373
440	0	0	2	Alcahuito3	lithic_p	8257526	242040	4375
441	0	0	2	Alcahuito4	lithic_p	8257802	242098	4376
442	0	442	2	Alcahuito4	lithic_p	8257875	242150	4376
442	0	442	2	Huancane1	site_a	8256924	241487	4400
443	0	0	2	Huancane1	lithic_a	8256911	241492	4395
444	0	442	2	Huancane1	lithic_p	8256876	241522	4393
445	0	0	2	Huancane1	lithic_a	8256922	241495	4395
446	446	442	2	Huancane1	struct_a	8256922	241474	4400
447	447	442	2	Huancane1	struct_a	8256927	241460	4401
448	448	442	2	Huancane1	struct_a	8256906	241443	4400
449	445	442	2	Huancane1	lithic_p	8256901	241462	4398
450	443	442	2	Huancane1	lithic_p	8256897	241486	4395
451	0	442	2	Huancane1	ceram_p	8256915	241490	4395
451	0	442	2	Huancane1	ceram_p	8256981	241532	4395
452	0	442	2	Huancane1	lithic_p	8256914	241484	4398
453	0	442	2	Huancane1	lithic_p	8256877	241514	4393
454	0	454	2	Huancane5	site_a	8256807	241373	4395
455	455	454	2	Huancane5	struct_a	8256806	241356	4395
456	456	454	2	Huancane5	struct_a	8256810	241361	4395
457	457	454	2	Huancane5	struct_a	8256817	241370	4395
458	0	0	2	Huancane5	lithic_a	8256804	241374	4393
459	0	454	2	Huancane5	lithic_p	8256817	241367	4396
460	0	454	2	Huancane5	lithic_p	8256817	241367	4396
461	0	454	2	Huancane5	lithic_p	8256795	241357	4392
462	0	454	2	Huancane5	lithic_p	8256798	241374	4392
463	0	454	2	Huancane5	lithic_p	8256805	241348	4395
464	0	464	2	Huancane6	site_a	8256760	241440	4385
465	0	464	2	Huancane6	lithic_p	8256753	241433	4383
466	0	466	2	Marihuire3	site_a	8256814	240783	4456
467	0	0	2	Marihuire3	lithic_p	8256774	240805	4448
468	0	466	2	Marihuire3	ceram_p	8256810	240792	4455
469	0	469	2	Marihuire1	site_a	8256840	240560	4463
470	0	469	2	Marihuire1	ceram_p	8256824	240552	4455
471	0	471	2	Marihuire2	site_a	8256686	240522	4429

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
472	0	0	2	Huancane7	lithic_p	8256575	241147	4405
473	0	473	2	Huancane7	site_a	8256678	241242	4391
474	473	474	3	Huancane8	site_a	8256707	241367	4387
474	473	474	3	Taukamayo2	lithic_p	8284471	237093	3887
475	0	474	2	Huancane8	lithic_p	8256697	241366	4386
477	0	0	2	Huancane1	lithic_p	8256785	241610	4381
478	0	478	2	Huancane8	site_a	8256946	241883	4383
479	0	478	2	Huancane8	lithic_p	8256902	241877	4382
480	0	0	2	Huancane8	lithic_p	8256995	241986	4382
481	481	340	2	Amarani1	struct_a	8259534	242079	4383
482	0	482	2	Amarani6	site_a	8258999	241867	4380
483	483	482	2	Amarani6	struct_a	8258991	241867	4380
484	0	484	2	Amarani5	site_a	8258992	242269	4370
485	0	0	2	Amarani5	lithic_a	8259054	242244	4370
486	485	484	2	Amarani5	lithic_p	8259054	242235	4370
487	485	484	2	Amarani5	lithic_p	8259060	242239	4370
488	485	484	2	Amarani5	lithic_p	8259062	242237	4370
489	485	484	2	Amarani5	lithic_p	8259069	242246	4371
490	485	484	2	Amarani5	lithic_p	8259068	242244	4371
491	485	484	2	Amarani5	lithic_p	8259060	242227	4370
492	485	484	2	Amarani5	lithic_p	8259040	242224	4369
493	0	484	2	Amarani5	lithic_p	8259032	242213	4369
494	0	484	2	Amarani5	ceram_p	8259025	242192	4370
495	485	484	2	Amarani5	ceram_p	8259062	242232	4370
496	0	484	2	Amarani5	lithic_p	8259023	242222	4369
497	0	484	2	Amarani5	ceram_p	8259014	242276	4371
498	0	0	2	Amarani5	lithic_a	8258991	242327	4372
499	498	484	2	Amarani5	lithic_p	8258992	242306	4371
500	0	500	2		site_p	8258833	242064	4391
501	0	501	2	Amarani5	struct_l	8258855	242100	4384
502	0	484	2	Amarani5	ceram_p	8259007	242280	4371
503	0	484	2	Amarani5	lithic_p	8258998	242289	4371
504	0	484	2	Amarani5	lithic_p	8258990	242301	4371
505	0	0	2	Amarani5	lithic_a	8258989	242325	4372
506	0	484	2	Amarani5	ceram_p	8258993	242311	4371
507	0	484	2	Amarani5	ceram_p	8258986	242307	4371
508	498	484	2	Amarani5	lithic_p	8258983	242317	4371
509	498	484	2	Amarani5	lithic_p	8258985	242317	4371
510	498	484	2	Amarani5	lithic_p	8258989	242322	4371
511	498	484	2	Amarani5	lithic_p	8259004	242331	4371

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
512	0	484	2	Amarani5	lithic_p	8258924	242331	4372
513	0	484	2	Amarani5	lithic_p	8258922	242317	4372
514	0	484	2	Amarani5	lithic_p	8258872	242322	4372
515	0	484	2	Amarani5	lithic_p	8258870	242324	4372
516	0	484	2	Amarani5	lithic_p	8258865	242322	4372
517	0	484	2	Amarani5	lithic_p	8258872	242343	4372
518	519	484	2	Amarani5	struct_a	8258863	242334	4372
519	0	484	2	Amarani5	lithic_p	8258833	242330	4371
520	0	484	2	Amarani5	lithic_p	8258817	242370	4370
521	0	0	2	Alcahuito1	lithic_p	8258156	241737	4375
522	0	392	2	Alcahuito1	lithic_p	8258071	241689	4377
523	0	0	2	Amarani5	lithic_p	8259165	242400	4371
524	0	524	1	Molinos3	site_a	8268362	224432	4264
525	0	525	1	Molinos4	site_a	8268310	224798	4367
526	0	526	1	Molinos5	site_a	8268345	224901	4364
527	0	527	1	Molinos6	site_a	8268325	225456	4458
528	0	0	1		ceram_p	8268082	226042	4551
529	0	529	1	Mamacocha1	site_a	8268136	226300	4526
530	0	0	1	Mamacocha1	lithic_a	8268127	226305	4525
531	0	531	1	Mamacocha8	site_a	8267823	226348	4636
532	0	532	1	Mamacocha2	site_a	8268123	226398	4526
533	0	0	1	Mamacocha2	lithic_a	8268117	226400	4533
534	534	532	1	Mamacocha2	struct_a	8268116	226402	4526
535	0	532	1	Mamacocha2	lithic_p	8268124	226395	4533
536	0	536	1	Mamacocha3	site_a	8268009	226495	4581
537	0	536	1	Mamacocha3	lithic_p	8268011	226493	4580
538	0	538	1	Mamacocha4	site_a	8267979	226539	4594
539	0	539	1	Mamacocha5	site_a	8268027	226686	4609
540	0	539	1	Mamacocha5	lithic_p	8268095	226632	4597
541	542	539	1	Mamacocha5	ceram_p	8267994	226758	4629
542	0	0	1	Mamacocha5	lithic_a	8268062	226642	4601
543	0	0	1	Mamacocha5	lithic_a	8268039	226649	4605
544	0	0	1	Mamacocha5	lithic_a	8268074	226637	4601
545	542	539	1	Mamacocha5	ceram_p	8268040	226640	4605
546	0	539	1	Mamacocha5	ceram_p	8268021	226655	4609
547	547	539	1	Mamacocha5	struct_l	8268068	226645	4597
548	0	548	1	Mamacocha6	site_a	8268117	226816	4627
549	544	539	1	Mamacocha5	lithic_p	8268028	226659	4609
550	542	539	1	Mamacocha5	lithic_p	8268043	226647	4601
550	542	539	1	Mamacocha5	lithic_p	8268043	226647	4601

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
550	542	539	1	Mamacocha5	struct_p	8268053	226641	4602
550	542	539	1	Mamacocha5	struct_p	8268043	226648	4602
551	551	539	1	Mamacocha5	struct_a	8268062	226687	4607
552	552	539	1	Mamacocha5	struct_l	8268039	226651	4602
553	553	539	1	Mamacocha5	struct_a	8268030	226655	4605
554	554	539	1	Mamacocha5	struct_a	8268015	226641	4599
555	555	539	1	Mamacocha5	struct_a	8268000	226655	4609
556	556	539	1	Mamacocha5	struct_a	8267991	226684	4613
557	557	2039	2	Pausa2	site_a	8261048	242686	4367
557	557	2039	2	Pausa2	site_a	8261048	242686	4367
557	557	2039	2	Pausa2	struct_a	8261048	242686	4367
558	558	2039	2	Pausa2	struct_a	8261079	242727	4366
559	559	2039	2	Pausa2	struct_a	8261077	242728	4366
560	0	2039	2	Pausa2	site_p	8261042	242696	4362
561	0	2039	2	Pausa2	site_p	8261052	242714	4362
562	0	2039	2	Pausa2	lithic_p	8261038	242691	4367
563	0	2039	2	Pausa2	ceram_p	8261044	242691	4367
565	0	2039	2	Pausa2	lithic_p	8261083	242733	4364
566	0	2039	2	Pausa2	site_p	8261058	242677	4362
570	0	570	1	Vilcahuaman1	site_a	8268874	226624	4779
571	0	0	1	Vilcahuaman1	lithic_a	8268916	226583	4774
572	0	0	1	Vilcahuaman1	lithic_a	8268954	226532	4758
573	0	570	1	Vilcahuaman1	ceram_p	8268929	226564	4766
574	0	0	1	Vilcahuaman1	lithic_a	8268844	226678	4781
575	0	575	1	Valdevia8	site_a	8268623	226776	4783
576	0	0	1	Valdevia8	lithic_a	8268622	226787	4775
577	0	0	1	Valdevia8	lithic_a	8268623	226759	4772
578	578	575	1	Valdevia8	struct_a	8268618	226796	4789
579	579	0	1		struct_a	8268570	227001	4821
580	0	580	1	Molinos2	site_a	8268501	224468	4216
581	583	580	1	Molinos2	lithic_p	8268489	224488	4220
582	0	0	1	Molinos2	lithic_a	8268500	224488	4231
583	583	580	1	Molinos2	struct_a	8268489	224486	4231
584	582	580	1	Molinos2	lithic_p	8268498	224495	4228
585	582	580	1	Molinos2	lithic_p	8268495	224487	4220
586	582	580	1	Molinos2	lithic_p	8268503	224483	4220
587	0	0	3	callalli2	lithic_p	8283314	238447	4185
588	0	588	3	Callalli1	site_a	8283392	238634	4128
589	0	589	3	callalli2	site_a	8283446	238359	4156
590	0	590	3	callalli3	site_a	8283508	238665	4100

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
591	0	591	3	callalli4	site_a	8283621	238731	4073
592	0	592	3	callalli5	site_a	8283673	238456	4077
593	593	0	3	callalli5	lithic_p	8283845	238383	4020
594	0	594	3	callalli6	site_a	8284009	238537	3967
595	0	595	3	callalli7	site_a	8283972	238781	4007
596	0	596	3	callalli8	site_a	8284270	238973	3941
597	0	597	3	callalli9	site_a	8284099	238897	3970
598	0	598	3	callalli11	ceram_p	8284384	238649	3931
598	0	598	3	Callalli10	site_a	8284042	238879	3982
599	0	599	3	callalli11	site_a	8284344	238619	3928
600	0	599	3	callalli11	ceram_p	8284333	238623	3929
601	0	601	3		site_p	8284685	238135	3889
602	0	602	3	Auccinamayo1	site_a	8284875	238716	3905
603	0	603	3	Auccinamayo2	site_a	8285360	238981	4004
604	604	603	3	Auccinamayo2	struct_a	8285364	238984	4004
605	0	0	3		ceram_p	8285987	238612	4087
606	0	606	3	Auccinamayo3	site_a	8285016	238673	3927
607	0	607	3	Auccinamayo4	site_a	8286143	238891	4161
608	0	607	3	Auccinamayo4	ceram_p	8286131	238903	4149
609	0	0	3		struct_l	8285950	239128	4109
611	0	611	3	Banos1	site_a	8284391	235581	3899
612	0	612	3	Banos2	site_a	8284293	235731	3905
613	0	0	3	Banos2	lithic_a	8284283	235737	3908
614	0	0	3	Banos2	lithic_a	8284284	235736	3908
615	614	612	3	Banos2	lithic_p	8284281	235733	3906
616	614	612	3	Banos2	lithic_p	8284279	235736	3906
617	613	612	3	Banos2	lithic_p	8284279	235747	3908
618	0	612	3	Banos2	lithic_p	8284302	235719	3902
619	0	619	3	Banos3	site_a	8284339	235805	3906
620	0	0	3	Banos3	lithic_a	8284344	235798	3906
621	0	0	3	Banos3	lithic_a	8284349	235819	3910
622	622	619	3	Banos3	struct_a	8284337	235795	3906
623	0	623	3	Banos4	site_a	8284752	235657	3899
624	624	623	3	Banos4	ceram_a	8284715	235628	3897
625	0	625	3	Banos5	site_a	8284859	235832	3904
626	626	625	3	Banos5	ceram_a	8284827	235841	3902
627	0	627	3	Banos6	site_a	8284845	235766	3891
628	0	0	3	Banos5	lithic_a	8284891	235835	3904
629	0	629	3	Puca Mocco6	site_a	8284904	236091	3908
630	0	630	3	Puca Mocco2	site_a	8284773	236175	3909

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
631	631	630	3	Puca Mocco2	struct_a	8284775	236188	3911
632	632	630	3	Puca Mocco2	struct_a	8284777	236171	3909
632	632	630	3	Puca Mocco2	struct_a	8284777	236171	3909
633	633	630	3	Puca Mocco2	ceram_a	8284775	236176	3911
634	632	630	3	Puca Mocco2	ceram_p	8284778	236184	3911
635	0	635	3	Puca Mocco7	site_a	8284801	236238	3911
636	0	636	3	Callalli Antigua3	site_a	8284742	236269	3908
637	637	636	3	Callalli Antigua3	struct_a	8284749	236269	3908
638	638	636	3	Callalli Antigua3	struct_a	8284728	236268	3908
639	639	0	3	Callalli Antigua3	ceram_a	8284708	236277	3907
640	0	640	3	Callalli Antigua4	site_a	8284630	236310	3916
641	0	641	3	Callalli Antigua5	site_a	8284595	236432	3921
642	0	642	3	Callalli Antigua6	site_a	8284633	236412	3918
643	0	643	3	Puca Mocco1	site_a	8284708	236381	3905
644	0	0	3	Callalli Antigua7	ceram_p	8284789	236366	3903
645	0	0	3	Callalli Antigua3	ceram_p	8284776	236291	3906
646	0	0	3	Callalli Antigua7	ceram_p	8284804	236350	3902
647	0	647	3	Callalli Antigua7	site_a	8284833	236372	3901
648	0	0	3	Callalli Antigua7	ceram_p	8284868	236337	3901
649	0	0	3	Puca Mocco8	lithic_p	8284935	236182	3904
650	0	650	3	Puca Mocco8	site_a	8285022	236199	3901
651	0	0	3	Puca Mocco9	struct_l	8285153	235971	3910
651	0	0	3	Banos7	struct_l	8284967	235856	3910
652	0	652	3	Banos7	site_a	8284959	235894	3906
653	0	653	3	Puca Mocco3	site_a	8284966	235751	3884
654	0	654	3	Puca Mocco4	site_a	8284756	235556	3878
655	0	655	3	Puca Mocco9	site_a	8285299	235994	3882
656	656	655	3	Puca Mocco9	struct_a	8285277	235994	3890
657	0	657	3	Puca Mocco5	site_a	8285285	236075	3881
658	0	658	3	Puca Mocco5	lithic_p	8285287	236075	3877
659	0	659	3	Callalli Antigua8	site_a	8285077	236327	3875
660	0	660	3	Callalli Antigua9	site_a	8285077	236483	3865
661	0	661	3	Puca Mocco10	site_a	8285077	236165	3906
662	0	662	3	Callalli Antigua1	site_a	8284909	236463	3884
663	663	662	3	Callalli Antigua1	struct_a	8284984	236435	3878
664	664	662	3	Callalli Antigua1	struct_a	8285002	236448	3874
665	665	662	3	Callalli Antigua1	struct_a	8284906	236509	3882
666	666	662	3	Callalli Antigua1	ceram_a	8284878	236527	3882
667	0	667	3	Callalli Antigua2	site_a	8285073	236533	3862
668	0	0	3	Callalli Antigua2	lithic_a	8285067	236548	3859

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
669	0	0	3	Callalli Antigua2	lithic_a	8285084	236534	3859
670	0	0	3	Callalli Antigua11	lithic_p	8284738	236829	3879
671	0	671	3	Callalli Antigua11	site_a	8284737	237002	3877
672	0	672	3	Taukamayo2	site_a	8284466	237102	3887
673	673	672	3	Taukamayo2	struct_a	8284470	237096	3887
674	673	672	3	Taukamayo2	lithic_p	0	0	3885
675	0	675	3	Taukamayo1	site_a	8284366	237143	3895
676	0	0	3	Taukamayo1	lithic_a	8284410	237132	3887
677	0	0	3	Taukamayo1	lithic_a	8284377	237153	3888
678	0	0	3	Taukamayo1	lithic_a	8284387	237145	3888
679	0	0	3	Taukamayo1	lithic_a	8284368	237153	3890
680	678	675	3	Taukamayo1	lithic_p	8284380	237142	3888
681	681	675	3	Taukamayo1	ceram_a	8284389	237148	3887
682	678	675	3	Taukamayo1	lithic_p	8284385	237151	3888
683	678	675	3	Taukamayo1	lithic_p	8284387	237147	3887
684	677	675	3	Taukamayo1	lithic_p	8284375	237146	3888
685	677	675	3	Taukamayo1	lithic_p	8284370	237157	3888
687	0	687	3	Taukamayo12	site_a	8284286	237087	3910
688	689	687	3	Taukamayo12	lithic_p	8284306	237070	3902
689	0	0	3	Taukamayo12	lithic_a	8284306	237074	3903
690	689	687	3	Taukamayo12	lithic_p	8284293	237106	3899
691	0	691	3	Taukamayo3	site_a	8284192	237092	3907
692	0	0	3	Taukamayo3	lithic_a	8284196	237092	3907
693	0	0	3	Taukamayo3	lithic_a	8284195	237095	3907
694	0	694	3	Taukamayo4	site_a	8283839	237067	3920
695	0	0	3	Taukamayo4	lithic_a	8283850	237075	3913
696	0	0	3	Taukamayo4	lithic_a	8283850	237077	3913
697	0	0	3	Taukamayo6	ceram_p	8283787	237035	3916
698	0	698	3	Taukamayo6	site_a	8283797	236998	3920
699	699	698	3	Taukamayo6	struct_a	8283799	236999	3920
700	700	698	3	Taukamayo6	ceram_a	8283796	236994	3920
701	0	701	3	Taukamayo11	site_a	8283642	237077	3937
702	0	0	3	Taukamayo11	lithic_a	8283600	237057	3938
703	0	0	3	Taukamayo11	lithic_a	8283645	237080	3938
704	0	704	3	Callalli14	site_a	8283803	237615	3951
705	0	705	3	Zorromayo	site_a	8283555	237453	3953
706	706	705	3	Zorromayo	struct_a	8283597	237425	3951
707	707	705	3	Zorromayo	struct_a	8283588	237427	3951
708	708	705	3	Zorromayo	struct_a	8283567	237435	3951
709	709	705	3	Zorromayo	struct_a	8283537	237453	3953

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
710	0	0	3	Zorromayo	lithic_a	8283543	237459	3953
711	0	0	3	Zorromayo	lithic_a	8283509	237465	3959
712	0	0	3	Zorromayo	lithic_a	8283495	237474	3959
713	0	0	3	Zorromayo	lithic_a	8283460	237480	3959
714	0	0	3	Zorromayo	lithic_a	8283440	237482	3961
715	0	715	3	Taukamayo7	site_a	8283567	236967	3933
716	0	0	3	Taukamayo7	lithic_a	8283568	236965	3934
717	0	717	3	Taukamayo8	site_a	8283598	236814	3943
718	0	0	3	Taukamayo8	lithic_a	8283602	236816	3941
720	0	720	3	Taukamayo9	site_a	8283535	236745	3960
721	0	721	3	Taukamayo13	site_a	8284314	236840	3990
722	0	721	3	Taukamayo13	ceram_p	8284302	236844	3974
723	0	0	3	Taukamayo13	lithic_a	8284312	236841	3974
724	0	724	3	Taukamayo10	site_a	8283603	236567	3970
725	0	725	3	Taukamayo10	lithic_p	8283562	236583	3970
725	0	725	3	Rusocane2	site_a	8264488	224500	4317
726	0	0	4	Condorpaccha2	struct_p	8264559	224725	4329
728	0	728	4	Condorpaccha2	site_a	8265059	225629	4491
729	0	729	4	Condorpaccha4	site_a	8264337	225669	4566
730	730	729	4	Condorpaccha4	struct_a	8264338	225664	4566
731	731	729	4	Condorpaccha4	struct_a	8264344	225689	4575
732	0	732	4	Condorpaccha5	site_a	8264351	225785	4588
733	0	733	4	Condorpaccha6	site_a	8264331	225868	4602
734	0	734	4	Camino Lecceta	site_a	8264003	229618	4951
735	0	735	4	Lecceta2	site_a	8265940	230187	4966
736	0	0	4	Lecceta2	lithic_a	8265934	230213	4965
737	0	0	4	Lecceta2	lithic_a	8265945	230145	4966
741	742	738	4	Lecceta2	ceram_p	8265942	230055	4969
742	0	738	4	Lecceta2	struct_l	8265940	230049	4971
743	0	0	4	Lecceta2	lithic_a	8265942	230066	4969
744	0	0	4	Lecceta2	lithic_a	8266007	230079	4968
745	0	745	4	Lecceta3	site_a	8266195	230105	4967
746	0	0	4	Lecceta3	lithic_a	8266191	230093	4968
747	0	0	4	Lecceta3	lithic_a	8266192	230094	4968
748	0	0	4	Lecceta3	lithic_a	8266190	230085	4968
749	0	745	4	Lecceta3	struct_l	8266190	230077	4971
750	0	750	4		site_p	8266886	230912	4958
751	751	751	4	Torarana6	struct_l	0	0	5015
752	0	752	3	Pocechata1	site_a	8285185	237158	3900
753	0	753	3	Pocechata2	site_a	8285145	237142	3894

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
754	0	0	3	Pocechata2	lithic_a	8285147	237150	3896
755	0	755	3	Pocechata3	site_a	8285163	236986	3879
756	0	0	3	Pocechata3	lithic_a	8285156	236988	3880
757	0	0	3	Pocechata3	lithic_a	8285158	236986	3880
758	0	755	3	Pocechata3	ceram_p	8285182	236989	3884
760	0	760	3	Pocechata4	site_a	8285217	236903	3879
761	0	761	3	Pocechata5	site_a	8285233	236820	3871
762	0	0	3	Pocechata5	lithic_a	8285222	236856	3876
763	0	763	3	Confluencia3	site_a	8285438	236729	3885
764	0	764	3	Confluencia2	site_a	8285471	236686	3883
765	765	764	3	Confluencia2	struct_a	8285482	236697	3882
766	0	0	3	Confluencia2	lithic_a	8285476	236696	3883
767	0	767	3	Confluencia1	site_a	8285507	236535	3872
768	0	0	3	Confluencia1	lithic_a	8285506	236534	3878
769	0	769	4	Torarana1	site_a	8267864	232650	4912
770	0	770	4	Torarana2	site_a	8267903	232684	4906
771	0	771	4	Torarana3	site_a	8267813	233307	4833
772	0	0	4	Torarana3	lithic_a	8267818	233308	4828
773	0	773	4		site_a	0	0	4625
774	0	774	4	Torarana4	site_a	8267607	233763	4707
775	0	775	4		site_a	0	0	4709
776	0	775	4		site_a	0	0	4851
777	0	776	4	puma3	ceram_p	8266480	233368	4872
778	0	778	4	puma3	lithic_p	8266359	233195	4873
779	0	779	4	puma3	site_a	8266394	233182	4871
780	0	779	4	puma3	lithic_p	0	0	4873
781	0	781	3	Ccencco1	site_a	8284800	239141	3911
782	0	782	3	Anccasuyo4	site_a	8285274	239744	3959
783	0	783	3	Anccasuyo2	site_a	8285451	239849	3974
784	0	784	3	Anccasuyo3	site_a	8285333	239864	3962
785	0	785	3	Anccasuyo1	site_a	8285705	239957	3997
786	786	785	3	Anccasuyo1	struct_a	8285688	239933	3998
787	787	785	3	Anccasuyo1	struct_a	8285675	239932	3995
788	788	785	3	Anccasuyo1	struct_a	8285681	239940	3997
789	789	785	3	Anccasuyo1	struct_a	8285691	239939	3997
790	0	790	3	Anccasuyo1	lithic_p	8285691	239949	3995
791	791	785	3	Anccasuyo1	struct_a	8285681	239980	3995
792	0	792	3	Anccasuyo5	site_a	8285521	240119	3981
793	0	793	3	Ccencco2	site_a	8285391	240218	3981
794	0	794	3	Anccasuyo5	site_a	8285231	239837	3969

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
795	795	794	3	Anccasuyo5	lithic_p	0	0	3967
796	0	796	3	Anccasuyo6	site_a	8285108	239739	3980
797	797	796	3	Anccasuyo6	struct_a	8285108	239734	3980
798	798	796	3	Anccasuyo6	ceram_a	8285108	239747	3981
799	0	799	3	Anccasuyo7	site_a	8284973	239649	3955
800	800	799	3	Anccasuyo7	struct_a	8284988	239654	3955
801	800	799	3	Anccasuyo7	ceram_p	8284989	239658	3956
802	0	802	3	Cab. De Leon1	site_a	8284357	239319	3929
803	0	802	3	Cab.De Leon1	ceram_p	8284360	239335	3932
804	0	804	3	Cab.De Leon2	site_a	8284246	239257	3939
805	0	805	3	Cab.De Leon3	site_a	8284311	239135	3929
806	0	806	3	Sullullumba	site_a	8287883	235602	3893
807	0	0	3	Sullullumba	lithic_a	8287887	235601	3893
808	0	0	3	Sullullumba	lithic_a	8287905	235603	3897
809	0	806	3	Sullullumba	lithic_p	8287889	235603	3897
810	0	806	3	Sullullumba	lithic_p	8287883	235598	3897
811	0	811	3	Ancash Pata	site_a	8288494	235896	3926
812	812	811	3	Ancash Pata	struct_a	8288492	235900	3926
813	0	0	3		ceram_p	8288737	235811	3887
814	0	0	3		ceram_p	8288765	235856	3892
815	0	0	3	Catahue Pampa	site_p	8288864	235857	3918
816	0	816	3	Catahue Pampa	site_a	8288924	235992	3884
817	0	817	2	Huanatira1	site_a	8260562	242521	4371
818	0	817	2	Huanatira1	site_p	8260554	242587	4370
819	0	817	2	Huanatira1	ceram_p	8260467	242571	4370
820	0	817	2	Huanatira1	site_p	8260626	242445	4377
821	0	0	2	Huanatira1	lithic_a	8260591	242483	4373
822	0	817	2	Huanatira1	site_p	8260611	242491	4375
823	0	817	2	Huanatira1	site_p	8260614	242501	4375
824	0	817	2	Huanatira1	site_p	8260605	242488	4375
825	0	817	2	Huanatira1	site_p	8260596	242461	4375
826	0	817	2	Huanatira1	site_p	8260577	242463	4375
827	0	817	2	Huanatira1	site_p	8260583	242478	4375
828	0	0	2	Huanatira1	lithic_a	8260595	242482	4373
829	829	817	2	Huanatira1	struct_a	8260583	242467	4375
830	829	817	2	Huanatira1	struct_p	8260558	242468	4376
831	0	817	2	Huanatira1	site_p	8260592	242456	4375
832	832	817	2	Huanatira1	ceram_a	8260586	242528	4371
833	0	0	2	Huanatira1	lithic_a	8260495	242489	4372
834	0	0	2	Huanatira1	lithic_a	8260496	242485	4372

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
835	835	817	3		struct_a	8286495	241781	4113
835	835	817	3	Huanatira1	site_p	8260496	242491	4372
836	836	0	3	Ccencco	struct_a	8286335	241535	4088
837	0	837	3	Ccencco	site_a	8286270	241722	4105
838	838	837	3	Ccencco	struct_l	8286268	241727	4108
839	839	0	3		ceram_a	8284868	240096	3945
840	0	840	3	Ccencco3	site_a	8284676	239833	3949
841	0	841	5	Llallahue3	site_a	8277242	239447	4053
842	842	841	5	Llallahue3	struct_a	8277252	239453	4057
843	843	841	5	Llallahue3	struct_a	8277234	239441	4053
844	0	841	5	Llallahue3	site_p	8277241	239453	4054
844	0	841	5	Llallahue3	site_p	8277242	239454	4059
845	0	841	5	Llallahue3	ceram_p	8277238	239444	4054
846	846	0	5	Llallahue3	struct_a	8277313	239273	4070
847	0	847	5	Nasaparco1	site_a	8277783	238214	4295
848	848	847	5	Nasaparco1	struct_l	8277800	238198	4295
849	0	0	5	Nasaparco1	lithic_a	8277796	238203	4295
850	849	847	5	Nasaparco1	struct_p	8277793	238202	4295
851	0	851	5	Nasaparco2	site_a	8277688	237496	4326
852	852	851	5	Nasaparco2	struct_a	8277689	237494	4326
853	0	0	5		site_p	8283120	236895	3951
854	0	0	5		site_p	8283245	236913	3942
855	0	855	2	Huanatira2	site_a	8260330	242611	4372
856	856	855	2	Huanatira2	struct_a	8260272	242558	4373
857	857	855	2	Huanatira2	struct_a	8260303	242562	4374
858	858	855	2	Huanatira2	struct_a	8260280	242597	4372
859	859	855	2	Huanatira2	struct_a	8260308	242621	4371
860	860	855	2	Huanatira2	struct_a	8260375	242636	4369
861	861	855	2	Huanatira2	struct_a	8260362	242636	4369
862	862	855	2	Huanatira2	struct_a	8260392	242614	4368
863	0	855	2	Huanatira2	site_p	8260205	242566	4371
863	0	855	2	Huanatira2	site_p	8260206	242566	4368
864	0	855	2	Huanatira2	ceram_p	8260206	242567	4371
865	0	0	2	Huanatira2	lithic_a	8260228	242546	4372
866	0	0	2	Huanatira2	lithic_a	8260247	242569	4372
866	0	0	2	Huanatira2	lithic_a	8260247	242569	4372
867	0	855	2	Huanatira2	site_p	8260242	242573	4368
868	0	855	2	Huanatira2	site_p	8260248	242563	4368
869	0	0	2	Huanatira2	lithic_a	8260217	242509	4373
869	0	0	2	Huanatira2	lithic_a	8260217	242509	4373

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
870	0	855	2	Huanatira2	site_p	8260214	242509	4368
871	0	855	2	Huanatira2	site_p	8260219	242513	4368
872	0	855	2	Huanatira2	site_p	8260358	242673	4369
873	859	855	2	Huanatira2	site_p	8260267	242622	4371
874	874	855	2	Huanatira2	ceram_a	8260324	242654	4370
876	0	0	2	Huanatira2	lithic_a	8260326	242652	4370
877	0	855	2	Huanatira2	site_p	8260325	242656	4368
878	0	855	2	Huanatira2	site_p	8260328	242651	4368
879	0	0	2	Huanatira2	lithic_a	8260377	242669	4369
880	0	0	2	Huanatira2	lithic_a	8260362	242673	4369
881	0	855	2	Huanatira2	site_p	8260364	242673	4368
882	0	855	2	Huanatira2	site_p	8260365	242675	4368
883	879	855	2	Huanatira2	site_p	8260378	242676	4368
884	0	0	2	Huanatira2	lithic_a	8260398	242634	4369
885	0	855	2	Huanatira2	site_p	8260381	242626	4368
886	0	855	2	Huanatira2	site_p	8260399	242630	4368
887	0	855	2	Huanatira2	site_p	8260420	242644	4368
888	0	855	2	Huanatira2	site_p	8260387	242631	4368
889	860	855	2	Huanatira2	site_p	8260370	242612	4368
890	0	0	2	Huanatira2	lithic_a	8260306	242586	4372
891	0	855	2	Huanatira2	site_p	8260308	242605	4368
892	0	855	2	Huanatira2	site_p	8260296	242578	4368
893	0	855	2	Huanatira2	site_p	8260298	242593	4368
894	0	894	2	Huanatira3	site_a	8260117	242474	4380
895	895	894	2	Huanatira3	struct_a	8260150	242432	4382
896	896	894	2	Huanatira3	struct_a	8260144	242426	4383
897	897	894	2	Huanatira3	struct_a	8260143	242432	4383
898	0	894	2	Huanatira3	lithic_p	8260131	242496	4377
899	0	0	2	Huanatira3	lithic_a	8260157	242467	4381
900	0	900	2	Huanatira3	site_a	8260760	242448	4384
901	901	900	2	Huanatira3	struct_a	8260743	242463	4378
902	0	0	2	Huanatira3	lithic_a	8260757	242485	4377
903	903	900	2	Huanatira3	struct_l	8260786	242388	4395
904	0	0	2	Huanatira3	lithic_a	8260787	242417	4384
905	904	900	2	Huanatira3	lithic_p	8260786	242416	4385
906	0	900	2	Huanatira3	site_p	8260789	242419	4385
907	0	900	2	Huanatira3	site_p	8260786	242422	4385
908	904	900	2	Huanatira3	ceram_p	8260791	242408	4385
909	0	909	5	Achacota1	site_a	8276870	239040	4129
910	0	910	5	Collpa	site_a	8275687	234483	4489

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
911	0	0	5	Collpa	lithic_a	8275645	234441	4497
912	0	910	5	Collpa	site_p	8275627	234443	4497
913	0	910	5	Collpa	site_p	8275644	234437	4497
914	0	910	5	Collpa	site_p	8275644	234440	4497
915	911	910	5	Collpa	lithic_p	8275646	234438	4497
916	911	910	5	Collpa	ceram_p	8275646	234435	4497
917	0	0	5	Collpa	lithic_a	8275718	234422	4488
918	917	910	5	Collpa	lithic_p	8275715	234424	4487
918	917	910	5	Collpa	lithic_a	8275652	234451	4497
919	919	910	5	Collpa	struct_l	8275716	234394	4488
920	919	910	5	Collpa	ceram_p	8275717	234402	4488
921	921	910	5	Collpa	struct_l	8275708	234440	4487
922	0	910	5	Collpa	lithic_p	8275612	234429	4499
923	923	910	5	Collpa	lithic_a	0	0	0
924	0	0	5	Collpa	lithic_a	8275703	234434	4493
925	924	910	5	Collpa	lithic_p	8275700	234432	4488
926	0	926	3	callalli13	site_a	8283802	239064	4005
927	927	926	3	callalli13	struct_a	8283827	239078	4006
928	0	0	3	callalli13	lithic_a	8283855	239063	4006
929	0	0	3	callalli13	lithic_a	8283786	239065	4006
930	929	926	3	callalli13	lithic_p	8283777	239072	4006
931	929	926	3	callalli13	ceram_p	8283796	239067	4006
932	0	933	3	callalli12	site_a	8283819	239189	4005
933	928	926	3	callalli13	lithic_p	8283875	239063	4005
934	934	0	3	Cabeza de Leon	struct_a	8283900	240044	4109
935	0	935	3	Cabeza de Leon	site_a	8283976	239825	4087
936	0	935	3	Cabeza de Leon	ceram_p	8283953	239850	4091
937	0	937	3	Pukara Quelkata	site_a	8283894	240828	4058
938	0	938	2	Huanatira4	site_a	8260824	242343	4402
939	0	0	2	Huanatira4	lithic_a	8260803	242334	4399
940	0	0	2	Huanatira4	lithic_a	8260802	242339	4399
941	939	938	2	Huanatira4	lithic_p	8260798	242332	4399
942	940	938	2	Huanatira4	lithic_p	8260793	242331	4399
943	940	938	2	Huanatira4	lithic_p	8260792	242331	4399
944	940	938	2	Huanatira4	lithic_p	8260792	242326	4399
945	940	938	2	Huanatira4	lithic_p	8260796	242340	4399
946	940	938	2	Huanatira4	lithic_p	8260789	242341	4399
947	0	938	2	Huanatira4	lithic_p	8260784	242348	4395
948	0	938	2	Huanatira4	site_p	8260810	242334	4402
949	939	938	2	Huanatira4	lithic_p	8260800	242330	4399

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
950	0	950	2	Huanatira5	site_a	8260742	242135	4426
951	0	950	2	Huanatira5	lithic_p	8260728	242183	4407
952	0	950	2	Huanatira5	lithic_p	8260723	242143	4417
953	0	950	2	Huanatira5	lithic_p	8260803	242203	4414
954	0	950	2	Huanatira5	lithic_p	8260743	242192	4407
955	955	950	2		struct_l	8260581	241856	4485
956	0	956	2	Huanatira6	site_a	8260938	242410	4422
957	957	956	2	Huanatira6	struct_l	8261017	242376	4461
958	958	956	2	Huanatira6	struct_a	8261019	242366	4460
959	959	0	2	Pausa2 A02-39	struct_l	8261093	242574	4382
960	0	956	2	Huanatira6	lithic_p	8260986	242378	4456
961	0	956	2	Huanatira6	lithic_p	8260906	242449	4403
962	0	900	2	Huanatira3	lithic_p	8260726	242500	4377
963	0	900	2	Huanatira3	lithic_p	8260727	242495	4377
964	0	900	2	Huanatira3	lithic_p	8260729	242489	4377
966	0	966	4	puma4	site_a	8266114	232024	4876
967	0	967	4	Torarana7	site_a	8268132	231799	4993
968	968	967	4	Torarana7	struct_l	8268108	231804	4991
969	0	0	4	Torarana7	lithic_a	8268125	231800	4990
970	0	967	4	Torarana7	site_p	8268119	231800	4982
971	0	971	4	Torarana9	site_a	8268211	231678	4977
972	0	0	4	Torarana9	lithic_a	8268209	231680	4974
973	0	971	4	Torarana9	site_p	8268195	231666	4977
974	0	974	4	Torarana5	site_a	8268508	230985	5024
975	0	975	4	Torarana6	site_a	8268138	231161	5015
976	976	975	4	Torarana6	struct_l	8268129	231133	5008
977	0	0	4	Torarana6	lithic_a	8268126	231172	5015
978	0	975	4	Torarana6	site_p	8268121	231174	5008
979	0	979	4	Erhuarayo1	site_a	8265718	240958	4499
981	0	0	4	Erhuarayo1	lithic_a	8265717	240958	4496
982	982	979	4	Erhuarayo1	lithic_p	8265738	240942	4491
983	0	0	4	Erhuarayo1	lithic_a	8265714	240961	4499
984	0	979	4	Erhuarayo1	site_p	8265711	240959	4496
985	985	985	3	Quelkata	site_p	8283827	241197	3951
991	0	0	2	Pausa2 A02-39	lithic_a	8261062	242702	4367
992	0	2039	2	Pausa2 A02-39	site_p	8261058	242702	4362
993	0	2039	2	Pausa2 A02-39	site_p	8261069	242704	4362
994	0	0	2	Pausa2 A02-39	lithic_a	8261099	242736	4364
995	0	2039	2	Pausa2 A02-39	site_p	8261100	242732	4362
996	0	2039	2	Pausa2 A02-39	site_p	8261095	242732	4362

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
997	997	2039	2	Pausa2 A02-39	ceram_a	8261089	242735	4364
998	0	0	2	Pausa2 A02-39	lithic_a	8261082	242719	4366
999	0	2039	2	Pausa2 A02-39	lithic_p	8261053	242730	4366
1000	0	1000	5	Kacapunku1	site_a	8281329	244011	3985
1001	1001	1000	5	Kacapunku1	struct_l	8281294	244032	3985
1002	1002	1000	5	Kacapunku1	struct_l	8281308	244003	3985
1003	1003	1000	5	Kacapunku1	struct_l	8281315	243983	3981
1004	0	0	5	Kacapunku1	lithic_a	8281325	244009	3981
1005	0	1000	5	Kacapunku1	site_p	8281327	244006	3976
1006	0	1000	5	Kacapunku1	site_p	8281323	244010	3976
1007	1004	1000	5	Kacapunku1	lithic_p	8281328	244004	3981
1008	1004	1000	5	Kacapunku1	lithic_p	8281325	244002	3981
1009	0	1000	5	Kacapunku1	lithic_p	8281315	243986	3985
1010	0	0	5	Kacapunku1	lithic_a	8281348	244008	3977
1011	0	1000	5	Kacapunku1	site_p	8281348	244007	3976
1012	0	1000	5	Kacapunku1	site_p	8281346	244002	3976
1013	0	0	5	Kacapunku1	lithic_a	8281334	244015	3980
1014	0	1000	2	Chiripascapa	site_a	8261405	242846	4376
1015	0	1014	2	Chiripascapa	lithic_p	8261359	242797	4377
1016	0	1014	2	Chiripascapa	lithic_p	8261328	242908	4376
1017	0	1014	2	Chiripascapa	lithic_p	8261375	242886	4372
1018	0	1014	2	Chiripascapa	lithic_p	8261371	242901	4372
1019	0	1014	2	Chiripascapa	lithic_p	8261416	242822	4375
1020	0	1014	2	Chiripascapa	lithic_p	8261461	242849	4372
1021	0	1014	2	Chiripascapa	lithic_p	8261419	242875	4372
1022	0	1014	2	Chiripascapa	lithic_p	8261412	242867	4372
1023	0	0	2	Chiripascapa	lithic_a	8261368	242873	4376
1024	0	0	2	Chiripascapa	lithic_a	8261366	242888	4376
1025	0	1025	2	Pausa3	site_a	8261363	242706	4381
1026	0	0	2	Pausa3	lithic_a	8261377	242724	4377
1027	0	1025	2	Pausa3	site_p	8261379	242731	4381
1028	0	1025	2	Pausa3	site_p	8261376	242737	4381
1029	0	1025	2	Pausa3	site_p	8261376	242745	4381
1030	0	1025	2	Pausa3	lithic_p	8261390	242676	4386
1031	0	1025	2	Pausa3	lithic_p	8261376	242718	4381
1032	0	1025	2	Pausa3	lithic_p	8261373	242741	4376
1033	0	1025	2	Pausa3	lithic_p	8261358	242746	4376
1034	0	1025	2	Pausa3	lithic_p	8261347	242749	4376
1035	0	1025	2	Pausa3	lithic_p	8261356	242754	4376
1036	0	1025	2	Pausa3	lithic_p	8261358	242754	4376

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
1037	0	1025	2	Pausa3	lithic_p	8261357	242757	4376
1038	0	0	2	Pausa3	lithic_a	8261364	242670	4375
1039	0	1025	2	Pausa3	site_p	8261366	242671	4381
1040	0	1025	2	Pausa3	site_p	8261367	242677	4381
1041	1041	1025	2	Pausa3	ceram_a	8261365	242655	4385
1042	0	1025	2	Pausa3	lithic_p	8261365	242662	4382
1043	0	0	2	Pausa3	lithic_a	8261373	242703	4381
1044	0	1025	2	Pausa3	lithic_p	8261392	242720	4381
1045	1045	1025	2	Pausa3	struct_a	8261351	242623	4391
1046	1045	1025	2	Pausa3	lithic_p	0	0	4391
1047	0	1025	2	Pausa3	lithic_p	8261382	242765	4376
1048	0	1025	2	Pausa3	lithic_p	8261412	242734	4387
1049	0	1049	2	Chiripascapa	site_a	8261368	242535	4414
1050	0	1049	2	Chiripascapa	struct_l	8261341	242515	4414
1051	1052	1025	2	Chiripascapa	lithic_p	8261364	242522	4414
1052	0	1049	2	Chiripascapa	lithic_a	8261374	242528	4414
1052	0	1049	2	Chiripascapa	ceram_p	8261371	242521	4414
1053	0	1049	2	Chiripascapa	site_p	8261371	242521	4423
1054	0	1049	2	Chiripascapa	site_p	8261371	242521	4423
1055	0	1049	2	Chiripascapa	ceram_p	8261350	242526	4403
1056	0	1049	2	Chiripascapa	ceram_p	8261374	242532	4404
1057	0	1025	2	Chiripascapa	lithic_p	8261474	242855	4372
1058	0	1058	2	Chiripascapa2	site_a	8261528	242866	4372
1059	1059	1058	2	Chiripascapa2	struct_a	8261535	242856	4374
1060	0	0	2	Chiripascapa2	lithic_a	8261531	242876	4370
1061	0	1025	2	Chiripascapa2	lithic_p	8261619	242895	4379
1062	0	1025	2	Taquepalca	lithic_p	8261645	242903	4379
1063	0	0	2	Taquepalca	ceram_p	8261653	242939	4377
1064	0	1064	2	Taquepalca	site_a	8261739	242962	4397
1065	1065	1064	2	Taquepalca	Struct_l	8261742	242944	4398
1066	1066	1064	2	Taquepalca	Struct_a	8261732	242958	4397
1067	0	1064	2	Taquepalca	lithic_p	8261723	242947	4389
1068	0	1068	2	Erhuarayo2	site_a	8262203	242967	4384
1069	1069	1068	2	Erhuarayo2	Struct_l	8262184	242936	4384
1070	0	0	2	Erhuarayo2	lithic_a	8262203	242947	4377
1071	0	1068	2	Erhuarayo2	site_p	8262210	242949	4392
1072	0	1068	2	Erhuarayo2	Ceram_p	8262174	242979	4367
1072	0	1068	2	Erhuarayo2	site_p	8262205	242948	4392
1074	0	1074	3	Pokallacta	site_a	8285001	237776	3930
1075	1075	1074	3	Pokallacta	Struct_l	8284980	237791	3936

ArchID A03-	LocusID	SiteID	Block	Site_Name	File_Type	Northings	Eastings	Alt m
1075	1075	1074	3	Pokallacta	Struct_a	8284982	237783	3934
1076	1076	1074	3	Pokallacta	Struct_l	8284995	237813	3950
1076	1076	1074	3	Pokallacta	Struct_a	8284997	237795	3935
1077	1076	1074	3	Pokallacta	Ceram_p	8285006	237795	3950
1078	1076	1074	3	Pokallacta	lithic_p	8285004	237794	3950
1079	0	0	3	Pokallacta	lithic_p	8285075	237785	3948
1080	0	1074	3	Pokallacta	lithic_p	8285082	237717	3933
1082	0	1082	3	Confluencia4	site_a	8285653	237021	3958
1083	1083	1082	3	Confluencia4	Struct_a	8285645	237020	3958
1085	0	1085	3	Secceta1	site_a	8285964	236628	3872
1086	0	0	3	Secceta1	lithic_a	8285945	236618	3875
1087	0	0	3	Secceta1	Ceram_p	8286003	236682	3878
1088	0	1088	3	Secceta2	site_a	8285904	236631	3875
1089	1089	0	3	Secceta2	Struct_a	8285822	236674	3868
1090	1090	1088	3	Secceta2	Struct_a	8285896	236637	3878
1091	0	0	3	Secceta2	Struct_l	8285902	236622	3875
1092	1092	0	3		Struct_a	8285688	236661	3863
1093	0	2026	3	Taukamayo1	site_p	8284385	237147	3887
1094	0	675	3	Taukamayo1	site_p	8284380	237144	3887
1095	0	675	3	Taukamayo1	site_p	8284368	237153	3887
1096	0	675	3	Taukamayo1	site_p	8284369	237149	3887
1097	678	2026	3	Taukamayo1	Ceram_p	8284387	237142	3888
1098	0	2026	3	Taukamayo1	lithic_p	8284367	237151	3888
1099	0	2026	3	Taukamayo1	lithic_p	8284395	237127	3887
1100	0	2026	3	Taukamayo1	lithic_p	8284388	237148	3887
1200	0	2039	2	Pausa2	Site_p	0	0	4367
1201	0	2039	2	Pausa2	Site_p	0	0	4365
1202	0	2039	2	Pausa2	Site_p	0	0	4365
1203	0	2039	2	Pausa2	Site_p	0	0	4365
1205	0	2002	3	Taukamayo1	Site_p	0	0	3892
1206	0	675	3	Taukamayo1	Site_p	0	0	3892
1208	0	675	3	Taukamayo1	Site_p	0	0	3891
1209	0	201	1	Saylluta2	TU1x1m	8269481	226709	4815
1210	0	219	1	Cantera	TU1x1m	8269005	228164	4974
1211	0	126	1	Mayemeja1	TU1x1m	0	0	4901

A.2. Lot ID Registry

All excavated contexts were assigned a LotID number after the fact. This number was transformed into a lab numbering system for individual artifact proveniencing with this function [2000 + (1000 * LotID#)] as described in Section 5.6.3. The Lot ID numbers below are hotlinks that will reference artifacts in the online database.

LotID L03-	Block	Site	Unit	Quad	Level	Feature	Excav_Date	Notes
1	3	a02026	1		2	0a	11/5/2003	
2	3	a02026	1	x	2	0a	11/5/2003	
3	3	a02026	1	a	2	0a	11/5/2003	
4	3	a02026	1		3	0a	11/5/2003	
5	3	a02026	1	x	3	0a	11/5/2003	
6	3	a02026	1		4	1	11/6/2003	
7	3	a02026	1	x	4	1	11/6/2003	
8	3	a02026	1		5	1	11/6/2003	
9	3	a02026	1		5	2	11/6/2003	
10	3	a02026	1	x	5	1	11/6/2003	
11	3	a02026	1	x	5	2	11/6/2003	
12	3	a02026	1	a	6	1	11/7/2003	
13	3	a02026	1	b	6	1	11/7/2003	
14	3	a02026	1	x	6	1	11/7/2003	
15	3	a02026	1	xa	6	1	11/7/2003	
16	3	a02026	1		7	1	11/8/2003	
17	3	a02026	1		7	3	11/8/2003	
18	3	a02026	1	x	7	1	11/8/2003	
19	3	a02026	1	x	7	3	11/8/2003	
20	3	a02026	1		8	1	11/10/2003	
21	3	a02026	1		8	4	11/10/2003	
22	3	a02026	1	x	8	1	11/8/2003	
23	3	a02026	1		9	1	11/10/2003	AMS: 1313+/-36 (650-780 AD)
24	3	a02026	1		9	4	11/10/2003	
25	3	a02026	1	x	9	1	11/10/2003	
26	3	a02026	1	x	11	1	11/11/2003	
27	3	a02026	1	b	11	1	11/11/2003	
28	3	a02026	1	a	11	1	11/11/2003	
29	3	a02026	1		10	1	11/11/2003	

LotID L03-	Block	Site	Unit	Quad	Level	Feature	Excav_Date	Notes
30	3	a02026	1	b	10	5	11/11/2003	
31	3	a02026	1	x	10	1	11/11/2003	
32	3	a02026	1	a	12	1	11/11/2003	
33	3	a02026	1	b	12	1	11/11/2003	
34	3	a02026	1	x	12	1	11/11/2003	
35	3	a02026	1	a	13	1	11/11/2003	
36	3	a02026	1	b	13	1	11/11/2003	
37	3	a02026	1	x	13	1	11/12/2003	
38	3	a02026	1	c	14	1	11/12/2003	
39	3	a02026	1	c	15	1	11/12/2003	
40	3	a02026	2	b	5		11/21/2003	Profile II
41	3	a02026	2		6		11/21/2003	Profile II
42	3	a02026	2		1		11/19/2003	Profile II
43	3	a02026	2		2		11/19/2003	Profile II
44	3	a02026	2		3		11/19/2003	Profile II
45	3	a02026	2	a	5		11/21/2003	profile II
46	3	a02026	2	a	1		11/12/2003	Profile II
47	3	a02026	2	a	3		11/12/2003	Profile II
48	3	a02026	2	a	4		11/12/2003	Profile II
49	3	a02026	2	b	1		11/12/2003	Profile II
50	3	a02026	2	b	2		11/12/2003	Profile II
51	3	a02026	2	b	3		11/12/2003	Profile II
52	3	a02026	2	c	2		11/12/2003	Profile II
53	3	a02026	2	c	3		11/12/2003	Profile II
54	3	a02026	2	d	3		11/12/2003	Profile II
55	3	a02026	2	d	4		11/12/2003	Profile II
56	3	a02026	2				11/12/2003	Profile II
57	3	a02026	2				11/12/2003	From Profile Wall
58	2	a02039	4		1	0a	10/1/2003	
59	2	a02039	4		2	1	10/2/2003	
60	2	a02039	4		3	1	10/17/2003	AMS: 1822+/-37BP (120AD-260AD)
61	2	a02039	4		3	2	10/17/2003	
62	2	a02039	4		4	1	10/18/2003	
63	2	a02039	4		4	2	10/18/2003	
64	2	a02039	4		5	1	10/18/2003	
65	2	a02039	4		5	2	10/18/2003	
66	2	a02039	4		5	3	10/18/2003	
67	2	a02039	4		6	1	11/1/2003	
68	2	a02039	4		6	2	11/1/2003	
69	2	a02039	4		6	3	11/1/2003	
70	2	a02039	4		7	4	11/1/2003	

LotID L03-	Block	Site	Unit	Quad	Level	Feature	Excav_Date	Notes
71	2	a02039	4		8	4	11/2/2003	
72	2	a02039	4				11/3/2003	Profile Norte
73	2	a02039	4		4		11/3/2003	Profile N Wall
74	2	a02039	4				11/3/2003	Profile SW
75	2	a02039	4				11/1/2003	Profile Oeste
76	2	a02039	3		4	1	10/2/2003	
77	2	a02039	3		4	3	10/2/2003	
78	2	a02039	3		5	1	10/17/2003	
79	2	a02039	3		5	3	10/17/2003	
80	2	a02039	3	a	6	1	10/18/2003	
81	2	a02039	3		6	3	10/18/2003	
82	2	a02039	3	a	7	1	11/1/2003	
83	2	a02039	3	b	7	1	11/1/2003	
84	2	a02039	3				10/18/2003	N Side wall
85	2	a02039	3			1-2	11/2/2003	Under Big Rocks
86	2	a02039	3		1	0a	9/30/2003	
87	2	a02039	3		2	0a	10/1/2003	
88	2	a02039	3		2	1	10/1/2003	
89	2	a02039	3		3	1	10/1/2003	
90	2	a02039	3		3	2	10/1/2003	
91	2	a02039	3		3	0a	10/1/2003	
92	2	a02039	2		1	0a	9/28/2003	
93	2	a02039	2		2	0a	9/28/2003	
94	2	a02039	2		2		9/28/2003	
95	2	a02039	2		3	0a	9/29/2003	
96	2	a02039	2		3	1	9/29/2003	
97	2	a02039	2		4	1	9/29/2003	AMS: 1586+/-35 (400-570AD)
98	2	a02039	2		4	2	9/30/2003	
99	2	a02039	2		5	2	9/30/2003	
100	2	a02039	2		5	1	9/30/2003	
101	2	a02039	2		5	3	9/30/2003	
102	2	a02039	1		1	0a	9/28/2003	
103	2	a02039	1		2	0a	9/28/2003	
104	2	a02039	1		3	0a	9/29/2003	
105	2	a02039	1		3	1	9/28/2003	0a + F1
106	2	a02039	1		4	0a	9/29/2003	
107	2	a02039	1		4	1	9/29/2003	0a + F1
108	2	a02039	1		5	0a	9/29/2003	
109	2	a02039	1		5	0b	9/29/2003	
110	2	a02039	2		6	1	10/1/2003	
111	2	a02039	2		6	2	10/1/2003	

LotID L03-	Block	Site	Unit	Quad	Level	Feature	Excav_Date	Notes
112	1	q02002	1	a	1	0a	8/20/2003	a03-201
113	1	q02002	1	b	1		8/20/2003	a03-201
114	1	q02002	1	b	1	0a	8/21/2003	a03-201
115	1	q02002	1	c	1	0a	8/21/2003	a03-201
116	1	q02002	1	d	1		8/20/2003	a03-201
117	1	q02002	1	d	1	0a	8/21/2003	a03-201
118	1	q02002	1	a	2	0a	8/21/2003	a03-201
119	1	q02002	1	b	2	0a	8/21/2003	a03-201
120	1	q02002	1	c	2	0a	8/21/2003	a03-201
121	1	q02002	1	d	2	0a	8/21/2003	a03-201
122	1	q02002	1		3	0a	8/22/2003	a03-201
123	1	q02002	1		4	0a	8/22/2003	a03-201
124	1	q02002	1		5	1	8/23/2003	a03-201
125	1	q02002	1		5	0a	8/22/2003	a03-201
126	1	q02002	1		5	2	8/23/2003	a03-201
127	1	q02002	1		6	0a	8/23/2003	a03-201
128	1	q02002	1		6	1	8/23/2003	a03-201
129	1	q02002	1		7	0a	8/24/2003	a03-201
130	1	q02002	1		8	0a	8/25/2003	a03-201
131	1	q02002	1		9	0a	8/25/2003	a03-201
132	1	q02002	1		9	1	8/25/2003	a03-201
133	1	q02002	1		9	2	8/25/2003	a03-201
134	1	q02002	1		10	1	8/26/2003	a03-201
135	1	q02002	1		10	2	8/26/2003	a03-201
136	1	q02002	1		10	3	8/26/2003	a03-201
137	1	q02002	1		11	1	9/1/2003	a03-201
138	1	q02002	1		11	2	9/1/2003	a03-201
139	1	q02002	1		12	1	9/1/2003	a03-201
140	1	q02002	1		12	2	9/1/2003	a03-201
141	1	q02002	1		13	1	9/1/2003	a03-201
142	1	q02002	1		13	2	9/1/2003	a03-201
143	1	q02002	1		14	1	9/3/2003	a03-201
144	1	q02002	1		14	2	9/3/2003	a03-201
145	1	q02002	1		15	0a	9/3/2003	a03-201
146	1	q02002	1		16	0a	9/6/2003	a03-201
147	1	q02002	1				9/3/2003	a03-201, Perfil Oeste
148	1	q02002	2		1	0a	8/22/2003	a03-219
149	1	q02002	2		2	0a	8/22/2003	a03-219
150	1	q02002	2		3	0a	8/23/2003	a03-219
151	1	q02002	2		4	0a	8/23/2003	a03-219
152	1	q02002	2		5	0a	8/24/2003	a03-219

LotID L03-	Block	Site	Unit	Quad	Level	Feature	Excav_Date	Notes
153	1	q02002	2		6	0a	8/24/2003	a03-219
154	1	q02002	2		7	0a	8/24/2003	a03-219
155	1	q02002	2		8	0a	8/24/2003	a03-219
156	1	q02002	2		9	0a	8/25/2003	a03-219
157	1	q02002	2		10	0a	8/25/2003	a03-219
158	1	q02002	2		11	0a	8/25/2003	a03-219
159	1	q02002	3		1	0a	9/4/2003	
160	1	q02002	3		2	0a	9/4/2003	
161	1	q02002	3		3	1	9/5/2003	
162	1	q02002	3		4	1 (S2)	9/6/2003	AMS: 3149+/-53 (1530-1290BC)
163	1	q02002	3		5	F1+0b	9/5/2003	
164	1	q02002	3		6	0b (S3)	9/7/2003	AA61375
165	1	q02002	3		6	5	9/7/2003	
166	1	q02002	3		7	0c (S4)	9/8/2003	
167	3	a02026	2	b	4		11/21/2003	Prefile II
168	3	a02026	2	c	4		11/21/2003	Prefile II
169	3	a02026	2		4		11/21/2003	Prefile II
170	3	a02026	1	x			11/21/2003	Prefile
171	3	a03990	1		3b		11/28/2003	
172	3	a03990	1		3e		11/28/2003	
173	3	a02026	1	c	13	4	11/12/2003	
174	3	a02026	2		13	4	11/12/2003	
175	1	q02002	3		7	4	9/7/2003	

– Appendix B –

Selected Obsidian Sources in Southern Peru

This a brief description and photographs of material from a few obsidian sources in the region. The map (Figure 4-12, Table 4-3) and discussion in Section 4.4 provide additional information relevant to this list.

B.1. Aconcagua Obsidian Source

Other names: Aconcahua, **Latitude:** -16.8422, **Longitude:** -69.8632, **Reference:** Frye, Aldenderfer, Glascock 1998. West of Mazo Cruz (Puno) and east of Osmore (Moquegua), Peru

Figure B-1. Nodule from the Aconcagua source. Photo courtesy of Mark Aldenderfer.

B.2. Alca Obsidian Source

Other names: Umasca, Cusco Type, **Latitude:** -15.1202, **Longitude:** -72.6928,

References: Burger, Asaro, Trawick and Stross 1998b; Jennings and Glascock 2002; Rademaker, Sandweiss, Malpass, Umire, de la Vera Cruz, Fortin and Morris 2004. Southeast of Alca in the Cotahuasi Valley, Arequipa, Peru. A University of Maine team has recently located primary deposits on the north flanks of Nevado Firura at 4400 to 4800 masl, a higher elevation zone than was indicated by previous studies.

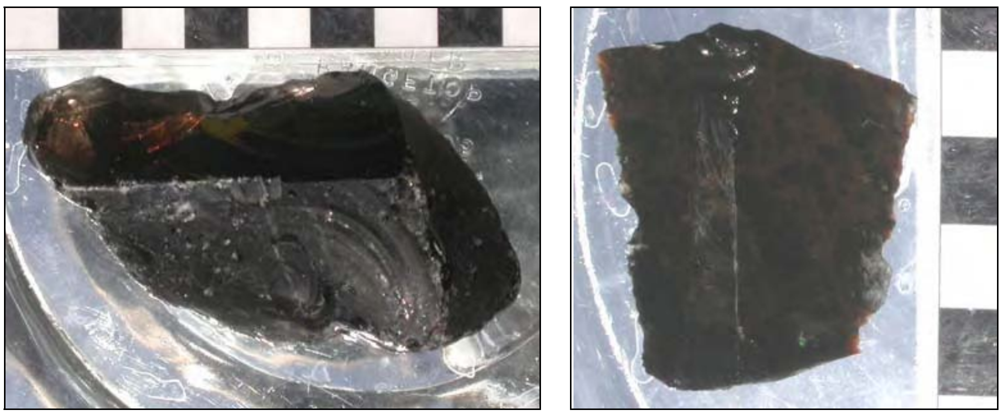


Figure B-2. Some nodules of Alca obsidian have a brownish tint.

B.3. Chivay Obsidian Source

Other names: Cotallalli, Cotallaulli, Titicaca Basin Type, **Latitude:** -15.6423, **Longitude:** -71.5355, **References:** Brooks et al. 1997; Burger et al. 1998. East of Chivay in the Colca Valley, Arequipa, Peru. Photos below show examples of Chivay obsidian nodules.

Figure B-3. Nodule of Chivay obsidian from Maymeja weighing 1750g and 23.3 cm long. This nodule was not utilized (scars are geological in origin), perhaps because it has irregularities in the form of tiny crystals.

The nodules below were selected to show the variability of cortex encountered in the source area.

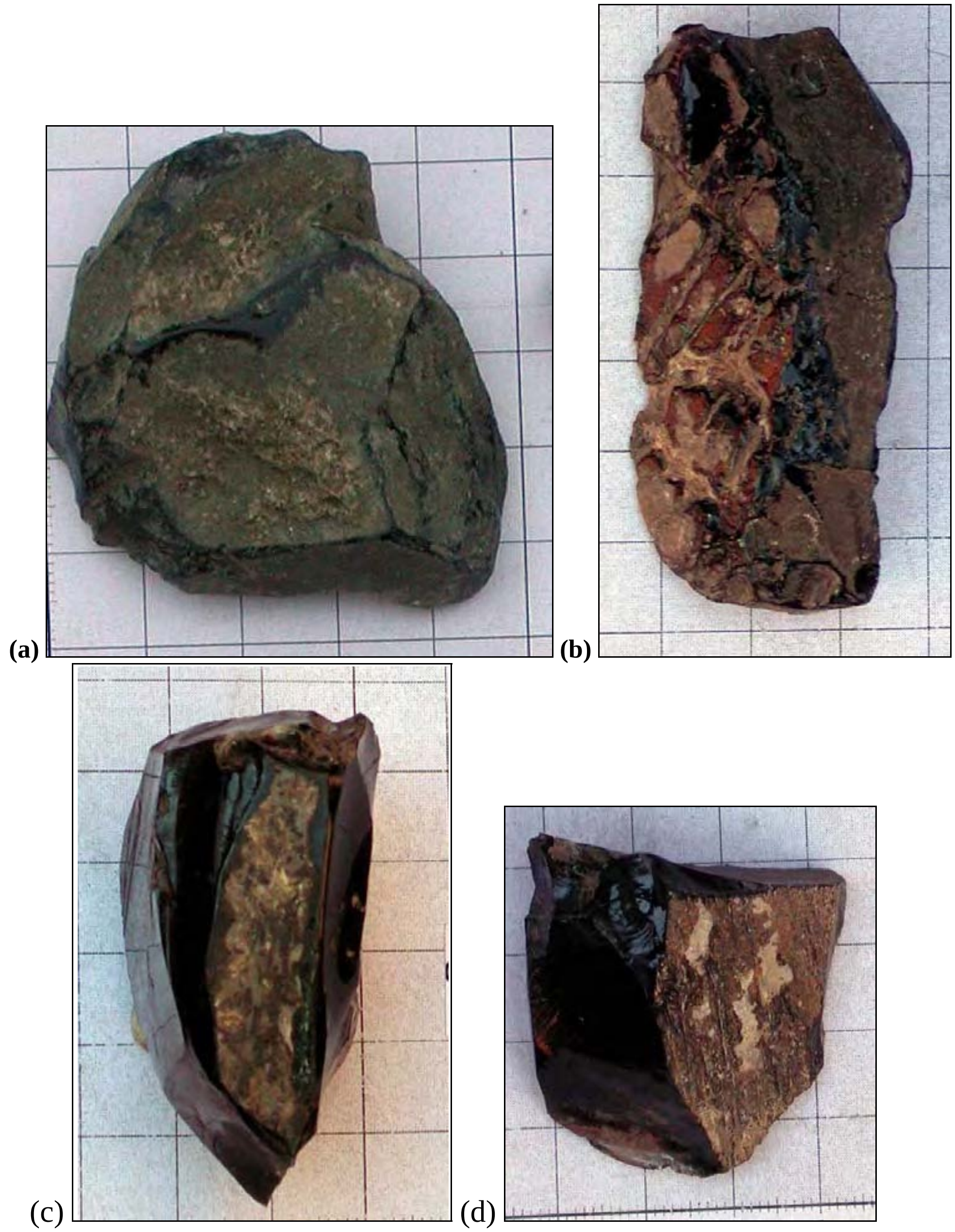


Figure B-4. Chivay obsidian (a, *L03-161.341*) nodule from quarry pit area with thin, angular cortex with tephra welded to exterior; (b, *L03-160.178*), an unmodified side of a grey core showing rough, tabular cortex with rounded corners, reddish tint is just a reflection. Three large flakes (not showing) were removed from opposite side of this core (c, L03-165.37) Core with cortical face of extremely thin cortex, some of the cortex is glassy while other parts appear opaque and perlitic; (d, *L03-159.194*) a core with cortical face on right showing a thin but "corduroy" cortex, and small quantities of light tephra welded to the outside.

B.4. Uyo Uyo Obsidian Source

Other names: Oyo Oyo, Caracachi, **Latitude:** -15.6155, **Longitude:** -71.6760, **References:** Brooks 1998, Wernke 2003. North of town of Ichupampa in the main Colca Valley.

Figure B-5. Nodule of Uyo Uyo obsidian with irregularities perhaps caused by air bubbles in the magma.

– Appendix C –

Obsidian Artifact Examples and Representations from the Andes

These photos present some examples of the diversity of formal obsidian tools that have been found in the south-central Andes (Burger and Asaro 1977: 14-17). A discussion of obsidian use in the region can be found in this dissertation in Section 3.6. By count, and perhaps by weight, the most common artifact type in the region is the simple flake. Obsidian flakes have wide utility as cutting implements. The most common bifacial implement produced with obsidian was without question the projectile point. The points are predominantly the small, triangular point variety that was produced after 3,300 BCE in the south-central Andes. It is important to note that many of the photos below, meant to illustrate various obsidian forms in the central and south-central Andes, are fine examples of obsidian implements but they were likely Quispisisa type obsidian because they derive from Nasca and Wari contexts. Photos of a selection of artifacts found in the Upper Colca project are found above in the text, or can be browsed online at

http://www.MapAspects.org/colca/

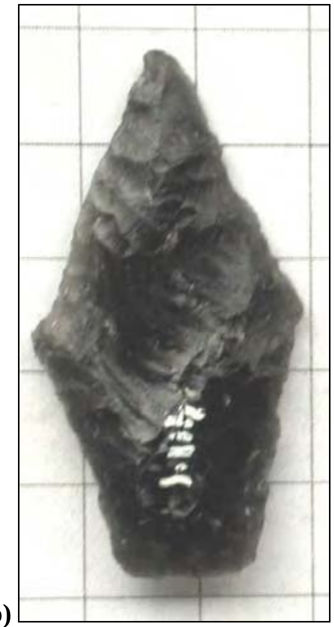
(a)  (b) 

Figure C-1. Obsidian projectile points from the Upper Colca survey project. (a) stemmed point from Block 2 [A03-260] was classified as a 4d (Late Archaic); (b) obsidian point from Block 2[A03-411] is a type 1b (Early Archaic) or a 2c (Middle Archaic) form.

Figure C-2. Obsidian point (Cat. 609) from Terminal Archaic context at Jiskairumoko, XRF showed this to be from the Chivay source (Craig 2005: 834, 913).

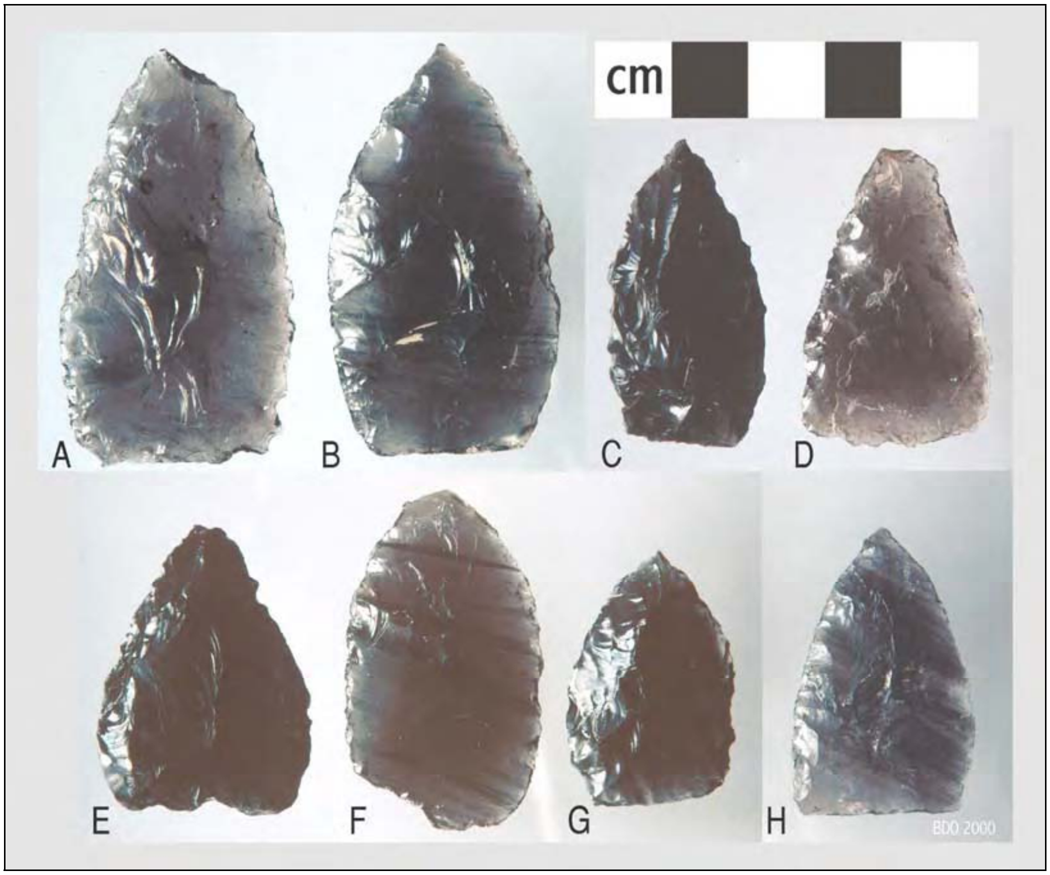


Figure C-3. Bifacially flaked obsidian "Wari style" points or knives from surface contexts in Moquegua as part of the "Catrastro Arqueológico del Drenaje del Osmore Superior" (B. D. Owen and Goldstein 2001: Fig. 11). A. From site 295; B. Site 366; C. Site 314; D. Site 135; E. Site 354, Pampa del Arrastrado; F. Site 354, Pampa del Arrastrado; G. Site 354, Pampa del Arrastrado; H. Site 561, Cerro Baúl formal architecture. Photos courtesy of Bruce Owen.

Figure C-4. Rollout of Tiwanaku *q'ero* showing bows and black-tipped arrows (top) near the rim of vessel (Posnansky 1957: XXa).

Figure C-5. Early Nasca ritual obsidian knife hafted to painted dolphin palate (Disselhoff 1972: 277).

Figure C-6. Representations of black-tipped projectiles are diagnostic to Nasca B1 and B2 ceramics (Carmichael et al. 1998: 151).

Figure C-7. Paracas textile with figure holding black-tipped projectiles (Lavalle and Lang 1983: 95)

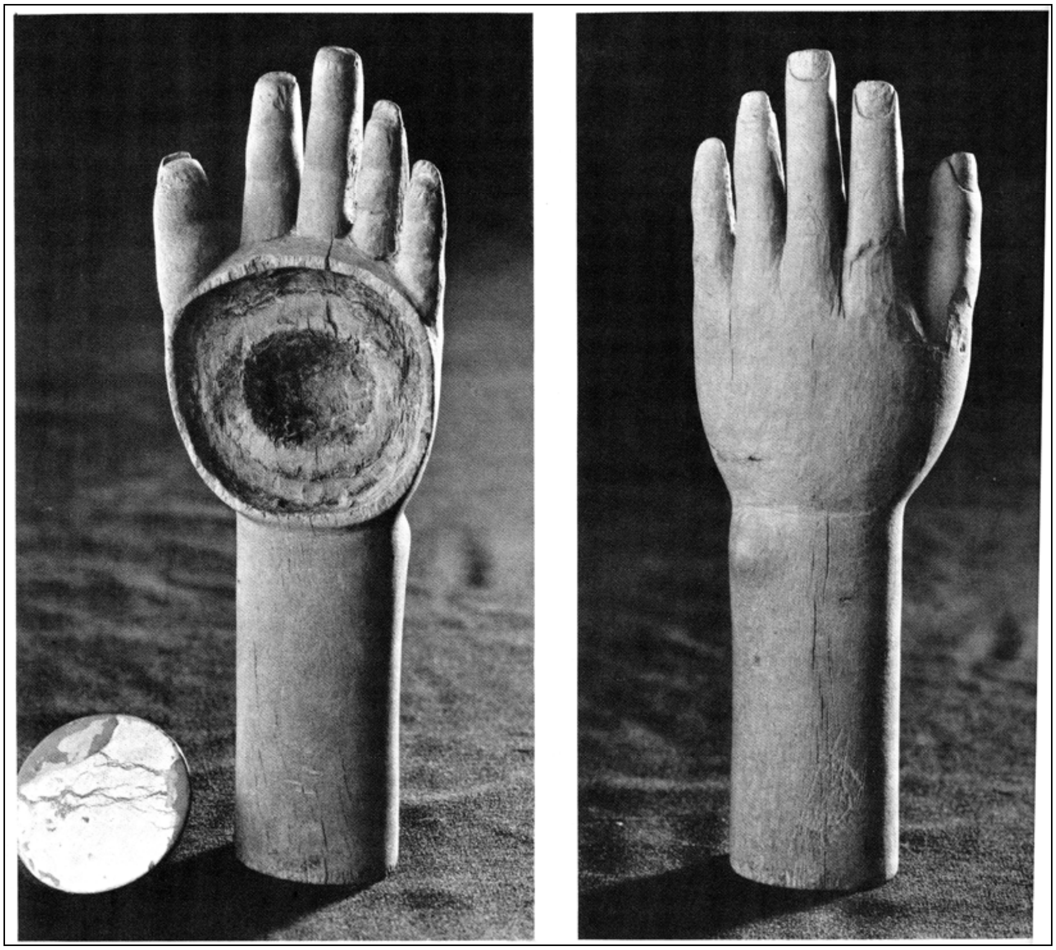


Figure C-8. Wooden hand mirror with obsidian inlay, Wari (Lavalle and Perú 1990: 185).

Figure C-9. Obsidian point hafted on harpoon found in a Paracas necropolis, Ica, Peru (Engel 1966: 180c).

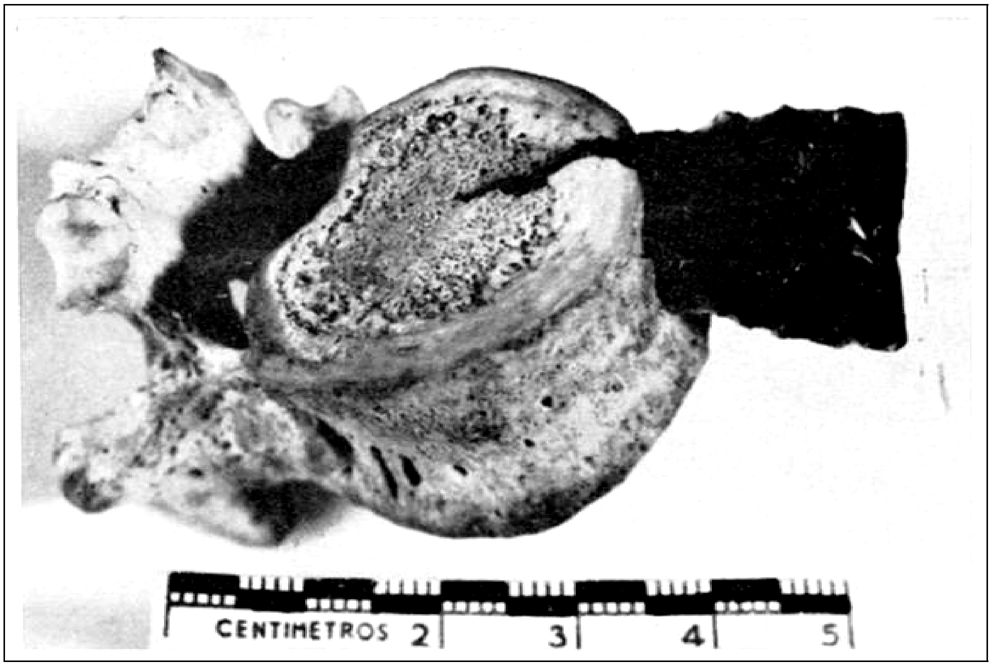


Figure C-10. An obsidian point embedded in a human lumbar vertebra that apparently entered through the stomach (from Ravines 1967: 230).

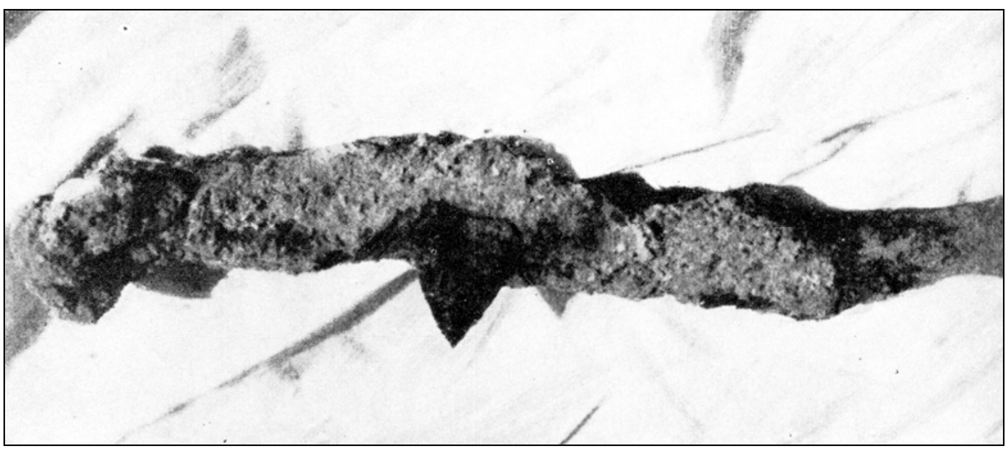


Figure C-11. Obsidian Point penetrating through arm muscle near left humerus found at Carhua in Ica, Peru (Engel 1966: 212).

– References Cited –

Abbott, Mark B., Michael W. Binford, Mark Brenner and Kerry R. Kelts
1997a A 3500 14c Year High-Resolution Record of Water-Level Changes in Lake Titicaca, Bolivia/Peru. *Quaternary Research* 47(2): 169-180.

Abbott, Mark B., Geoffrey O. Seltzer, Kerry R. Kelts and John Southon
1997b Holocene Paleohydrology of the Tropical Andes from Lake Records. *Quaternary Research* 47(1): 70-80.

Abrams, Michael, Simon Hook and Bhaskar Ramachandran
2002 *Aster User Handbook, V2: Advanced Spaceborne Thermal Emission and Relection Radiometer*, Jet Propulsion Laboratory. ftp://asterweb.jpl.nasa.gov/outgoing/handbook/aster_user_guide_v2.pdf

Acheson, James M.
2002 Transaction Cost Economics: Accomplishments, Problems, and Possibilities. In *Theory in Economic Anthropology*, edited by Jean Ensminger, pp. 27-58. AltaMira Press, Walnut Creek, CA.

Adams, Robert McCormick
1974 Anthropological Perspectives on Trade. *Current Anthropology* 15(3): 239-258.

Adiabatic lapse rate, saturated
1999. In *A Dictionary of Earth Sciences*, edited by Ailsa Allaby and Michael Allaby. Oxford Reference Online: http://www.oxfordreference.com/views/ENTRY.html?subview=Main&entry=t13.e7410 , accessed 8 September, 2006.

Ahler, Stanley A.
1973 Chemical Analysis of Deposits at Rodgers Shelter, Missouri. *Plains Anthropologist* 18(60): 116-131.

Alberti, Giorgio and Enrique Mayer (editors)
1974 *Reciprocidad E Intercambio En Los Andes Peruanos*. Instituto de Estudios Peruanos, Lima.

Alden, John R.
1982 Marketplace Exchange as Indirect Distribution: An Iranian Example. In *Contexts for Prehistoric Exchange*, edited by Jonathon E. Ericson and Timothy K. Earle, pp. 83-102. Academic Press, New York.

Aldenderfer, Mark S.
1982 Methods of Cluster Validation for Archaeology. *World Archaeology* 14(1): 61-72.

1989 The Archaic Period in the South-Central Andes. *Journal of World Prehistory* 3(2): 117-158.

1993a *Domestic Architecture, Ethnicity, and Complementarity in the South-Central Andes*. University of Iowa Press, Iowa City.

1993b Ritual, Hierarchy, and Change in Foraging Societies. *Journal of Anthropological Archaeology* 12(1): 1-40.

1997 Jiskairumoko and Early Sedentary Settlement in the Southwestern Lake Titicaca Basin. Paper presented at the 37th Annual Meeting of the Institute for Andean Studies, Berkeley, CA.

1998a Kaillachuro: A Formative Mortuary Complex from the Southwestern Lake Titicaca Basin. Paper presented at the 39th Annual Meeting of the Institute for Andean Studies, UC Berkeley.

1998b *Montane Foragers: Asana and the South-Central Andean Archaic*. University of Iowa Press, Iowa City.

1999a The Late Preceramic - Early Formative Transition on the South-Central Andean Littoral. In *Pacific Latin America in Prehistory: The Evolution of Archaic and Formative Cultures*, edited by Michael Blake, pp. 213-221. WSU Press, Pullman, WA.

1999b The Pleistocene/Holocene Transition in Peru and Its Effects Upon Human Use of the Landscape. *Quaternary International* 53-4: 11-19.

1999c Quelcatani's Place in the Andean Past: A Summary. Paper presented at the 64th Annual Meeting of the Society for American Archaeology, Chicago, IL.

2000 Cronología y Conexiones: Evidencias Preceramicas de Asana. In *El Periodo Arcaico En El Peru: Hacia Una Definición De Los Orígenes*, edited by Peter Kaulicke, pp. 375-391. vol. 3. Boletin de Arqueologia, Pontifica Universidad Catolica del Peru, Lima, Peru.

2001 Andean Pastoral Origins and Evolution: The Role of Ethnoarchaeology. In *Ethnoarchaeology of Andean South America: Contributions to Archaeological Method and Theory*, edited by Lawrence A. Kuznar, pp. 19-30. International Monographs in Prehistory, Ann Arbor, MI.

2003 Moving up in the World: Archaeologists Seek to Understand How and When People Came to Occupy the Andean and Tibetan Plateaus. *American Scientist* 91(6): 542-550.

2005 Preludes to Power in the Highland Late Preceramic Period. In *Foundations of Power in the Prehispanic Andes*, edited by Kevin J. Vaughn, Dennis Ogburn and Christina A. Conlee, pp. 13-35. American Anthropological Association, Arlington, VA.

2006 Costly Signaling, the Sexual Division of Labor, and Plant and Animal Domestication in the Andean Highlands. In *Behavioral Ecology and the Transition to Agriculture*, edited by Douglas J. Kennett and Bruce Winterhalder, pp. 167-196. University of California Press, Berkeley.

in press (editor) *Winaypach aka Markan Jaqipxtwa: Qillqatani and the Evolution of Andean Pastoralism*. University of Arizona Press, Tucson, AZ.

Ammerman, Albert J.

1979 Study of Obsidian Exchange Networks in Calabria. *World Archaeology* 11(1): 95-110.

Ammerman, Albert J., C. Matessi, L. L. Cavalli-Sforza

1978 Some New Approaches to the Study of the Obsidian Trade in the Mediterranean and Adjacent Areas. In *The Spatial Organisation of Culture*, edited by Ian Hodder, pp. 179-190. New Approaches in Archaeology. University of Pittsburgh Press, Pittsburgh.

Andrefsky, William
1994 The Geological Occurence of Lithic Material and Stone Tool Production Strategies. *Geoarchaeology* 9: 375-391.

1998 *Lithics: Macroscopic Approaches to Analysis*. Cambridge Manuals in Archeology. Cambridge University Press, Cambridge.

Anovitz, L. M., J. M. Elam, L. R. Riciputi and D. R. Cole
1999 The Failure of Obsidian Hydration Dating: Sources, Implications, and New Directions. *Journal of Archaeological Science* 26(7): 735-752.

Aoyama, Kazuo
2005 Classic Maya Warfare and Weapons: Spear, Dart, and Arrow Points of Aguateca and Copan. *Ancient Mesoamerica* 16: 291-304.

Appadurai, Arjun
1986 Commodities and the Politics of Value. In *The Social Life of Things: Commodities in Cultural Perspective*, edited by Arjun Appadurai, pp. 3-63. Cambridge University Press, Cambridge.

Aramaki, Shigeo, Naoki Onuma and Felix Portillo
1984 Petrography and Major Element Chemistry of the Volcanic Rocks of the Andes, Southern Peru. *Geochemical Journal* 18: 217-232.

Argollo, Jaime and Philippe Mourguiart
2000 Late Quaternary Climate History of the Bolivian Altiplano. *Quaternary International* 72(1): 37-51.

Arkush, Elizabeth
2005 *Colla Fortified Sites: Warfare and Regional Power*. Ph.D. Dissertation, University of California, Los Angeles.

Arnold, Jeanne E.
1991 Transformation of a Regional Economy: Sociopolitical Evolution and the Production of Valuables in Southern California. *Antiquity* 65(953-962).

Baied, Carlos A. and Jane C. Wheeler
1993 Evolution of High Andean Puna Ecosystems - Environment, Climate, and Culture Change over the Last 12,000 Years in the Central Andes. *Mountain Research and Development* 13(2): 145-156.

Baker, P. A., G. O. Seltzer, S. C. Fritz, R. B. Dunbar, M. J. Grove, P. M. Tapia, S. L. Cross, H. D. Rowe and J. P. Broda
2001 The History of South American Tropical Precipitation for the Past 25,000 Years. *Science* 291(5504): 640-643.

Bamforth, Douglas B.
1986 Technological Efficiency and Tool Curation. *American Antiquity* 51(1): 38-50.

Bandelier, Adolph F.
1904 Aboriginal Trephining in Bolivia. *American Anthropologist* 6(4): 440-446.

Bandy, Matthew S.
2001 *Population and History in the Ancient Titicaca Basin.* Ph.D. Dissertation, University of California, Berkeley.

2004 Fissioning, Scalar Stress, and Social Evolution in Early Village Societies. *American Anthropologist* 106(2): 322-333.

2005 Trade and Social Power in the Titicaca Basin Formative. In *Foundations of Power in the Prehispanic Andes*, edited by Kevin J. Vaughn, Dennis Ogburn and Christina A. Conlee, pp. 91-111. American Anthropological Association, Arlington, Va.

Banning, E. B.
2002 *Archaeological Survey*. Manuals in Archaeological Method and Theory. Plenum, New York.

Barth, Fredrik
1967 Economic Spheres in Darfur. In *Themes in Economic Anthropology*, edited by Raymond William Firth, pp. 149-174, Association of Social Anthropologists of the Commonwealth. and St. Antony's College (University of Oxford). Tavistock Publications, London.

Bastien, Joseph W.
1978 *Mountain of the Condor: Metaphor and Ritual in an Andean Ayllu*. West, St. Paul, MN.

1987 *Healers of the Andes: Kallawaya Herbalists and Their Medicinal Plants*. University of Utah Press, Salt Lake City.

Baugh, Timothy G. and Jonathon E. Ericson (editors)
1994 *Prehistoric Exchange Systems in North America*. Plenum Press, New York.

Beck, Colleen
1991 Cross-Cutting Relationships: The Relative Dating of Ancient Roads on the North Coast of Peru. In *Ancient Road Networks and Settlement Hierarchies in the New World,* edited by Charles D. Trombold, pp. 66-79. Cambridge University Press, Cambridge, England.

Benavides, Maria A.
1989 Las Visitas a Yanquecollaguas De Los Siglos Xvi Y Xvii: Organizacion Social Y Tenencia De Tierras. *Bulletin de l'Institut Français d'Etudes Andines* 18(2): 241-267.

Benavides, Mario A.
1991 Cheqo Wasi, Huari. In *Huari Administrative Structure: Prehistoric Monumental Architecture and State Government,* edited by William H. Isbell and Gordon F. McEwan, pp. 55-69. Dumbarton Oaks Research Library and Collection, Washington, D.C.

Bennett, Wendell C.
1934 *Excavations at Tiahuanaco*. American Museum of Natural History, New York.

1946 The Archaeology of the Central Andes. In *Handbook of South American Indians,* edited by Julian H. Steward, pp. 61-147. vol. 2. Smithsonian Institution, Bureau of Ethnology, Washington, D.C.

Berdan, Francis
1989 Trade and Markets in Precapitalist States. In *Economic Anthropology,* edited by Stuart Plattner, pp. 78-107. Stanford University Press, Stanford, Calif.

Bettinger, Robert L.
1982 Aboriginal Exchange and Territoriality in Owens Valley, California. In *Contexts for Prehistoric Exchange,* edited by Jonathon E. Ericson and Timothy K. Earle, pp. 103-127. Academic Press, New York.

Binford, Lewis R.
1962 Archaeology as Anthropology. *American Antiquity* 28(2): 217-225.

1979 Organization and Formation Processes: Looking at Curated Technologies. *Journal of Anthropological Research* 35(3): 255-273.

1992 Seeing the Present and Interpreting the Past – and Keeping Things Straight. In *Space, Time, and Archaeological Landscapes*, edited by Jacqueline Rossignol and LuAnn Wandsnider, pp. 43-59. Plenum Press, New York.

Birdsell, Joseph B.
1970 Local Group Composition among the Australian Aborigines: A Critique of the Evidence from Fieldwork Conducted since 1930. *Current Anthropology* 11(2): 115-142.

Bittmann, Bente and Juan R. Munizaga
1979 El Arco En América: Evidencia Temprana Y Directa. *Indiana* 5: 229-251.

Blanton, Richard E.
1998 Reply to Hirth's "The Distributional Approach: A New Way to Identify Marketplace Exchange in the Archaeological Record". *Current Anthropology* 39(4): 463-464.

Blanton, Richard E., Gary M. Feinman, Stephen A. Kowaleski and Peter N. Peregrine
1996 A Dual-Process Theory for the Evolution of Mesoamerican Civilization. *Current Anthropology* 37(1): 1-86.

Bleed, P.
2001 Trees of Chains, Links or Branches: Conceptual Alternative for Consideration of Stone Tool Production and Other Sequential Activities. *Journal of Archaeological Method and Theory* 8(1): 101-127.

Boëda, Éric
1991 Approche De La Variabilité Des Systèmes De Production Lithique Des Industries De Paléolithique Inférieur Et Moyen: Chronique D'une Variabilité Attendue. *Techniques et Culture* 17-18: 37-79.

Bohannan, Paul
1965 *Social Anthropology*. Holt Rinehart and Winston, New York.

Bohannan, Paul and George Dalton
1962 Introduction. In *Markets in Africa*, edited by Paul Bohannan and George Dalton, pp. 1-28. Northwestern University Press, Chicago.

Bonavia, Duccio
1996 *Los Camélidos Sudamericanos: Una Introducción a Su Estudio*. Translated by Espanol. Travaux De L'institut Francais D'études Andines 93. IFEA : UPCH : Conservation International, Lima, Perú.

Boone, James L.
1992 Competition, Conflict, and the Development of Social Hierarchies. In *Evolutionary Ecology and Human Behavior*, edited by Eric Alden Smith and Bruce Winterhalder, pp. 301-338. Foundations of Human Behavior. Aldine de Gruyter, New York.

Bourdieu, Pierre
1977 *Outline of a Theory of Practice*. Cambridge University Press, Cambridge.

Bradley, Bruce A.
1975 Lithic Reduction Sequences: A Glossary and Discussion. In *Lithic Technology: Making and Using Stone Tools*, edited by Earl Herbert Swanson, pp. 5-13. Mouton, The Hague.

Bradley, Richard and Mark R. Edmonds
1993 *Interpreting the Axe Trade: Production and Exchange in Neolithic Britain*. Cambridge University Press, Cambridge.

Braswell, Geoffrey E.
2002 Praise the Gods and Pass the Obsidian?: The Organization of Ancient Economy in San MartíN Jilotepeque, Guatemala. In *Ancient Maya Political Economies,* edited by Marilyn A. Masson and David A. Freidel, pp. 285-306. AltaMira Press, Walnut Creek, CA.

Braswell, Geoffrey E., John E. Clark, Kazuo Aoyama, Hearther I. McKillop and Michael D. Glascock
2000 Determining the Geological Provenance of Obsidian Artifacts from the Maya Region: A Test of the Efficacy of Visual Sourcing. *Latin American Antiquity* 11(3): 269-282.

Brooks, Sarah O.
1998 *Prehistoric Agricultural Terraces in the Rio Japo Basin, Colca Valley, Peru.* Ph. D. Dissertation, University of Wisconsin.

Brooks, Sarah O., Michael D. Glascock and Martin Giesso
1997 Source of Volcanic Glass for Ancient Andean Tools. *Nature* 376: 449-450.

Browman, David L.
1970 *Early Peruvian Peasants: The Culture History of a Central Highlands Valley.* Ph.D. Dissertation, Harvard University.

1974 Pastoral Nomadism in the Andes. *Current Anthropology* 15(2): 188-196.

1977 The Altiplano Mode of Economic Integration in the Andes. Paper presented at the Presented at the American Anthropological Association, Houston, Texas.

1980 Tiwanaku Expansion and Altiplano Economic Patterns. *Estudios arqueológicos* 5: 107-120.

1981a New Light on Andean Tiwanaku. *American Scientist* 69(4): 408-419.

1981b Review: Prehistoric Hunters of the High Andes. *Human ecology* 9: 257-260.

1989 Origins and Development of Andean Pastoralism: An Overview of the Past 6000 Years. In *The Walking Larder: Patterns of Domestication, Pastoralism and Predation*, edited by J. Clutton-Brock, pp. 256-268. Unwin Hyman, London.

1990 Camelid Pastoralism in the Andes: Llama Caravan Fleteros, and Their Importance in Production and Distribution. In *Nomads in a Changing World*, edited by Philip C. Salzman and John G. Galaty, pp. 395-438. Istituto Universitario Orientale, Naples.

1994 Titicaca Basin Archaeolinguistics - Uru, Pukina and Aymara Ad 750-1450. *World Archaeology* 26(2): 235-251.

1998 Lithic Provenience Analysis and Emerging Material Complexity at Formative Period Chiripa, Bolivia. *Andean Past* 5: 301-324.

Brown, James A.

1985 Long Term Trends to Sedentism and the Emergence of Cultural Complexity in the American Midwest. In *Prehistoric Hunter-Gatherers: The Emergence of Cultural Complexity*, edited by T. Douglas Price and James A. Brown, pp. 201-234. Academic Press, Orlando.

Brumfiel, Elizabeth M.

1980 Specialization, Market Exchange, and the Aztec State: A View from Huexotla. *Current Anthropology* 21(4): 459-478.

Brumfiel, Elizabeth M. and Timothy K. Earle (editors)

1987a *Specialization, Exchange, and Complex Societies*. Cambridge University Press, Cambridge Cambridgeshire ; New York.

1987b Specialization, Exchange, and Complex Societies : An Introduction. In *New Directions in Archaeology*, pp. 1-9. Cambridge University Press, Cambridge Cambridgeshire ; New York.

Brush, Stephen B.

1976 Man's Use of an Andean Ecosystem. *Human Ecology* 4(2): 147-166.

1977 *Mountain, Field, and Family: The Economy and Human Ecology of an Andean Valley*. University of Pennsylvania Press, Philadelphia.

Bryan, Kirk
1950 *Flint Quarries, the Sources of Tools and, at the Same Time, the Factories of the American Indian; with a Consideration of the Theory of The "Blank" And Some of the Technique of Flint Utilization*. The Museum, Cambridge,.

Burchard, Roderick E.
1974 Coca Y Trueque De Alimientos. In *Reciprocidad E Intercambio En Los Andes Peruanos*, edited by Giorgio Alberti and Enrique Mayer, pp. 209-251. Instituto de Estudios Peruanos, Lima.

Burger, Richard L.
2003 Conclusions: Cultures of the Ecuadorian Formative in Their Andean Context. In *Archaeology of Formative Ecuador: A Symposium at Dumbarton Oaks, 7 and 8 October 1995*, edited by J. Scott Raymond and Richard L. Burger, pp. 465-486. Dumbarton Oaks Research Library and Collection, Washington, D.C.

Burger, Richard L. and Frank Asaro
1977 *Trace Element Analysis of Obsidian Artifacts from the Andes: New Perspectives on Pre-Hispanic Economic Interaction in Peru and Bolivia - Lbl6343*. Lawrence Berkeley Laboratory.

1978 *Obsidian Distribution and Provenience in the Central Highlands and Coast of Peru During the Preceramic Period*. Contributions to the University of California Archaeology Research Facility 36. University of California, Berkeley, pp. 61-83.

Burger, Richard L., Frank Asaro, Helen V. Michael, Fred H. Stross and Ernesto Salazar
1994 An Initial Consideration of Obsidian Procurement and Exchange in Prehispanic Ecuador. *Latin American Antiquity* 5(3): 228-255.

Burger, Richard L., Frank Asaro, Guido Salas and Fred Stross
1998a The Chivay Obsidian Source and the Geological Origin of Titicaca Basin Type Obsidian Artifacts. *Andean Past* 5: 203-223.

Burger, Richard L., Frank Asaro, Paul Trawick and Fred Stross
1998b The Alca Obsidian Source: The Origin of Raw Material for Cuzco Type Obsidian Artifacts. *Andean Past* 5: 185-202.

Burger, Richard L. and Michael D. Glascock
2000 Locating the Quispisisa Obsidian Source in the Department of Ayacucho, Peru. *Latin American Antiquity* 11(3): 258-268.

2001 The Puzolana Obsidian Source: Locating the Geologic Source of Ayacucho Type Obsidian. *Andean Past* 6: 289-307.

2002 Tracking the Source of Quispisisa Type Obsidian from Huancavelica to Ayacucho. In *Andean Archaeology I: Variations in Sociopolitical Organization*, edited by William Harris Isbell and Helaine Silverman, pp. 341-368. Kluwer Academic/Plenum Publishers, New York.

Burger, Richard L., Karen L. Mohr Chávez and Sergio J. Chávez
2000 Through the Glass Darkly: Prehispanic Obsidian Procurement and Exchange in Southern Peru and Northern Bolivia. *Journal of World Prehistory* 14(3): 267-362.

Burton, John
1984 Quarrying in a Tribal Society. *World Archaeology* 16(2): 234-247.

Cahlander, Adele, Elayne Zorn and Ann P. Rowe
1980 *Sling Braiding of the Andes*. Weaver's Journal. Monograph 4. Colorado Fiber Center, Boulder.

Cardona Rosas, Augusto
2002 *Arqueología De Arequipa: De Sus Albores a Los Incas*. CIARQ Centro de Investigaciones Arqueológicas de Arequipa, Arequipa, Perú.

Carmichael, Patrick H., Alfred L. Kroeber and Donald Collier (editors)
1998 *The Archaeology and Pottery of Nazca, Peru: Alfred L. Kroeber's 1926 Expedition*. AltaMira Press, Walnut Creek, CA.

Carr, Thomas L. and Mort D. Turner
1996 Investigating Regional Lithic Procurement Using Multi-Spectral Imagery and Geophysical Exploration. *Archaeological Prospection* 3(3): 109-127.

Casarett, Louis J., Curtis D. Klaassen, Mary O. Amdur and John Doull
1996 *Casarett and Doull's Toxicology : The Basic Science of Poisons*. 5th ed. McGraw-Hill, New York.

Casaverde Rojas, Juvenal
1977 El Trueque En La Economía Pastoril. In *Pastores De Puna: Uywamichiq Punarunakuna*, edited by Jorge A. Flores Ochoa, pp. 168-191. 1. ed. Estudios de la Sociedad Rural. vol. 5. Instituto de Estudios Peruanos, Lima.

Cashdan, Elizabeth
1983 Territoriality among Human Foragers: Ecological Models and an Application to Four Bushman Groups. *Current Anthropology* 24(1): 47-66.

Casimir, Michael J. and Aparna Rao (editors)
1992 *Mobility and Territoriality: Social and Spatial Boundaries among Foragers, Fishers, Pastoralists, and Peripatetics*. St. Martin's Press, New York.

Chagnon, Napoleon A.
1968 *Yanomamö, the Fierce People*. Case Studies in Cultural Anthropology. Holt Rinehart and Winston, New York.

Chappell, Sylvia
1986 Alternative Sources in Regional Exchange Systems: A Gravity Model Approach. *Proceedings of the Prehistoric Society* 52: 131-142.

Chávez, José Antonio
1978 *El Periodo Precerámico De La Cueva De Quelkata.* Bachiller, Universidad Catolica Santa Maria.

Chávez, Karen L. Mohr
1980 The Archaeology of Marcavalle, an Early Horizon Site in the Valley of Cusco. *Baessler-Archiv, Neue Folge* 28(203-329).

1988 The Significance of Chiripa in Lake Titicaca Basin Developments. *Expedition* 30(3): 17-26.

Chávez, Karen Lynne Mohr
1977 *Marcavalle: The Ceramics from an Early Horizon Site in the Valley of Cusco, Peru, and the Implications for South Highland Socio-Economic Interactions.* Ph.D. Dissertation, University of Pennsylvania.

Childe, V. Gordon
1936 *Man Makes Himself*. Watts & Co., London.

Christaller, Walter
1966 [1933] *Central Places in Southern Germany*. Translated by Carlisle Whiteford Baskin. Prentice-Hall, Englewood Cliffs, N.J.

Cipolla, Lisa M.
2005 Preceramic Period Settlement Patterns in the Huancané-Putina River Valley, Northern Titicaca Basin, Peru. In *Advances in Titicaca Basin Archaeology-1*, edited by Charles Stanish, Amanda Cohen and Mark Aldenderfer, pp. 55-63. Cotsen Institute of Archaeology, Los Angeles, California.

Clapperton, Chalmers M.
1993 *Quaternary Geology and Geomorphology of South America*. Elsevier, New York.

Clark, John E.
1997 Prismatic Blademaking, Craftsmanship, and Production: An Analysis of Obsidian Refuse from Ojo De Agua, Chiapas, Mexico. *Ancient Mesoamerica* 8(1): 137-159.

2003 A Review of Twentieth-Century Mesoamerican Obsidian Studies. In *Mesoamerican Lithic Technology: Experimentation and Interpretation*, edited by Kenneth G. Hirth, pp. 15-54. University of Utah Press, Salt Lake City.

Clark, John E. and Michael Blake
1994 Power of Prestige: Competitive Generosity and the Emergence of Risk in Lowland Mesoamerica. In *Factional Competition and Political Development in the New World*, edited by Elizabeth M. Brumfiel and John W. Fox, pp. 17-30. Cambridge University Press, Cambridge England.

Clark, John E. and Thomas A. Lee
1984 Formative Obsidian Exchange and the Emergence of Public Economies in Chiapas, Mexico. In *Trade and Exchange in Early Mesoamerica.* , edited by Kenneth G. Hirth, pp. 235-274. University of New Mexico Press, 1984, Albuquerque.

Clarkson, Chris
2002 An Index of Invasiveness for the Measurement of Unifacial and Bifacial Retouch: A Theoretical, Experimental and Archaeological Validation. *Journal of Archaeological Science* 29: 65-75.

Clarkson, Chris, Lucio Vinicius and Marta Mirazon Lahr
2006 Quantifying Flake Scar Patterning on Cores Using 3d Recording Techniques. *Journal of Archaeological Science* 33(1): 132-142.

Close, Angela E.
1996 Carry That Weight: The Use and Transportation of Stone Tools. *Current Anthropology* 37(3): 545.

1999 Distance and Decay: An Uneasy Relationship. *Antiquity* 73(279): 24-32.

Cobb, Charles R.
2000 *From Quarry to Cornfield: The Political Economy of Mississippian Hoe Production*. University of Alabama Press, Tuscaloosa.

Cobean, Robert H., Michael D. Coe, E. Perry, K. Turekian and D. Kharkar
1971 Obsidian Trade at San Lorenzo Tenochtitlan, Mexico. *Science* 174: 66-671.

Cobean, Robert H., Michael D. Glascock, Terrance L. Stocker and James R. Vogt
1991 High-Precision Trace-Element Characterization of Major Mesoamerican Obsidian Sources and Further Analyses of Artifacts from San Lorenzo Tenochtitlan, Mexico. *Latin American Antiquity* 2(1): 69-91.

Cobean, Robert H. and Terrance L. Stocker
2002 Obsidian Sources on or near the Slopes of Pico De Orizaba Volcano. In *A World of Obsidian: The Mining and Trade of a Volcanic Glass in Ancient Mexico [Un Mundo De Obsidiana: Minería Y Comercio De Un Vidrio Volcánico En El México Antiguo]*, edited by Robert H. Cobean, pp. 131-182. Instituto Nacional de Anhropologia e Historia.

Cobo, Bernabé
1990 [1653] *Inca Religion and Customs*. University of Texas Press, Austin.

Codd, Edgar F.
1970 A Relational Model of Data for Large Shared Data Banks. *Communications of the ACM* 13(6): 377-387.

Coe, Michael D.
1960 Archeological Linkages with North and South America at La Victoria, Guatemala. *American Anthropologist* 62(3): 363-393.

Concha Contreras, Juan
1975 Relación Entre Pastores Y Agricultores. *Allpanchis, revista anual* 8: 67-101.

Conklin, William
1983 Pucara and Tiahuanaco Tapestry: Time and Style in a Sierra Weaving Tradition. *Ñawpa Pacha* 21: 1-44.

Conlee, Christina A.
2000 *Late Prehispanic Occupation of Pajonal Alto, Nasca, Peru: Implications for Imperial Collapse and Societal Reformation.* Ph.D. Dissertation, University of California, Santa Barbara.

Connolly, James and Mark Lake
2006 *Geographical Information Systems in Archaeology*. Manuals in Archaeology. Cambridge University Press, Cambridge, UK.

Cook, Noble David
1982 *The People of the Colca Valley: A Population Study*. Westview Press, Boulder, Colo.

Costin, Cathy Lynne
2000 The Use of Ethnoarchaeology for the Archaeological Study of Ceramic Production. *Journal of Archaeological Method and Theory* 7(4): 377-403.

Couture, Nicole C.
2003 Ritual, Monumentalism, and Residence at Mollo Kontu. In *Tiwanaku and Its Hinterland: Archaeology and Paleoecology of an Andean Civilization, Vol. 2*, edited by Alan L. Kolata, pp. 202-225. 2 vols. Smithsonian Institution Press, Washington, DC.

Craig, Nathan M.
1999 Real-Time Gis Construction and Digital Data Recording of the Jiskairumoko Excavation, Peru. *SAA Bulletin* 18(1).

2005 *The Formation of Early Settled Villages and the Emergence of Leadership: A Test of Three Theoretical Models in the Rio Ilave, Lake Titicaca Basin, Southern Peru.* Ph.D. Dissertation, University of California, Santa Barbara. http://www.archaeo.info/craig/craig2005_dissertation_jiska.pdf

Craig, Nathan M. and Mark Aldenderfer
2002 Domestic Architecture from the Late Archaic South-Central Andean Site of Jiskairumoko. Paper presented at the Society for American Archaeology, 67th, Denver, CO.

Craig, Nathan M. and Mark S. Aldenderfer
in press Trends in Early Non-Local Obsidian Artifacts from the Rio Ilave Viewed from Surface Survey and Late Archaic Excavations. In *Advances in Titicaca Basin Archaeology*, edited by Charles Stanish and Elizabeth A. Klarich. vol. 2. Cotsen Institute of Archaeology at UCLA, Los Angeles, Calif.

Crespo, Juan Carlos
1977 Los Collaguas En La Visita De Alonso Fernandez De Bonilla. In *Collaguas 1*, edited by Franklin Pease G. Y and David J. Robinson, pp. 53-91. Pontíficia Universidad Católica del Perú Fondo Editorial, Lima.

Curtin, Philip
1984 *Cross-Cultural Trade in World History*. Cambridge University Press, Cambridge.

Custred, H. Glynn
1973 *Symbols and Control in a High Altitude Andean Community.* Ph.D. Dissertation, Indiana University.

1974 Llameros Y Comerio Interregional. In *Reciprocidad E Intercambio En Los Andes Peruanos*, edited by G. Alberti and E. Mayer. vol. 10. Instituto de Estudio Peruanos, Lima.

D'Altroy, Terence N.
1992 *Provincial Power in the Inka Empire*. Smithsonian Institution Press, Washington.

D'Harcourt, Raoul
1962 *Textiles of Ancient Peru and Their Techniques*. Translated by Sadie Brown. University of Washington Press, Seattle.

Dalton, George
1961 Economic Theory and Primitive Society. *American Anthropologist* 63(1): 1-25.

1969 Theoretical Issues in Economic Anthropology. *Current Anthropology* 10(1): 63-102.

Dana, Peter
1998 The Geographer's Craft: Coordinate Systems. University of Colorado, Boulder, Colorado.

Danby, Colin
2002 The Curse of the Modern: A Post Keynesian Critique of the Gift|Exchange Dichotomy. In *Social Dimensions in the Economic Process*, edited by Norbert Dannhaeuser and Cynthia Ann Werner, pp. 13-42. 1st ed. Research in Economic Anthropology. vol. 21. JAI, Amsterdam.

Darras, Véronique
1991 *Technologies Prehispaniques De L'obsidienne: Les Centres De Production De La Région De Zináparo-Prieto*, Université de Paris I.

1999 *Tecnologías Prehispánicas De La Obsidiana: Los Centros De Producción De La Región De Zináparo-Prieto, Michoacán, México*. Centre francais d'études mexicaines et centramériaines, México.

Davila M., David (editor)
1988 *Geológia Del Cuadrangulo De Cailloma, Hoja 31-S*. Instituto Geológico Minero y Metalúrgico, scale 1:100,000.

Davila M., David, Guillermo Diaz H. and Manuel Montoya R.
1988 Mapa Geológico del Cuadrangulo de Cailloma. Instituto Geológico Minero y Metalúrgico, scale 1:100,000.

Davis, J.T.
1961 Trade Routes and Economic Exchange among the Indians of California. *University of California Archaeological Survey, Report 54*: 1-71.

de la Vega, Edmundo, Kirk L. Frye and Tiffiny Tung
2005 The Cave Burial from Molino-Chilacachi. In *Advances in Titicaca Basin Archaeology-1*, edited by Charles Stanish, Amanda Cohen and Mark Aldenderfer, pp. 185-196. Cotsen Institute of Archaeology, Los Angeles, California.

de la Vera Cruz, Pablo A.
1987 Cambio En Los Patrones De Asentamiento Y El Uso Y Abandono De Los Andenes En Cabanaconde, Valle Del Colca, Peru. In *Pre-Hispanic Agricultural Fields in the Andean Region*, edited by William M. Denevan, Kent Mathewson and Gregory W. Knapp, pp. 89-128. vol. 359(i). B.A.R. International Series, Oxford, England.

1988 *Estudio Arqueológico En El Valle De Cabanaconde, Arequipa*. Bachiller Thesis, Universidad Católica Santa María.

1989 *Cronología Y Corología De La Cuenca Del Río Camaná-Majes-Colca, Arequipa.* Licenciatura Thesis, Universidad Católica Santa María.

Denevan, William M. (editor)
1986 *The Cultural Ecology, Archaeology, and History of Terracing and Terrace Abandonment in the Colca Valley of Southern Peru. Technical Report to the National Science Foundation and the National Geographic Society*. 1. 2 vols. University of Wisconsin, Madison, WI.

1988 *The Cultural Ecology, Archaeology, and History of Terracing and Terrace Abandonment in the Colca Valley of Southern Peru. Technical Report to the National Science Foundation and the National Geographic Society*. 2. University of Wisconsin, Madison, WI.

Denevan, William M., Kent Mathewson and Gregory W. Knapp (editors)
1987 *Pre-Hispanic Agricultural Fields in the Andean Region*. 359i, ii. 2 vols. B.A.R., Oxford, England.

Dibble, Harold L.
1997 Platform Variability and Flake Morphology: Comparison of Experimental and Archaeological Data and Implications for Interpreting Prehistoric Lithic Technological Strategies. *Lithic Technology* 22(2): 150-170.

Dibble, Harold L. and Andrew Pelcin
1995 The Effect of Hammer Mass and Velocity on Flake Mass. *Journal of Archaeological Science* 22: 429-439.

Diez de San Miguel, Garci
1964 [1567] *Visita Hecha a La Provincia De Chucuito Por Garci Diez De San Miguel En El Año 1567. Versión Paleográfica De La Visita Y Una Biografía Del Visitador Por Waldemar Espinoza Soriano.* Documentos Regionales para la Casa de la Cultura del Perú, Lima.

Dillehay, Tom D.
1993 Archaeological Trends in the South Cone of South America. *Journal of Archaeological Research* 1(3): 235-266.

Dillehay, Tom D. and Lautaro Nuñez
1988 Camelids, Caravans, and Complex Societies. In *Recent Studies in Precolumbian Archaeology*, edited by Nicholas J. Saunders and O. de Montmollin, pp. 603-633. vol. 421. BAR International, Oxford.

Dillian, Carolyn D.
2002 *More Than Toolstone: Differential Utilization of Glass Mountain Obsidian.* Ph.D., University of California, Berkeley.

Disselhoff, Hans Dietrich
1972 *Das Imperium Der Inka Und Die Indianischen Frühkulturen Der Andenländer; Von Den Jahrtausende Alten Felsbilden Bis Zu Den Andinen Hochkulturen Südamerikas*. Safari-Verlag, Berlin.

Dornbusch, Uwe
1998 Current Large Scale Climatic Conditions in Southern Peru and Their Influence on Snowline Altitudes. *Erdkunde* 52: 41-54.

Doutriaux, Miriam
2004 *Imperial Conquest in a Multiethnic Setting: The Inka Occupation of the Colca Valley, Peru.* Ph.D. Dissertation, University of California, Berkeley.

Dransart, Penny
2002 *Earth, Water, Fleece, and Fabric: An Ethnography and Archaeology of Andean Camelid Herding*. Routledge, London.

Drennan, Robert D.
1984 Long-Distance Transport Costs in Prehispanic Mesoamerica. *American Anthropologist* 86(1): 105-112.

Dubois, C.
1935 Wintun Ethnography. *University of California Publications in American Archaeology and Ethnology* 28(5): 279-403.

Dunnell, Robert C.
1992 The Notion Site. In *Space, Time, and Archaeological Landscapes*, edited by Jacqueline Rossignol and LuAnn Wandsnider, pp. 21-41. Plenum Press, New York.

Dunnell, Robert C. and W. S. Dancey
1983 The Siteless Survey: A Regional Scale Data Collection Strategy. *Advances in Archaeological Method and Theory* 6: 267-287.

Earle, Timothy K.
1977a Exchange Systems in Archaeological Perspective. In *Exchange Systems in Prehistory*, edited by Timothy K. Earle and Jonathon E. Ericson, pp. 3-12. Academic Press, New York.

1977b A Reappraisal of Redistribution: Complex Hawaiian Chiefdoms. In *Exchange Systems in Prehistory*, edited by Timothy K. Earle and Jonathon E. Ericson, pp. 213-229. Academic Press, New York.

1982 Prehistoric Economics and the Archaeology of Exchange. In *Contexts for Prehistoric Exchange*, edited by Jonathon E. Ericson and Timothy K. Earle, pp. 1-12. Academic Press, New York.

1985 Commodity Exchange and Markets in the Inka State. In *Markets and Marketing*, edited by Stuart Plattner. Society for Economic Anthropology, University Press of America, New York.

1987 Chiefdoms in Archaeological and Ethnohistorical Perspective. *Annual Review of Anthropology* 16: 279-308.

1991 *Chiefdoms: Power, Economy, and Ideology*. School of American Research Advanced Seminar Series. Cambridge University Press, New York.

1994 Positioning Exchange in the Evolution of Human Society. In *Prehistoric Exchange Systems in North America*, edited by Timothy G. Baugh and Jonathon E. Ericson, pp. 419-437. Plenum Press, New York.

1997 *How Chiefs Come to Power: The Political Economy in Prehistory*. Stanford University Press, Stanford, Calif.

2001 Exchange and Social Stratification in the Andes: The Xauxa Case. In *Empire and Domestic Economy*, edited by Terence N. D'Altroy and Christine Ann Hastorf, pp. 297-314. Kluwer Academic, New York.

2002 Commodity Flows and the Evolution of Complex Societies. In *Theory in Economic Anthropology*, edited by Jean Ensminger, pp. 79-103. AltaMira Press, Walnut Creek, CA.

Earle, Timothy K. and Andrew L. Christenson (editors)
1980 *Modeling Change in Prehistoric Subsistence Economies*. Academic Press, New York.

Ebert, James I.
1992 *Distributional Archaeology*. University of New Mexico Press, Albuquerque.

Echeverría, Francisco Xavier
1952 [1804] Memoria De La Santa Iglesia De Arequipa. In *Memorias Para La Historia De Arequipa*, edited by Víctor M. Barriga, pp. 80-104. vol. 4. Editorial La Colmena, Arequipa.

Edmonds, Mark M.
1990 Description, Understanding and the Chaîne Opératoire. *Archaeological reviews from Cambridge* 9(1): 55-70.

Ellis, Christopher J.
1997 Factors Influencing the Use of Stone Projectile Tips. In *Projectile Technology*, edited by Heidi Knecht, pp. 37-74. Plenum Press, New York.

Ellison, R. and J. De La Cruz
1985 Mapa Geológico Del Cuadrangulo De Callalli, Hoja 32-T. Instituto Geológico Minero y Metalúrgico, scale 1:100,000.

Engel, Frédéric André

1963 A Preceramic Settlement on the Central Coast of Peru: Asia, Unit I. *Transactions of the American Philosophical Society, new series* 53(3): 3-139.

1966 *Paracas: Cien Siglos De Cultura Peruana*. Editorial J. Mejía Baca, Lima.

Ensminger, Jean

2002 Experimental Economics: A Powerful New Method for Theory Testing in Anthropology. In *Theory in Economic Anthropology*, edited by Jean Ensminger, pp. 59-78. AltaMira Press, Walnut Creek, CA.

Ericson, Jonathon E.

1977a Egalitarian Exchange Systems in California: A Preliminary View. In *Exchange Systems in Prehistory*, edited by Timothy K. Earle and Jonathon E. Ericson, pp. 109-126. Academic Press, New York.

1977b *The Evolution of Prehistoric Exchange Systems in California: Results of Tracing and Dating Techniques.* Ph.D. Dissertation, University of California, Los Angeles.

1981 *Exchange and Production Systems in California Prehistory*. British Archaeological Reports International Series S 110. British Archaeological Reports.

1982 Production for Obsidian Exchange in California. In *Contexts for Prehistoric Exchange*, edited by Jonathon E. Ericson and Timothy K. Earle, pp. 129-148. Studies in Archaeology. Academic Press, New York.

1984 Towards the Analysis of Lithic Production Systems. In *Prehistoric Quarries and Lithic Production*, edited by Jonathon E. Ericson and Barbara A. Purdy, pp. 1-10. New Directions in Archaeology. Cambridge University Press, Cambridge.

Ericson, Jonathon E. and Timothy G. Baugh

1993 *The American Southwest and Mesoamerica: Systems of Prehistoric Exchange*. Plenum Press, New York.

Ericson, Jonathon E. and Timothy K. Earle (editors)
1982 *Contexts for Prehistoric Exchange*. Academic Press, New York.

Feldman, Robert A.
1989 The Early Ceramic Periods of Moquegua. In *Ecology, Settlement, and History in the Osmore Drainage, Peru*, edited by Don Stephen Rice, Charles Stanish and Phillip R. Scarr, pp. 207-217. vol. 545i. 545i, 545ii vols. B.A.R., Oxford, England.

Findlow, Frank J. and Marisa Bolognese
1980 An Initial Examination of Prehistoric Obsidian Exchange in Hidalgo County, New Mexico. *The Kiva* 45: 227-251.

1982 Regional Modeling of Obsidian Procurement in the American Southwest. In *Contexts for Prehistoric Exchange*, edited by Jonathon E. Ericson and Timothy K. Earle, pp. 53-81. Academic Press, New York.

Fink, John H.
1983 Structure and Emplacement of a Rhyolitic Obsidian Flow; Little Glass Mountain, Medicine Lake Highland, Northern California. *Geological Society of America Bulletin* 94: 362-380.

Fink, Jonathan H. and Curtis R. Manley
1987 Origin of Pumiceous and Glassy Textures in Rhyolite Flows and Domes. In *The Emplacement of Silicic Domes and Lava Flows*, edited by The Society, pp. 77-88. Geological Society of America Special Paper 212. Geological Society of America, Boulder, Colo.

Fisher, Richard V. and Hans-Ulrich Schmincke
1984 *Pyroclastic Rocks*. Springer-Verlag, Berlin ; New York.

Flannery, Kent V.
1972 The Cultural Evolution of Civilizations. *Annual Review of Ecology and Systematics* 3: 399.

Flannery, Kent V., Joyce Marcus and Robert G. Reynolds
1989 *The Flocks of the Wamani: A Study of Llama Herders on the Punas of Ayacucho, Peru*. Academic Press, San Diego.

Flores Ochoa, Jorge A.
1968 *Los Pastores De Paratía: Una Introduccíon a Su Estudio*. Instituto Indigenista Interamericano, México.

1977 Pastoreo, Tejido E Intercambio. In *Pastores De Puna: Uywamichiq Punarunakuna*, edited by Jorge A. Flores Ochoa, pp. 133-154. Instituto de Estudios Peruanos, Lima.

1994 Modern-Day Herders: An Andean Legacy Continues. In *Gold of the Andes: The Llamas, Alpacas, Vicuñas and Guanacos of South America*, edited by Jorge A. Flores Ochoa, Javier Portús Pérez and Kim MacQuarrie, pp. 100-193. vol. 2. 2 vols. F.O. Patthey, Barcelona.

Flores Ochoa, Jorge A. and Yemira D. Najar Vizcarra
1976 El Likira, Intermediario Ambulante En La Cordillera De Canchis. *Antropología Andina* 1/2: 125-135.

Flores Ochoa, Jorge A., Javier Portús Pérez and Kim MacQuarrie (editors)
1994 *Gold of the Andes: The Llamas, Alpacas, Vicuñas and Guanacos of South America*. Volume 2. Patthey, Barcelona.

Foley, Robert
1981 Off-Site Archaeology: An Alternative Approach for the Short-Sited. In *Pattern of the Past — Studies in Honour of David Clarke*, edited by Ian Hodder, G. Issac and N. Hammond, pp. 157-183. Cambridge University Press, Cambridge.

Fortes, L. P., E. Lauría, C. Brunini, W. Amaya, L. Sánchez, H. Drewes and W. Seemüller
2006 Current Status and Future Developments of the Sirgas Project. *Geodäsie und Geoinformatik der Universität Hannover Nr.* 258: 59-70.

Fox, Andrew N. and Arthur Bloom, L.
1994 Snowline Altitude and Climate in the Peruvian Andes (5-17 S) at Present and During the Latest Pleistocene Glacial Maximum. *Journal of Geography* 103(7): 867-885.

Francis, Peter and Clive Oppenheimer
2004 *Volcanoes*. Oxford University Press, Oxford ; New York.

Friedman, J. and M. J. Rowlands
1978 Notes Towards an Epigenetic Model of the Evolution of 'Civilisation'. In *The Evolution of Social Systems*, edited by M. J. Rowlands and J. Friedman, pp. xiv, 562. Duckworth, London.

Frye, Kirk L., Mark Aldenderfer and Michael D. Glascock
1998 The Aconcahua Obsidian Source and Its Relation to South-Central Andean Exchange Systems. Paper presented at the 38th Annual Meeting of the Institute of Andean Studies, Berkeley, CA.

Frye, Kirk L. and Lee Steadman
2001 Incatunahuiri: A Case for Early Socio-Political Complexity in the Titicaca Basin. Paper presented at the 66th Annual Meeting of the Society for American Archaeology, New Orleans.

Funnell, Donald C. and Romola Parish
2001 *Mountain Environments and Communities*. Routledge Physical Environment Series. Routledge, London.

Gade, Daniel W.
1975 *Plants, Man and the Land in the Vilcanota Valley of Peru*. W. Junk, The Hague.

1999 *Nature and Culture in the Andes*. University of Wisconsin Press, Madison.

García Márquez, Manuel and Rosa Bustamante Montoro
1990 Arqueología Del Valle De Majes. *Gaceta Arqueológica Andina* 5(18/19): 25-40.

Garcilaso
1960 [1609] *Obras Completas Del Inca Garcilaso De La Vega*. Ediciones Atlas, Madrid.

Gelles, Paul H.
2000 *Water and Power in Highland Peru: The Cultural Politics of Irrigation and Development*. Rutgers University Press, New Brunswick, N.J.

Gerbe, Marie-Christine and Jean-Claude Thouret
2004 Role of Magma Mixing in the Petrogenesis of Tephra Erupted During the 1990-98 Explosive Activity of Nevado Sabancaya, Southern Peru. *Bulletin of Volcanology* 66(6): 541-561.

Giddens, Anthony
1979 *Central Problems in Social Theory: Action, Structure, and Contradiction in Social Analysis*. University of California Press, Berkeley.

Giesso, Martín
2000 *Stone Tool Production in the Tiwanaku Heartland: The Impact of State Emergence and Expansion on Local Households.* Ph.D., University of Chicago.

2003 Stone Tool Production in the Tiwanaku Heartland. In *Tiwanaku and Its Hinterland: Archaeology and Paleoecology of an Andean Civilization, Vol. 2*, edited by Alan L. Kolata, pp. 363-383. 2 vols. Smithsonian Institution Press, Washington, DC.

Gilmore, Raymond M.
1950 Fauna and Ethnozoology of South America. In *Handbook of South American Indians*, edited by Julian H. Steward, pp. 345-464. vol. 6. Smithsonian Institution, Bureau of Ethnology, Washington, D.C.

Glascock, Michael (editor)
2002 *Geochemical Evidence for Long-Distance Exchange*. Bergin and Garvey, Westport, Conn.

Glascock, Michael D. and Martin Giesso
1994 New Perspectives on Obsidian Procurement in the Titicaca Basin, Bolivia, Presented at the International Archaeology Symposium, Ankara, Turkey.

Glowacki, M.
1996 *The Wari Occupation of the Southern Highlands of Peru: A Ceramic Perspective from the Site of Pikillacta.* Ph.D. Dissertation, Brandeis.

Godelier, Maurice
1979 Epistemological Comments on the Problems of Comparing Modes of Production and Societies. In *Toward a Marxist Anthropology: Problems and Perspectives,* edited by Stanley Diamond, pp. 71-92. Mouton, The Hague

Goldstein, Melvyn C. and Donald A. Messerschmidt
1980 The Significance of Latitudinality in Himalayan Mountain Ecosystems. *Human ecology* 8(2): 117-34.

Goldstein, Paul S.
1989 Tiwanaku Occupation of Moquegua. In *Ecology, Settlement, and History in the Osmore Drainage, Peru*, edited by Don Stephen Rice, Charles Stanish and Phillip R. Scarr, pp. 219-256. vol. 545i. 545i, 545ii vols. B.A.R., Oxford, England.

2000 Exotic Goods and Everyday Chiefs: Long-Distance Exchange and Indigenous Sociopolitical Development in the South Central Andes. *Latin American Antiquity* 11(4): 335-361.

2005 *Andean Diaspora: The Tiwanaku Colonies and the Origins of South American Empire*. University Press of Florida, Gainesville.

Gomez Rodríguez, J. de la C.
1985 Tecnología Del Pastoreo En Las Comunidades Del Cañon Del Colca, Arequipa, Peru. *Talleres de la Central de Credito Cooperativo del Peru, Arequipa*.

Gorenflo, L. J. and Nathan Gale
1990 Mapping Regional Settlement in Information Space. *Journal of Anthropological Archaeology* 9(3): 240.

Gottdiener, Mark
1995 *Postmodern Semiotics : Material Culture and the Forms of Postmodern Life*. Blackwell, Oxford, UK ; Cambridge.

Gould, Richard A., Dorothy A. Koster and Ann H. L. Sontz
1971 The Lithic Assemblage of the Western Desert Aborigines of Australia. *American Antiquity* 36(2): 149-169.

Gould, Richard A. and Sherry Saggers
1985 Lithic Procurement in Central Australia: A Closer Look at Binford’s Idea of Embeddedness in Archaeology. *American Antiquity* 50(1): 117-136.

Graeber, David
2001 *Toward an Anthropological Theory of Value: The False Coin of Our Own Dreams*. Palgrave, New York.

Granovetter, Mark
1985 Economic Action and Social Structures: The Problem of Embeddedness. *American Journal of Sociology* 91(3): 481-510.

Gregory-Wodzicki, Kathryn M.
2000 Uplift History of the Central and Northern Andes: A Review. *Geological Society of America Bulletin* 112(7): 1091-1105. http://www.ldeo.columbia.edu/users/gregory/GSABulletin.pdf

Gregory, C. A.
1982 *Gifts and Commodities*. Academic Press, New York.

Grosjean, Martin, Lautaro Núñez and Isabel Cartajena
2005 Palaeoindian Occupation of the Atacama Desert, Northern Chile. *Journal of Quaternary Science* 20(7-8): 643-653.

Guillet, David W.
1983 Toward a Cultural Ecology of Mountains: The Central Andes and the Himalayas Compared. *Current Anthropology* 24: 561-574.

1992 *Covering Ground: Communal Water Management and the State in the Peruvian Highlands*. The University of Michigan Press, Ann Arbor.

Haas, Jonathan, Winifred Creamer and Alvaro Ruiz
2004 Dating the Late Archaic Occupation of the Norte Chico Region in Peru. *Nature* 432(23/30): 1020-1023.

2005 Power and the Emergence of Complex Polities in the Peruvian Preceramic. In *Foundations of Power in the Prehispanic Andes*, edited by Kevin J. Vaughn, Dennis Ogburn and Christina A. Conlee, pp. 13-35. American Anthropological Association, Arlington, VA.

Haggett, Peter
1966 *Locational Analysis in Human Geography*. Edward Arnold, London.

Hallam, B. R., S. E. Warren and C. Renfrew
1976 Obsidian in the Western Mediterranean: Characterisation by Neutron Activation Analysis and Optical Emission Spectroscopy. *Proceedings of the Prehistoric society* 42: 85-110.

Harding, Thomas G.
1967 *Voyagers of the Vitiaz Strait; a Study of a New Guinea Trade System*. University of Washington Press, Seattle.

Harris, Olivia
1982 Labour and Produce in an Ethnic Economy. In *Ecology and Exchange in the Andes*, edited by David Lehmann, pp. 70-96. Cambridge University Press, Cambridge.

1985 Ecological Duality and the Role of the Center: Northern Potosí. In *Andean Ecology and Civilization*, edited by Shozo Masuda, Isumi Shimada and Craig Morris, pp. 311-335. University of Tokyo Press, Tokyo.

Hartmann, Roswith
1971 Mercados Y Ferias Prehispánicos En El Area Andina. *Boletín de la Academia Nacional de Historia* 54(118): 214-235.

Harvey, David
1969 *Explanation in Geography*. Edward Arnold, London.

Hastorf, Christine A.
1999 *Early Settlement at Chiripa, Bolivia: Research of the Taraco Archaeological Project*. Contributions of the University of California Archaeological Research Facility 57. Archaeological Research Facility, Berkeley.

2005 The Upper (Middle and Late) Formative in the Titicaca Region. In *Advances in Titicaca Basin Archaeology-1*, edited by Charles Stanish, Amanda Cohen and Mark Aldenderfer, pp. 65-94. Cotsen Institute of Archaeology, Los Angeles, California.

Hawkins, M. and J. De La Cruz
1985 Mapa Geológico Del Cuadrangulo De Condoroma, Hoja 31-T. Instituto Geológico Minero y Metalúrgico, scale 1:100,000.

Hayden, Brian
1995 Pathways to Power. In *Foundations of Social Inequality*, edited by T. Douglas Price and Gary M. Feinman, pp. 15-86. Plenum Press, New York.

1998 Practical and Prestige Technologies: The Evolution of Material Systems. *Journal of Archaeological Method and Theory* 5(1): 1-55.

Healan, Dan M.
1997 Pre-Hispanic Quarrying in the Ucareo-Zinapecuaro Obsidian Source Area. *Ancient Mesoamerica* 8: 77-100.

Heath, E. G. and Vilma Chiara
1977 *Brazilian Indian Archery : A Preliminary Ethno-Toxological Study of the Archery of the Brazilian Indians*. Simon Archery Foundation, Manchester.

Helms, Mary W.
1992 Long-Distance Contacts, Elite Aspirations, and the Age of Discovery in Cosmological Context. In *Resources, Power, and Interregional Interaction*, edited by Edward M. Schortman and Patricia A. Urban, pp. 157-174. Plenum Press, New York.

Hemming, John
1970 *The Conquest of the Incas*. Macmillan, London.

Hiscock, Peter
2004 Slippery and Billy: Intention, Selection and Equifinality in Lithic Artefacts. *Cambridge Archaeological Journal* 14: 71-77.

Hodder, Ian
1974 Regression Analysis of Some Trade and Marketing Patterns. *World Archaeology* 6(2): 172-189.

1978 Some Effects of Distance on Patterns of Human Interaction. In *The Spatial Organisation of Culture*, edited by Ian Hodder, pp. 155-178. University of Pittsburgh Press, Pittsburgh.

1982 Toward a Contextual Approach to Prehistoric Exchange. In *Contexts for Prehistoric Exchange*, edited by Jonathon E. Ericson and Timothy K. Earle, pp. 199-211. Academic Press, New York.

Hodder, Ian and Clive Orton
1976 *Spatial Analysis in Archaeology*. New Cambridge University Press, Cambridge.

Hofman, J. L.
1991 Folsom Land Use: Projectile Point Variability as a Key to Mobility. In *Raw Material Economies among Prehistoric Hunter-Gatherers*, edited by A. Montet-White and S. Holen, pp. 335-355. University of Kansas Publications in Anthropology, Lawrence, KS.

Holmes, William Henry
1894 Natural History of Flaked Stone Implements. In *Mémoirs of the International Congress of Anthropology*, edited by C. S. Wake, pp. 120-139, Schulte, Chicago.

1900 The Obsidian Mines of Hidalgo, Mexico. *American anthropologist* 2: 405-416.

1919 *Handbook of Aboriginal American Antiquities, Part I, Introductory, the Lithic Industries*. Bulletin of American Ethnology 60. US Government Printing Office, Washington, DC.

Hostnig, Rainer
2003 *Arte Rupestre Del Perú: Inventario Nacional*. CONCYTEC Consejo Nacional de Ciencia y Tecnología, Lima, Perú.

Hughes, Richard E.
1994 Mosaic Patterning in Prehistoric California - Great Basin Exchange. In *Prehistoric Exchange Systems in North America*, edited by Timothy G. Baugh and Jonathon E. Ericson, pp. 363-383. Plenum Press, New York.

Hughes, Richard E. and Robert L. Bettinger
1984 Obsidian and Prehistoric Sociocultural Systems in California. In *Exploring the Limits: Frontiers and Boundaries in Prehistory*, edited by Suzanne P. DeAtley and Frank J. Findlow, pp. 153-. vol. 223, Oxford.

Hughes, Robin R.
1987 La Avifauna Del Colca - Birdlife in the Colca. In *Descubriendo El Valle Del Colca - Discovering the Colca Valley*, edited by Mauricio de Romaña, Jaime Blassi and Jorge Blassi, pp. 77-79. F.O. Patthey, Barcelona.

Hughes, Susan S.
1998 Getting to the Point: Evolutionary Change in Prehistoric Weaponry. *Journal of Archaeological Method and Theory* 5(4): 345-408.

Humphrey, Caroline and Stephen Hugh-Jones
1992 *Barter, Exchange, and Value: An Anthropological Approach*. Cambridge University Press, Cambridge.

Hunt, Robert C.
2002 Economic Transfers and Exchanges: Concepts for Describing Allocations. In *Theory in Economic Anthropology*, edited by Jean Ensminger, pp. 105-118. AltaMira Press, Walnut Creek, CA.

Hyslop, John
1976 *An Archaeological Investigation of the Lupaca Kingdom Its Origins*. Ph. D., Columbia.

1984 *Inka Road System*. Academic Press, Orlando, FL.

I.N.E.I.
1993 Ix Censo De Poblacion Y Iv De Vivienda. *Instituto Nacional de Estadistica e Informatica*. http://www.inei.gob.pe/

IGM, Instituto Geográfico Militar - Peru
1986 Chivay, Departamento Arequipa; Peru. Instituto Geográfico Militar, Lima.

Imhof, Eduard
1950 *Gelaende Und Karte*. Rentsch, Zurich.

Ingold, Tim
1980 *Hunters, Pastoralists, and Ranchers: Reindeer Economies and Their Transformations*. Cambridge University Press, New York.

Isbell, William
2004 Cultural Evolution in the Lake Titicaca Basin: Empirical Facts and Theoretical Expectations. *Reviews in Anthropology* 33(3): 209-241.

Isbell, William, Christine Brewster-Wray and Lynda E. Spickard
1991 Architecture and Spatial Organization at Huari. In *Huari Administrative Structure: Prehistoric Monumental Architecture and State Government*, edited by William Harris Isbell and Gordon Francis McEwan, pp. 19-53. Dumbarton Oaks Research Library and Collection, Washington, D.C.

Janusek, John W.
2004a *Identity and Power in the Ancient Andes: Tiwanaku Cities through Time*. Routledge, New York.

2004b Tiwanaku and Its Precursors: Recent Research and Emerging Perspectives. *Journal of Archaeological Research* 12(2): 121-183.

Jarvis, A., H. I. Reuter, A. Nelson and E. Guevara
2006 Hole-Filled Srtm for the Globe Version 3, Cgiar-Csi Srtm 90m Database. Consultative Group for International Agricultural Research

Jennings, Justin
2002 *Prehistoric Imperialism and Cultural Development in the Cotahuasi Valley, Peru.* Ph.D. Dissertation, University of California, Santa Barbara.

Jennings, Justin and Nathan Craig
2001 Politywide Analysis and Imperial Political Economy: The Relationship between Valley Political Complexity and Administrative Centers in the Wari Empire of the Central Andes. In *Journal of Anthropological Archaeology*, pp. 479. vol. 20.

Jennings, Justin and Michael D. Glascock
2002 Description and Method of Exploitation of the Alca Obsidian Source, Peru. *Latin American Antiquity* 13(1): 107-118.

Jochim, Michael A.
1976 *Hunter-Gatherer Subsistence and Settlement: A Predictive Model.* Academic Press, New York.

Johnson, A. M.
1976 The Climate of Peru, Bolivia, and Ecuador. In *Climates of Central and South America*, edited by Werner Schwerdtfeger, pp. 147-200. World Survey of Climatology. vol. 12. Elsevier, New York.

Johnson, Allen W. and Timothy K. Earle
1987 *The Evolution of Human Societies: From Foraging Group to Agrarian State*. Stanford University Press, Stanford, Calif.

2000 *The Evolution of Human Societies: From Foraging Group to Agrarian State*. 2nd ed. Stanford University Press, Stanford, Calif.

Johnson, Gregory A.
1982 Organizational Structure and Scalar Stress. In *Theory and Explanation in Archaeology*, edited by Colin Renfrew, Michael J. Rowlands and Barbara A. Segraves, pp. 389-421. Academic Press, New York.

Kadwell, Miranda, Matilde Fernandez, Helen F. Stanley, Ricardo Baldi, Jane C. Wheeler, Raul Rosadio and Michael W. Bruford
2001 Genetic Analysis Reveals the Wild Ancestors of the Llama and the Alpaca. *Proceedings of the Royal Society London B* 268(1485): 2575-2584.

Kantner, John
1996 *An Evaluation of Chaco Anasazi Roadways*. Society for American Archaeology.

Karátson, David, Jean-Claude Thouret, Ichio Moriya and Alejandro Lomoschitz
1999 Erosion Calderas: Origins, Processes, Structural and Climatic Control. *Bulletin of Volcanology* 61(3): 174-193.

Kelly, Robert L.
1992 Mobility Sedentism: Concepts, Archaeological Measures, and Effects. *Annual Review of Anthropology* 21: 43-66.

1995 *The Foraging Spectrum: Diversity in Hunter-Gatherer Lifeways*. Smithsonian Institution Press, Washington.

Kennett, Douglas J. and Bruce Winterhalder (editors)
2006 *Behavioral Ecology and the Transition to Agriculture*. University of California Press, Berkeley.

Khazanov, Anatoly M.
1984 *Nomads and the Outside World*. Translated by Julia Crookenden. Cambridge University Press, New York.

Kidder, Alfred
1956 Digging in the Titicaca Basin. *University Museum Bulletin* 20(3): 16-29.

Kirch, Patrick V.
1991 Prehistoric Exchange in Western Melanesia. *Annual Review of Anthropology* 20: 141-165.

Klarich, Elizabeth A.
2005 *From the Monumental to the Mundane: Defining Early Leadership Strategies at Late Formative Pukara, Peru.* Ph.D. Dissertation, University of California, Santa Barbara.

Klein, Andrew G., Geoffrey O. Seltzer and Bryan L. Isacks
1999 Modern and Last Local Glacial Maximum Snowlines in the Central Andes of Peru, Bolivia, and Northern Chile. *Quaternary Science Reviews* 18: 63-84.

Klinck, B. A. and O. Palacios M.
1985 Mapa Geológico Del Cuadrangulo De Chivay, Hoja 32-S. Instituto Geológico Minero y Metalúrgico, scale 1:100,000.

Klink, Cynthia
2005 Archaic Period Research in the Rio Huenque Valley, Peru. In *Advances in Titicaca Basin Archaeology-1,* edited by Charles Stanish, Amanda Cohen and Mark Aldenderfer, pp. 13-24. Cotsen Institute of Archaeology, Los Angeles, California.

2006 Lithics and Land-Use: Using Projectile Points to Assess Preceramic Settlement Patterns in the Peruvian Altiplano. In *Society for American Archaeology*, San Juan, Puerto Rico.

Klink, Cynthia and Mark Aldenderfer
1996 Archaic Period Settlement on the Altiplano: Comparison of Two Recent Surveys in the Southwestern Lake Titicaca Basin. Paper presented at the Conference of Andean and Amazonian Archaeology and Ethnohistory, Beloit, WI.

2005 A Projectile Point Chronology for the South-Central Andean Highlands. In *Advances in Titicaca Basin Archaeology-1,* edited by Charles Stanish, Amanda Cohen and Mark Aldenderfer, pp. 25-54. Cotsen Institute of Archaeology, Los Angeles, California.

Knapp, A. Bernard
1990 Production, Location, and Integration in Bronze Age Cyprus. *Current Anthropology* 31(2): 147-176.

Kohl, Philip L.
1975 The Archeology of Trade. *Dialectical Anthropology* 1(1): 43-50.

Kolata, Alan L.
1993 *The Tiwanaku: Portrait of an Andean Civilization*. The Peoples of America. Blackwell, Cambridge, MA.

2003 *Tiwanaku and Its Hinterland: Archaeology and Paleoecology of an Andean Civilization, Vol. 2*. 2 vols. Smithsonian Institution Press, Washington, DC.

Kopytoff, Igor
1986 The Cultural Biography of Things. In *The Social Life of Things: Commodities in Cultural Perspective*, edited by Arjun Appadurai, pp. 64-91. Cambridge University Press, Cambridge.

Korfmann, Manfred
1973 The Sling as a Weapon. *Scientific American* 229(4): 34-42.

Kristiansen, K.
1984 Ideology and Material Culture: An Archaeological Perspective. In *Marxist Perspectives in Archaeology*, edited by Matthew Spriggs, pp. 72-100. Cambridge University Press, Cambridge.

Kroeber, Alfred L.
1925 Handbook of the Indians of California. *Bureau of American Ethnology Bulletin* 78: 1-995.

Kuznar, Lawrence A.
1990 *Economic Models, Ethnoarchaeology, and Early Pastoralism in the High Sierra of the South Central Andes.* Ph. D. Dissertation, Northwestern University.

1995 *Awatimarka: The Ethnoarchaeology of an Andean Herding Community*. Case Harcourt Brace College Publishers, Fort Worth, TX.

Kvamme, Kenneth L.
1988 Development and Testing of Quantitative Models. In *Quantifying the Present and Predicting the Past: Theory, Method, and Application of Archaeological Predictive Modeling*, edited by W. James Judge, Lynne Sebastian and Jeffrey H. Altschul, pp. 325-428. U.S. Dept. of the Interior Bureau of Land Management, Denver, Colo.

1992 A Predictive Site Location Model on the High Plains: An Example with an Independent Test. In *Plains Anthropologist*, pp. 19-50. vol. 37.

Lake, Mark W.
2003 Visibility Studies in Archaeology: A Review and Case Study. *Environment and Planning B-Planning & Design* 30: 689-707.

Lake, Mark W., P. E. Woodman and Stephen J. Mithen
1998 Tailoring Gis Software for Archaeological Applications: An Example Concerning Viewshed Analysis. *Journal of Archaeological Science* 25(1): 27-38.

LaLone, Darrell E.
1982 The Inca as a Nonmarket Economy: Supply on Command Versus Supply and Demand. In *Contexts for Prehistoric Exchange*, edited by Jonathon E. Ericson and Timothy K. Earle, pp. 292-316. Academic Press, New York.

Lambert, Bernd
1977 Bilaterality in the Andes. In *Andean Kinship and Marriage*, edited by Ralph Bolton and Enrique Mayer, pp. 1-27. vol. 7. American Anthropological Association, Washington.

Lavalle, José Antonio de and Werner Lang
1983 *Arte Y Tesoros Del Perú*. Banco de Credito del Peru en la Cultura, Lima, Peru.

Lavalle, José Antonio de and Banco de Crédito del Perú
1990 *Culturas Precolombinas: Huari*. 2a ed. Arte Y Tesoros Del Perú. Banco de Crédito del Perú, Lima, Perú.

Lechtman, Heather
1976 Metallurgical Site Survey in the Peruvian Andes. *Journal of Field Archaeology* 3(1): 1-42.

1984 Andean Value Systems and the Development of Prehistoric Metallurgy. *Technology and Culture* 25(1): 1-36.

Lecoq, Patrice
1987 Caravanes De Lamas, Sel Et Échanges Dans Une Communauté De Potosi, En Bolivie. *Bulletin de l'Institut Français d'Etudes Andines* 16(3/4): 1-38.

1988 Una Ruta 'De La Sal' En El Sud Boliviano: Informe Del Viaje De Trueque Anual De Una Caravana De Llamas. *Revista del Museo Nacional de Etnografia y Folklore*, *La Paz* 1-2: 163-216.

Lévi-Strauss, Claude
1969 *The Elementary Structures of Kinship (Les Structures Élémentaires De La Parenté)*. Revised ed. Eyre & Spottiswoode, London,.

Lillesand, Thomas M., Ralph W. Kiefer and Jonathan W. Chipman
2004 *Remote Sensing and Image Interpretation*. 5th ed. Wiley, New York.

Linares Málaga, Eloy
1990 *Prehistoria De Arequipa* 1. CONCYTEC - UNSA, Arequipa, Perú.

1992 *Prehistoria De Arequipa* 2. CONCYTEC - UNSA, Arequipa, Perú.

Lloyd, C. D. and P. M. Atkinson
2004 Archaeology and Geostatistics. *Journal of Archaeological Science* 31: 151-165.

Lloyd, Janine M., T. M. Origer and D. A. Fredrickson (editors)
2002 *The Effects of Fire and Heat on Obsidian*. Cultural Resources Publication, Anthropology - Fire History. U.S. Department of the Interior, Bureau of Land Management.

Love, Thomas
1988 Andean Interzonal Bartering: Why Does It Persist in a Cash Market Economy? *Multidisciplinary Studies in Andean Anthropology* 8: 87-100.

Luedtke, Barbara E.
1984 Lithic Material Demand and Quarry Production. In *Prehistoric Quarries and Lithic Production*, edited by Jonathon E. Ericson and Barbara A. Purdy, pp. 65-76. Cambridge University Press, Cambridge.

1994 *An Archaeologist's Guide to Chert and Flint*. Institute of Archaeology University of California, Los Angeles.

Luhnow, Glennda G.
1997 *An Examination of the Ethnographic Boundary Shared by Gumbatwas and Kokiwas Modoc Tribelet, Northeastern California.* Master's Thesis, Sonoma State University.

MacNeish, R. S., R. K. Vierra, A. Nelken-Terner and C. J. Phagan (editors)
1980 *Prehistory of the Ayacucho Basin, Peru: Nonceramic Artifacts*. 3. 5 vols. University of Michigan Press, Ann Arbor, MI.

Málaga Medina, Alejandro
1977 Los Collaguas En La Historia De Arequipa En El Siglo Xvi. In *Collaguas 1*, edited by Franklin Pease G. Y and David J. Robinson, pp. 93-129. Pontíficia Universidad Católica del Perú Fondo Editorial, Lima.

Malinowski, Bronislaw
1922 *Argonauts of the Western Pacific: An Account of Native Enterprise and Adventure in the Archipelagoes of Melanesian New Guinea*. Dutton, New York.

1984 [1922] *Argonauts of the Western Pacific: An Account of Native Enterprise and Adventure in the Archipelagoes of Melanesian New Guinea*. Waveland Press, Prospect Heights, Ill.

Malpass, Michael
1987 Prehistoric Agricultural Terracing at Chijra in the Colca Valley, Peru: Preliminary Report i. In *Pre-Hispanic Agricultural Fields in the Andean Region*, edited by William M. Denevan, Kent Mathewson and Gregory W. Knapp, pp. 45-66. vol. 359(i). B.A.R. International Series, Oxford, England.

Malpass, Michael and Pablo Andres De la Vera Cruz

1986 Ceramic Sequence from Chijra, Colca Valley, Peru. In *The Cultural Ecology, Archaeology, and History of Terracing and Terrace Abandonment in the Colca Valley of Southern Peru*, edited by William M. Denevan, pp. 204-233. vol. 2. University of Wisconsin, Madison, WI.

1990 Cronologia Y Secuencia De La Cerámica De Chijra, Valle De Colca. *Gaceta Arqueológica Andina* 18/19: 41-57.

Manrique, Nelson

1985 *Colonialismo Y Pobreza Campesina: Caylloma Y El Valle Del Colca Siglos Xvi-Xx*. DESCO Centro de Estudios y Promoción del Desarrollo, Lima.

Maos, Jacob O.

1985 Water Resource Development and Land Settlement in Southern Peru: The Majes Project. *GeoJournal* 11(1): 69-78.

Marchant, R. and H. Hooghiemstra

2004 Rapid Environmental Change in African and South American Tropics around 4000 Years before Present: A Review. *Earth-Science Reviews* 66(3): 217-260.

Marino, Raul Jr. and Marco Gonzales-Portillo

2000 Preconquest Peruvian Neurosurgeons: A Study of Inca and Pre-Columbian Trephination and the Art of Medicine in Ancient Peru. *Neurosurgery* 47(4): 940-950.

Markowitz, Lisa B.

1992 *Pastoral Production and Its Discontents: Alpaca and Sheep Herding in Caylloma, Peru.* Ph.D. Dissertation, University of Massachusetts.

Márquez Ostria, J., P. Kussmaul and P. K. Hörmann

1975 Estudio Fotográfico Del Cerro Querimita Y Su Comparación Con Artefactos Líticos. *Centro de investigaciónes arqueológicas* Publicaccion (n.s.), no. 7. La Paz.

Masuda, Shozo, Isumi Shimada and Craig Morris (editors)

1985 *Andean Ecology and Civilization*. University of Tokyo Press, Tokyo.

Mauss, Marcel
1925 Essai Sur Le Don, Forme Et Raison De L'éChange Dans Les SociéTéS ArchaïQues. *Année sociologique*: 136.

1990 [1925] *The Gift: The Form and Reason for Exchange in Archaic Societies*. W.W. Norton, New York.

Mayer, Enrique
1971 Un Carnero Por Un Saco De Papas: Aspectos De Trueque De La Zona Chaupiwaranga, Pasco. *Revista del Museo Nacional (Lima)* XXXVII.

McBryde, Isabel
1984 Kulin Greenstone Quarries: The Social Contexts of Production and Distribution for the Mt William Site. *World Archaeology* 16(2): 267-285.

McEwan, Gordon Francis
1991 A Provincial Huari Center in the Valley of Cusco. In *Huari Administrative Structure: Prehistoric Monumental Architecture and State Government*, edited by William Harris Isbell and Gordon Francis McEwan, pp. 93-119. Dumbarton Oaks Research Library and Collection, Washington, D.C.

Metraux, Alfred
1946 Weapons. In *Handbook of South American Indians*, edited by Julian H. Steward, pp. 229-263. vol. 5. Smithsonian Institution, Bureau of Ethnology, Washington, D.C.

Miller, Daniel
1995 Consumption and Commodities. *Annual Review of Anthropology* 24: 141-161.

Miller, George R.
1979 *An Introduction to the Ethnoarchaeology of the Andean Camelids.* Ph.D. Dissertation, University of California, Berkeley.

Moholy-Nagy, Hattula
1975 Obsidian at Tikal, Guatemala. *Actas XLI, Congreso Internacional de Americanistas 1*: 511-518.

1976 Spatial Distribution of Flint and Obsidian Artifacts at Tikal, Guatemala. *Center for Archaeological Research. University of Texas at San Antonio special report* (4): 91-108.

1991 Flaked Chert Industry of Tikal, Guatemala. In *Maya Stone Tools: Selected Papers from the Second Maya Lithic Conference,* pp. 189-202. Madison : Prehistory Press.

1997 Middens, Construction Fill, and Offerings: Evidence for the Organization of Classic Period Craft Production at Tikal, Guatemala. *Journal of Field Archaeology* 24(3): 293-313.

1999 Mexican Obsidian at Tikal, Guatemala. *Latin American Antiquity* 10(3): 300-13.

Moseley, Michael E.

1975 *The Maritime Foundations of Andean Civilization*. Cummings Archaeology Series. Cummings Publishing Company, Menlo Park, CA.

Mourguiart, P.

2000 Historical Changes in the Environment of Lake Titicaca: Evidence from Ostracod Ecology and Evolution. *Advances in Ecological Research* 31: 497–520.

Mugnier, Clifford J.

2001 Grids and Datums: Republic of Bolivia. *American Society for Photogrammetry and Remote Sensing* 67(7): 777-778. http://www.asprs.org/resources/grids/07-2001-bolivia.pdf

2006 Grids and Datums: Republic of Perú. *American Society for Photogrammetry and Remote Sensing* 72(5): 495-496. http://www.asprs.org/resources/grids/05-2006-peru.pdf

Murra, John V.

1965 Herds and Herders in the Inca State. In *Man, Culture, and Animals: The Role of Animals in Human Ecological Adjustments.*, edited by Anthony Leeds and Andrew P. Vayda., pp. 185-215. vol. 78. American Association for the Advancement of Science (1970 printing), Washington, D.C.

1972 El "Control Vertical" De Un Máximo De Pisos Ecológicos En La Economia De Las Sociedades Andinas. In *Visita De La Provincia De Léon De Huánuco En 1562, I,* edited by Iñigo Ortiz de Zúñiga. Universidad Nacional Hermilio Valdizán, Huánuco, Peru.

1980 *The Economic Organization of the Inca State*. Research in Economic Anthropology. Supplement. JAI Press, Greenwich, Conn.

1985 Limits and Limitations of the 'Vertical Archipelago' in the Andes. In *Andean Ecology and Civilization*, edited by M. I. Shimada Shozo, C. Morris, pp. 15-20. University of Tokyo Press, Tokyo.

Neff, Hector and Michael Glascock
1995 The State of Nuclear Archaeology in North America. *Journal of Radioanalytical and Nuclear Chemistry* 196: 275-286.

Neira Avendaño, M.
1961 *Los Collaguas*, M.A. thesis, Universidad Nacional de San Agustin.

Neira Avendaño, Máximo
1990 Arequipa Prehispanica. In *Historia General De Arequipa*, edited by M. Neira Avendaño, G. Galdos Rodríguez, A. Málaga Medina, E. Q. Paz Soldán and J. G. Carpio Muñoz, pp. 5-213. M. J. Bustamante de la Fuente, Arequipa.

Neira Avendaño, Máximo
1968 Un Nuevo Complejo Lítico Y Pinturas Rupestres En La Gruta Su-3 De Sumbay. *Revista de la Facultad de Letras (Universidad Nacional de San Agustin de Arequipa)* 5: 43-75, Figs. 1-37.

Netherly, Patricia J.
1977 *Local Level Lords on the North Coast of Peru.* Ph.D. Dissertation, Cornell University.

Nielsen, Axel E.
2000 *Andean Caravans: An Ethnoarchaeology.* Ph.D., University of Arizona, Tucson.

2001 Ethnoarchaeological Perspectives on Caravan Trade in the South-Central Andes. In *Ethnoarchaeology of Andean South America : Contributions to Archaeological Method and Theory*, edited by Lawrence A. Kuznar, pp. 163-201. Ethnoarchaeological Series ; 4. vol. 4. International Monographs in Prehistory, Ann Arbor, Mich.

NIMA
1977 *Nima Report 8350.2, 4 July 1977*.

1995 Vector Smart Map Level 1 Performance Specification. National Imagery and Mapping Association. http://www.nima.mil/ast/fm/acq/VMAP_89033.pdf

Noble, Donald C., Pedro A. Navarro, Luis Quispesivana, Lisa Peters and Edwin H. McKee
2003 Ash-Flow Sheets of Early Miocene and Early Pliocene Age are Present in the Castillo De Callalli, Arequipa Department, Southern Peru. *Boletín de la Sociedad Geológica del Perú* 95: 33-38.

North, Douglass Cecil
1990 *Institutions, Institutional Change, and Economic Performance*. Cambridge University Press, Cambridge.

Nuñez, Lautaro and Tom D. Dillehay
1995 [1979] *Movilidad Giratoria, Armonía Social y Desarrollo en los Andes Meridionales: Patrones de Tráfico e Interacción Económica*. Universidad de Chile, Antofagasta.

Nuñez, Lautaro, Martin Grosjean and Isabel Cartajena
2002 Human Occupations and Climate Change in the Puna De Atacama, Chile. *Science* 298(5594): 821-824.

Núñez, Lautaro and Calogero M. Santoro
1988 Cazadores De La Puna Seca Y Salada Del Area Centro-Sur Andina. *Estudios Atacameños* 9: 11-60.

Oberem, Udo
1981 [1976] El Acceso a Recursos Naturales De Diferentes Ecologías En La Sierra Ecuatoriana. Siglo Xvi. In *Contribución a La Etnohistoria Ecuatoriana*, edited by Segundo Moreno Yáñez and Udo Oberem, pp. 406. 2 ed. Colección Pendoneros. vol. 20. Instituto Otavaleño de Antropología, Otavalo, Ecuador.

1985 [1974] Trade and Trade Goods in the Ecuadorian Montaña. In *Native South Americans: Ethnology of the Least Known Continent*, edited by Patricia J. Lyon, pp. 346-358. Waveland Press, Prospect Heights, IL.

Obsidian
2006. In *Encyclopaedia Britannica*. Retrieved 6 September, 2006, from Encyclopædia Britannica Online: http://search.eb.com/eb/article-9056670.

Ogburn, Dennis E.
2004a Evidence for Long-Distance Transportation of Building Stones in the Inka Empire, from Cuzco, Peru to Saraguro, Ecuador. *Latin American Antiquity* 15(4): 419-439.

2004b Power in Stone: The Long-Distance Movement of Building Blocks in the Inca Empire. *Ethnohistory* 51(1): 101-135.

ONERN
1973 *Inventario, Evaluación Y Uso Racional De Los Recursos Naturales De La Costa: Cuenca De Río Camaná-Majes* 2. 2 vols. Oficina Nacional de Evaluación de Recursos Naturales, Lima.

Ossa, Paul P. and Michael E. Moseley
1971 La Cumbre; a Preliminary Report on Research into the Early Liithic Occupation of the Moche Valley, Peru. *Nawpa Pacha* 9: 1-16.

Owen, Bruce
2001 The Economy of Metal and Shell Wealth Goods. In *Empire and Domestic Economy*, edited by Terence N. D'Altroy and Christine Ann Hastorf, pp. 265-293. Kluwer Academic, New York.

Owen, Bruce D. and Paul S. Goldstein
2001 Tiwanaku En Moquegua: Interacciones Regionales Y Colapso. In *Horizonte Medio*, edited by Peter Kaulicke, pp. 169-188. Boletin De Arqueología Pucp. vol. 2, Peter Kaulicke, general editor. 4 vols. Fondo Editorial de la Pontificia Universidad Católica del Perú, Lima.

Paduano, Gina M., Mark B. Bush, Paul A. Baker, Sherilyn C. Fritz and Geoffrey O. Seltzer
2003 A Vegetation and Fire History of Lake Titicaca since the Last Glacial Maximum. *Palaeogeography, Palaeoclimatology, Palaeoecology* 194: 259-279.

Palacios, O., J. de la Cruz, N. de la Cruz, B. A. Klinck, R. A. Allison and M. P. Hawkins
1993 *Geología De La Cordillera Occidental Y Altiplano Al Oeste Del Lago Titicaca-Sur Del Perú* Boletín No. 42. INGEMMET, República del Perú, Sector Energía y Metalúrgico, Lima.

Palacios Ríos, Félix
1981 Tecnología Del Pastoreo. In *La Tecnología En El Mundo Andino: Runakunap Kawsayninkupaq Rurasqankunaqa*, edited by Heather Lechtman and Ana María Soldi, pp. 217-232. Serie Antropológica. vol. 36. Universidad Nacional Autónoma de México, México.

Parodi, Alberto
1987 The Geomorphology of the Colca River Canyon. In *Descubriendo El Valle Del Colca - Discovering the Colca Valley*, edited by Mauricio de Romaña, Jaime Blassi and Jorge Blassi, pp. 31-53. 1a ed. F.O. Patthey, Barcelona.

Pastrana, Alejandro
1998 *La Explotación Azteca De La Obsidiana En La Sierra De Las Navajas*. Instituto Nacional de Antropología e Historia, México, D.F.

Pastrana, Alejandro and Kenneth G. Hirth
2003 Biface Production and Craft Specialization: A View from Sierra De Las Nevajas, Hidalgo. In *Mesoamerican Lithic Technology: Experimentation and Interpretation*, edited by Kenneth G. Hirth, pp. 197-207. University of Utah Press, Salt Lake City.

Patterson, Leland W.
1985 Distinguishing between Arrow and Spear Points on the Upper Texas Coast. *Lithic Technology* 14(2): 81-89.

Patterson, Thomas C.
1987 Merchant Capital and the Formation of the Inca State. *Dialectical Anthropology* 12(2): 217-227.

Pearson, O. P.
1951 Mammals in the Highlands of Southern Peru. *Bulletin of Comparative Zoology* 106(3).

Pease G. Y, Franklin
1977 Problemas Iniciales. In *Collaguas 1*, edited by Franklin Pease G. Y, pp. 131-167. Pontificia Universidad Católica Fondo Editorial, Lima.

Perry, Linda, Daniel H. Sandweiss, Dolores R. Piperno, Kurt Rademaker, Michael A. Malpass, Adán Umire and Pablo de la Vera
2006 Early Maize Agriculture and Interzonal Interaction in Southern Peru. *Nature* 440(7080): 76-79.

Pires-Ferreira, Jane W.
1976 Obsidian Exchange in Formative Mesoamerica. In *The Early Mesoamerican Village*, edited by Kent V. Flannery, pp. 292-306. Studies in Archeology. Academic Press, New York.

Pires-Ferreira, Jane W. and Kent V. Flannery
1976 Ethnographic Models for Formative Exchange. In *The Early Mesoamerican Village*, edited by Kent V. Flannery, pp. 286-292. Studies in Archeology. Academic Press, New York.

Platt, Tristan
1980 Espejos Y Maiz: El Concepto De Yanatin Entre Los Macha De Bolivia. In *Parentesco Y Matrimonio En Los Andes*, edited by E. Mayer and R. Bolton. Universidad de Católica, Lima.

Plattner, Stuart
1989 Introduction. In *Economic Anthropology*, edited by Stuart Plattner, pp. 1-20. Stanford University Press, Stanford, Calif.

Polanyi, Karl
1944 *The Great Transformation*. Beacon Press, Boston.

1957 The Economy as an Instituted Process. In *Trade and Market in the Early Empires: Economies in History and Theory*, edited by C.M. Arensberg, Karl Polanyi and H. W. Pearson, pp. 243-270. Free Press, New York.

1975 Traders and Trade. In *Ancient Civilization and Trade*, edited by Jeremy A. Sabloff and C. C. Lamberg-Karlovsky, pp. 133-154. 1st ed. School of American Research. University of New Mexico Press, Albuquerque.

Ponce Sanginés, C
1970 Las Culturas Wankarani Y Chiripa Y Su Relación Con Tiwanaku. *Academia Nacional de Ciencias de Bolivia* publicación 25.

Porras Barrenechea, Raúl
1937 *Las Relaciones Primitivas De La Conquista Del Perú*. Impr. les Presses modernes, Paris,.

Posnansky, Arthur
1957 *Tihuanacu, the Cradle of American Man* 3. Ministerio de Educacion, La Paz, Bolivia.

Pryor, Frederic L.
1977 *The Origins of the Economy: A Comparative Study of Distribution in Primitive and Peasant Economies*. Academic Press, New York.

Pulgar Vidal, Javier
1946 *Geografía Del Perú, Tomo I: Las Ocho Regiones Naturales Del Perú*. Universidad Nacional Mayor de San Marcos, Lima.

Purdy, Barbara A.
1984 Quarry Studies: Technological and Chronological Significance. In *Prehistoric Quarries and Lithic Production*, edited by Jonathon E. Ericson and Barbara A. Purdy, pp. 119-127. Cambridge University Press, Cambridge.

Quilter, Jeffrey
1991 Late Preceramic Peru. *Journal of World Prehistory* 5(4): 387-438.

Rademaker, Kurt, Dan Sandweiss, Michael Malpass, Adam Umire, Pablo de la Vera Cruz, Louis Fortin and Ben Morris
2004 Preceramic Utilization of the Alca Obsidian Source: Recent Results. Paper presented at the Northeast Conference on Andean Archaeology and Ethnohistory, Yale University.

Ramsey, C. Bronk
1995 Radiocarbon Calibration and Analysis of Stratigraphy: The Oxcal Program. *Radiocarbon* 37(6): 425-430.

2003 Oxcal Radiocarbon Calibration Program, Version 3.9. http://www.rlaha.ox.ac.uk/O/oxcal.php.

Rappaport, Roy A.
1967 *Pigs for the Ancestors: Ritual in the Ecology of a New Guinea People*. Yale University Press, New Haven.

Rathje, William L.
1971 The Origin and Development of Lowland Classic Maya Civilization. *American Antiquity* 36(3): 275-285.

1975 The Last Tango in Mayapan: A Tentative Trajectory of Production-Distribution Systems. In *Ancient Civilization and Trade*, edited by Jeremy A. Sabloff and C. C. Lamberg-Karlovsky, pp. 409-448. University of New Mexico Press, Albuquerque.

Rathje, William Laurens and Mark P. Leone, ed
1972 Praise the Gods and Pass the Metates: A Hypothesis of the Development of Lowland Rainforest Civilizations in Mesoamerica. In *Contemporary Archaeology; a guide to theory and contributions*, pp. 365-392. Carbonale, Illinois.

Ravines, Rogger
1967 A Pre-Columbian Wound. *American Antiquity* 32(2): 230-231.

1973 Secuencia Y Cambios En Los Artefactos Liticos Del Sur Del Perú. *Revista del Museo Nacional (Lima)* 38: 133-184.

1982 *Panorama De La Arqueología Andina*. 1a ed. Fuentes E Investigaciones Para La Historia Del Perú 6. Instituto de Estudios Peruanos, Lima.

Redman, Charles L. (editor)
1973 *Research and Theory in Current Archeology*. Wiley, New York.

1987 Surface Collection, Sampling, and Research Design: A Retrospective. *American Antiquity* 52(2): 249-265.

Renfrew, Colin
1969a The Sources and Supply of the Deh Luran Obsidian. In *Prehistory and Human Ecology of the Deh Luran Plain*, edited by Frank Hole, Kent V. Flannery and James A. Neely, pp. 429-433. University of Michigan Museum of Anthropology. vol. Memoirs 1. University of Michigan Press, Ann Arbor, MI.

1969b Trade and Culture Process in European Prehistory. *Current Anthropology* 10(2): 151-169.

1972 *The Emergence of Civilisation: The Cyclades and the Aegean in the Third Millennium B.C.* Studies in Prehistory. Methuen, London,.

1975 Trade as Action at a Distance: Questions of Integration and Communication. In *Ancient Civilization and Trade,* edited by Jeremy A. Sabloff and C. C. Lamberg-Karlovsky, pp. 3-60. University of New Mexico Press, Albuquerque.

1977a Alternative Models for Exchange and Spatial Distribution. In *Exchange Systems in Prehistory*, edited by Timothy K. Earle and Jonathon E. Ericson, pp. 71-90. Academic Press, New York.

1977b The Later Obsidian of Deh Luran – the Evidence of Chagha Sefid. In *Studies in the Archeological History of the Deh Luran Plain: The Excavation of Chagha Sefid*, edited by Frank Hole, pp. 289-311. Memoirs of the Museum of Anthropology, University of Michigan ; No. 9. Museum of Anthropology University of Michigan, Ann Arbor.

1986 Varna an the Emergence of Wealth in Prehistoric Europe. In *The Social Life of Things: Commodities in Cultural Perspective*, edited by Arjun Appadurai, pp. 141-168. Cambridge University Press, Cambridge.

Renfrew, Colin and John F. Cherry (editors)

1986 *Peer Polity Interaction and Socio-Political Change*. Cambridge University Press, New York.

Renfrew, Colin, J. E. Dixon and J. R. Cann

1968 Further Analysis of near Eastern Obsidians. *Proceedings of the Prehistoric Society* 34: 319-331.

Rennell, Francis James Rodd

1966 [1926] *People of the Veil. Being an Account of the Habits, Organisation and History of the Wandering Tuareg Tribes Which Inhabit the Mountains of Air or Asben in the Central Sahara*. Anthropological Publications, Oosterhout, N.B.

Rhoades, Robert E. and Stephen I. Thompson

1975 Adaptive Strategies in Alpine Environments: Beyond Ecological Particularism. *American Ethnologist* 2: 535-51.

Rick, John W.
1976 Downslope Movement and Archaeological Instrasite Spatial Analysis. *American Antiquity* 41(2): 133-144.

1980 *Prehistoric Hunters of the High Andes*. Academic Press, New York.

Ridings, Rosanna
1996 Where in the World Does Obsidian Hydration Dating Work? *American Antiquity* 61(1): 136-148.

Rigsby, Catherine A., Paul A. Baker and Mark S. Aldenderfer
2003 Fluvial History of the Rio Ilave Valley, Peru, and Its Relationship to Climate and Human History. *Palaeogeography, Palaeoclimatology, Palaeoecology* 194(1-3): 165-185.

Rivera Casanovas, Claudia
2003 Ch'iji Jawira: A Case of Ceramic Specialization in the Tiwanaku Urban Periphery. In *Tiwanaku and Its Hinterland: Archaeology and Paleoecology of an Andean Civilization, Vol. 2*, edited by Alan L. Kolata, pp. 296-315. 2 vols. Smithsonian Institution Press, Washington, DC.

Rivera, Fermin
1978 Análisis Tipológico De Las Puntas De Proyectil Wari. In *Congreso Peruano, El Hombre Y La Cultura Andina, Actas Y Trabajos (Tercer)*, edited by Ramiro Matos Mendieta, pp. 584-593. Editora Lasontay, Lima.

Rivera, Mario
1991 The Prehistory of Northern Chile: A Synthesis. *Journal of World Prehistory* 5(1): 1-47.

Rodbell, Donald T. and Geoffrey O. Seltzer
2000 Rapid Ice Margin Fluctuations During the Younger Dryas in the Tropical Andes. *Quaternary Research* 54(3): 328-338.

Romaña, Mauricio de
1987 Donde Vive La Vicuña - Where the Vicuña Lives. In *Descubriendo El Valle Del Colca - Discovering the Colca Valley*, edited by Mauricio de Romaña, Jaime Blassi and Jorge Blassi, pp. 67-83. F.O. Patthey, Barcelona.

Rostworowski, María
1976 Reflexiones Sobre La Reciprocidad Andina. *Revista del Museo Nacional* 42: 341-354.

1977 Pescadores Artesanos, Y Mercaderes Costeños En El Perú Prehispánico. In *Etnía Sociedad: Costa Peruana Prehispánica*, edited by María Rostworowski de Diez Canseco, pp. 211-264. Instituto de Estudios Peruanos, Lima.

Rowe, John H.
1946 Inca Culture at the Time of the Spanish Conquest. *Handbook of South American Indians* 2(143): 183-330.

1967 Stages and Periods in Archaeological Intrepretation. *Peruvian Archaeology; selected readings*: 1-15.

Sahlins, Marshall
1965 On the Sociology of Primitive Exchange. In *The Relevance of Models for Social Anthropology*, edited by Association for Social Anthropologists. Praeger, New York.

1972 *Stone Age Economics*. Aldine publishers, New York, NY.

Salomon, Frank
1985 The Dynamic Potential of the Complementarity Concept. In *Andean Ecology and Civilization*, edited by Shozo Masuda, Isumi Shimada and Craig Morris. University of Tokyo Press, Tokyo.

1986 *Native Lords of Quito in the Age of the Incas: The Political Economy of North-Andean Chiefdoms*. Cambridge University Press, New York.

Salzman, Philip Carl
1999 Is Inequality Universal? *Current Anthropology* 40(1): 31-61.

Sancho de La Hoz, Pedro
1968 [1534] Relación Para Su Majestad. In *Biblioteca Peruana, Tomo I*, pp. 275-343. Editores Técnicos Asociados, SA, Lima.

Sanders, William T., Jeffrey R. Parsons and Robert S. Santley
1979 *The Basin of Mexico: Ecological Processes in the Evolution of a Civilization*. Academic Press, New York.

Sanders, William T. and Robert S. Santley
1983 Tale of Three Cities: Energetics and Urbanism in Prehispanic Central Mexico. In *Prehistoric Settlement Patterns: Essays in Honor of Gordon R. Willey*, edited by Gordon Randolph Willey, Evon Zartman Vogt and Richard M. Leventhal, pp. 243-291. 1st ed. University of New Mexico Press, Albuquerque.

Sandor, Jon
1992 Long-Term Effects of Prehistoric Agriculture on Soils: Examples from New Mexico and Peru. In *Soils in Archaeology: Landscape Evolution and Human Occupation*, edited by Vance T. Holliday, pp. 217-246. Smithsonian Institution Press, Washington.

Sandweiss, Daniel H.
1992 *The Archaeology of Chincha Fishermen: Specialization and Status in Inka Peru*. Carnegie Museum of Natural History, Pittsburgh.

2003 Terminal Pleistocene through Mid-Holocene Archaeological Sites as Paleoclimatic Archives for the Peruvian Coast. *Palaeogeography Palaeoclimatology Palaeoecology* 194: 23-40.

Sandweiss, Daniel H., Kirk A. Maasch, D. F. Belknap, James B. Richardson, III and H. B. Rollins
1998a Discussion Of: Lisa E. Wells, 1996. The Santa Beach Ridge Complex, Journal of Coastal Research, 12(1), 1-17. *Journal of Coastal Research* 14(1): 367-373.

Sandweiss, Daniel H., Heather McInnis, Richard L. Burger, Asuncion Cano, Bernardino Ojeda, Rolando Paredes, Maria del Carmen Sandweiss and Michael D. Glascock
1998b Quebrada Jaguay: Early South American Maritime Adaptation. *Science* 281: 1830-1832.

Santley, Robert S.
1984 Obsidian Exchange, Economic Stratification, and the Evolution of Complex Society in the Basin of Mexico. In *Trade and Exchange in Early Mesoamerica*, edited by Kenneth G. Hirth, pp. 43-86. University of New Mexico Press, Albuquerque.

Santoro, Calogero M. and Lautaro Núñez
1987 Hunters of the Dry Puna and Salt Puna in Northern Chile. *Andean Past* 1: 57-110.

Sauer, Carl O.
1956 The Education of a Geographer. Paper presented at the Presidential address given by the Honorary President of the Association of American Geographers at its 52nd annual meeting, April 4, 1956, Montreal, Quebec.

Schick, Kathy and J. Desmond Clark
2003 Biface Technological Development and Variability in the Acheulian Industrial Complex in the Middle Awash Region of Afar Rift, Ethiopia. In *Multiple Approaches to the Study of Bifacial Technologies*, edited by University of Pennsylvania and Museum of Archaeology and Anthropology, pp. 1-30. University of Pennsylvania Museum of Archaeology and Anthropology, Philadelphia.

Schiffer, Michael B.
1975 Behavioral Chain Analysis: Activities, Organization, and the Use of Space. *Fieldiana* 65(103-174).

Schiffer, Michael Brian
1983 Toward the Identification of Formation Processes. *American Antiquity* 48(4): 675-706.

Schneider, Harold K.
1974 *Economic Man: The Anthropology of Economics*. Free Press, New York.

Schreiber, Katharina J.
1992 *Wari Imperialism in Middle Horizon Peru*. Museum of Anthropology University of Michigan, Ann Arbor.

Sellet, Frédéric
1993 Chaîne Opératoire: The Concept and Its Applications. *Lithic Technology* 18: 106-112.

Seltzer, G.O., D. T. Rodbell, P. A. Baker, S. C. Fritz, P. M. Tapia, H. D. Rowe and P. B. Dunbar
2002 Early Warming of Tropical South America at the Last Glacial-Interglacial Transition. *Science* 296: 1685-1686.

Service, Elman R.
1962 *Primitive Social Organization*. Random House, New York.

1975 *Origins of the State and Civilization: The Process of Cultural Evolution*. Norton, New York.

Shackley, M. Steven
1998 Gamma Rays, X-Rays and Stone Tools: Some Recent Advances in Archaeological Geochemistry. *Journal of Archaeological Science* 25: 259-270.

2005 *Obsidian: Geology and Archaeology in the North American Southwest*. University of Arizona Press, Tucson.

Shady Solis, Ruth , Jonathan Haas and Winifred Creamer
2001 Dating Caral, a Preceramic Site in the Supe Valley on the Central Coast of Peru. *Science* 292: 723-726.

Shea, Daniel
1987 Preliminary Discussion of Prehistoric Settlement and Terracing at Achoma in the Colca Valley, Peru. In *Pre-Hispanic Agricultural Fields in the Andean Region*, edited by William M. Denevan, Kent Mathewson and Gregory W. Knapp, pp. 67-88. vol. 359(i). B.A.R. International Series, Oxford, England.

Sheets, Payson D.
1975 Behavioral Analysis and the Structure of a Prehistoric Industry. *Current Anthropology* 16(3): 369-391.

1978 From Craftsmen to Cog: Quantitative Views of Mesoamerican Lithic Technology. In *Papers on the Economy and Architecture of the Ancient Maya*, edited by Raymond Sidrys, Institute of Archaeology University of California, Los Angeles.

Sheets, Payson D. and Guy R. Muto
1972 Pressure Blades and Total Cutting Edge: An Experiment in Lithic Technology. *Science* 175(4022): 632-634.

Shennan, Stephen
1997 *Quantifying Archaeology*. 2nd ed. Edinburgh University Press, Edinburgh.

Shepard, Anna Osler
1956 *Ceramics for the Archaeologist*. Carnegie Institution of Washington, Washington.

Shimada, Izumi
1982 Horizontal Archipelago and Coast-Highland Interaction in North Peru: Archaeological Models. In *El Hombre Y Su Ambiente En Los Andes Centrales*, edited by Luís Millones and Hiroyasu Tomoeda, pp. 137-210. Senri Ethnololgical Studies. vol. 10. National Museum of Ethnology, Senri, Japan.

Shippee, Robert
1932 Lost Valleys of Peru; Results of the Shippee-Johnson Peruvian Expedition. *Geographical review* 22: 562-581.

Shott, M. J., A. P. Bradbury, P. J. Carr and G. H. Odell
2000 Flake Size from Platform Attributes: Predictive and Empirical Approaches. *Journal of Archaeological Science* 27(10): 877-894.

Shott, Michael J.
1996 An Exegesis of the Curation Concept. *Journal of Anthropological Research* 52(3): 259-280.

1997 Stones and Shafts Redux: The Metric Descrimination of Chipped-Stone Dart and Arrow Points. *American Antiquity* 62(1): 86-101.

2003 Chaîne Opératoire and Reduction Sequence. *Lithic Technology* 28(2): 95-105.

Sidrys, Raymond V.
1976 Classic Maya Obsidian Trade. *American Antiquity* 41(4): 449-464.

1977 Mass-Distance Meaures for the Maya Obsidian Trade. In *Exchange Systems in Prehistory*, edited by Timothy K. Earle and Jonathon E. Ericson, pp. 91-107. Studies in Archeology. Academic Press, New York.

Simmel, Georg and David Frisby
2004 [1907] *The Philosophy of Money*. 3rd enl. ed. Routledge, London.

Smith, Bruce D.
2001 Low Level Food Production. *Journal of Archaeological Research* 9(1): 1-43.

Smith, Carol A.
1976a Exchange Systems and the Spatial Distribution of Elites: The Organization of Stratification in Agrarian Societies. In *Regional Analysis, Volume 2, Social Systems*, edited by Carol A. Smith, pp. 309–374. 2 vols. Academic Press, New York.

1976b Regional Economic Systems: Linking Geographical Models and Socioeconomic Problems. In *Regional Analysis, Volume 1, Economic Systems*, edited by Carol A. Smith, pp. 3-63. 2 vols. Academic Press, New York.

Smith, Jacqueline A., Geoffrey O. Seltzer, Daniel L. Farber, Donald T. Rodbell and ERobert C. Finkel
2005 Early Local Last Glacial Maximum in the Tropical Andes. *Science* 308: 678-681.

Smith, Michael E.
2004 The Archaeology of Ancient State Economies. *Annual Review of Anthropology* 33: 73-102.

Smith, Monica L.
1999 The Role of Ordinary Goods in Premodern Exchange. *Journal of Archaeological Method and Theory* 6(2): 109-135.

Snell, Daniel C.
1997 Appendix: Theories of Ancient Economies and Societies. In *Life in the Ancient near East, 3100-332 B.C.E*, edited by Daniel C. Snell, pp. 145-158. Yale University Press, New Haven Conn.

Spence, Michael W.
1967 The Obsidian Industry of Teotihuacán. *American Antiquity* 32(4): 507-514.

1981 Obsidian Production and the State of Teotihuacan. *American Antiquity* 46(4): 769-788.

1982 The Social Context of Production and Exchange. In *Contexts for Prehistoric Exchange*, pp. 173-197. New York : Academic Press, c1982.

1984 Craft Production and Polity in Early Teotihuacan. In *Trade and Exchange in Early Mesoamerica. Albuquerque*, pp. 87-114. University of New Mexico Press, 1984.

Speth, John D.
1972 Mechanical Basis of Percussion Flaking. *American Antiquity* 37(1): 34-60.

Spielmann, Katherine Ann
1986 Interdependence among Egalitarian Societies. *Journal of Anthropological Archaeology* 5: 279-312.

Standen, Vivien G.
2003 Bienes Funerarios Del Cementerio Chinchorro Morro 1: Descripción, Análisis E Interpretación. *Chungara* 35(2): 175-207.

Standen, Vivien G. and Bernardo T. Arriaza
2000 Trauma in the Preceramic Coastal Populations of Northern Chile: Violence or Occupational Hazards. *American Journal of Physical Anthropology* 112: 239-249.

Stanish, Charles
1992 *Ancient Andean Political Economy*. University of Texas Press, Austin.

2002 Tiwanaku Political Economy. In *Andean Archaeology I : Variations in Sociopolitical Organization*, edited by William H. Isbell and Helaine Silverman, pp. 169-198. Kluwer Academic/Plenum Publishers, New York.

2003 *Ancient Titicaca: The Evolution of Complex Society in Southern Peru and Northern Bolivia*. University of California Press, Berkeley.

Stanish, Charles, Richard L. Burger, Lisa M. Cipolla, Michael D. Glascock and Esteban Quelima
2002 Evidence for Early Long-Distance Obsidian Exchange and Watercraft Use from the Southern Lake Titicaca Basin of Bolivia and Peru. *Latin American Antiquity* 13(4): 444-454.

Stanish, Charles and Lee Steadman (editors)
1994 *Archaeological Research at Tumatumani, Juli, Peru*. Fieldiana Anthropology (n.s.) no. 23. Field Museum of Natural History, Chicago.

Starn, Orin
1991 Missing the Revolution: Anthropologists and the War in Peru. *Cultural Anthropology* 6(1): 63-91.

Steadman, Lee
1995 *Excavations at Camata: An Early Ceramic Chronology for the Western Lake Titicaca Basin, Peru.* Ph.D. Dissertation, University of California, Berkeley.

Steward, Julian H.
1955 *Theory of Culture Change: The Methodology of Multilinear Evolution*. University of Illinois Press, Urbana.

Steward, Julian Haynes
1938 *Basin-Plateau Aboriginal Sociopolitical Groups*. U.S. Govt. Print. Office, Washington.

Stone, Jane
1983 *The Socio-Economic Implications of Lithic Evidence from Huari, Peru.* Ph.D. Dissertation, State University of New York, Binghamton.

Stuiver, M., P.J. Reimer and T. F. Braziunas
1998 High-Precision Radiocarbon Calibration for Terrestrial and Marine Samples. *Radiocarbon* 40(3): 1127-1151.

Sullivan, Alan P. and Kenneth C. Rozen
1985 Debitage Analysis and Archaeological Interpretation. *American Antiquity* 50(4): 755-779.

Swanson, Kirk E.
1998 *Geology of the Orcopampa 30 Minute Quadrange, Southern Peru, with Special Focus on the Evolution of the Chinchón and Huayta Calderas.* Ph.D. Dissertation, University of Nevada, Reno.

Szakács, Alexandru and Michael Ort
2001 Comments on the Article "Erosion Calderas: Origins, Processes, Structural and Climatic Control" By Karã¡Tson D., Thouret J.-C., Moriya I., Lomoschitz A. (1999), Bulletin of Volcanology 61:174-193. *Bulletin of Volcanology* 63(4): 289-290.

Tapia Nuñez, Mario E. and Jorge A. Flores Ochoa
1984 *Pastoreo Y Pastizales De Los Andes Del Sur Del Perú*. Instituto Nacional de Investigación y Promoción Agropecuaria, Lima.

Tello, Julio C.
1929 *Antiguo Peru, Primera Epoca*, Lima, Peru.

Thomas, David Hurst
1975 Nonsite Sampling in Archaeology: Up the Creek without a Site? In *Sampling in Archaeology*, edited by J. W. Mueller, pp. 61-81. University of Arizona Press, Tucson.

1978 Arrowheads and Atlatl Darts: How the Stones Got the Shaft. *American Antiquity* 43(3): 461-472.

Thomas, R. Brooke
1973 *Human Adaptation to a High Andean Energy-Flow System*. Occasional Papers in Anthropology 7. Pennsylvania State University, College Park, PA.

Thorpe, R. S., P. W. Francis, M. Hammill and M. C. W. Baker
1982 The Andes. In *Andesites: Orogenic Andesites and Related Rocks*, edited by R. S. Thorpe, pp. 187-205. Wiley, New York.

Thorpe, R. S., P. W. Francis and R. S. Harmon
1981 Andean Andesites and Crustal Growth. *Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences* 301(1461, The Origin and Evolution of the Earth's Continental Crust): 305-320.

Thouret, Jean-Claude, Bradley Singer and Anthony Finizola
2005a The Central Andes in Peru: ‘Old’ Valleys in a ‘Young’ Mountain Range? Paper presented at the 6th International Symposium on Andean Geodynamics (ISAG 2005), Barcelona.

Thouret, Jean-Claude, E. Juvigne, J. Mariño, M. Moscol, A. Legeley-Padovani, I. Loutsch, J. Davila, S. Lamadon and M. Rivera
2002a Late Pleistocene and Holocene Tephro-Stratigraphy and Chronology in Southern Peru. *Sociedad Geológica del Perú* 93: 45-61.

Thouret, Jean-Claude, E. Juvingné, A. Gourgaud, P. Boivin and J. Dávila
2002b Reconstruction of the Ad1600 Huaynaputina Eruption Based on the Correlation of Geologic Evidence with Early Spanish Chronicles. *Journal of Volcanology and Geothermal Research* 115: 529-570.

Thouret, Jean-Claude, Anthony Finizola, Michel Fornari, Annick Legeley-Padovani, Jaime Suni and Manfred Frechen
2001 Geology of El Misti Volcano near the City of Arequipa, Peru. *Geol Soc Am Bull* 113(12): 1593-1610.

Thouret, Jean-Claude, Marco Rivera, Gerhard Wörner, Marie-Christine Gerbe, Anthony Finizola, Michel Fornari and Katherine Gonzales
2005b Ubinas: The Evolution of the Historically Most Active Volcano in Southern Peru. *Bulletin of Volcanology* 67(6): 557-589.

Tixier, Jacques, Marie-Louise Inizan and Hélène Roche
1980 *Préhistoire De La Pierre Taillée*. Cercle de recherches et d'études préhistoriques; Diffusion Association pour la promotion et la diffusion des connaissances archéologiques, Antibes Valbonne.

Tobler, Waldo
1993 *Three Presentations on Geographical Analysis and Modeling, Technical Report 93-1*. National Center for Geographic Information and Analysis. http://www.ncgia.ucsb.edu/Publications/Tech_Reports/93/93-1.PDF

Toledo, F. d.
1924 [1570-1575] Libro De La Visita General Del Virrey Toledo (1570-1575). *Revista Histórica, Organo del Instituto Histórico del Perú* 7(2): 114-216.

Tomka, Steve A.
2001 "Up and Down We Move...": Factors Conditioning Agro-Pastoral Settlement Organization in Mountainous Settings. In *Ethnoarchaeology of Andean South America : Contributions to Archaeological Method and Theory*, edited by Lawrence A. Kuznar, pp. 138-162. International Monographs in Prehistory, Ann Arbor, MI.

Torrence, Robin
1981 *Obsidian in the Aegean: A Methodology for the Study of Prehistoric Exchange.* Ph.D. Dissertation, University of New Mexico, Albuquerque.

1986 *Production and Exchange of Stone Tools Prehistoric Obsidian in the Aegean*. New Cambridge University Press, Cambridge.

Tostevin, Gilbert B.
2006 Levels of Theory and Social Practice in the Reduction Sequence and Chaîne Opératoire Methods of Lithic Analysis. Paper presented at the 71st Annual Meeting of the Society for American Archaeology, San Juan, Puerto Rico.

Tourtellot, Gair and Jeremy A. Sabloff
1972 Exchange Systems among the Ancient Maya. *American Antiquity* 37(1): 126-135.

Trigger, Bruce G.
2003 *Understanding Early Civilizations: A Comparative Study*. Cambridge University Press, Cambridge.

Trinkler, Emil
1931 *The Stormswept Roof of Asia : By Yak, Camel & Sheep Caravan in Tibet, Chinese Turkistan & over the Kara-Koram*. J. B. Lippincott, Philadelphia.

Tripcevich, Nicholas
2002 *Viewshed Analysis of the Ilave River Valley*. Master's Thesis. http://colca.mapaspects.org/papers_talks/datapaper/Tripcevich_Viewshed02.pdf

2004a Flexibility by Design: How Mobile Gis Meets the Needs of Archaeological Survey. *Cartography and Geographic Information Science* 31(3): 137-151.

2004b Interfaces: Mobile Gis in Archaeological Survey. *The SAA Archaeological Record* 4(3): 17-22.

Troll, Carl
1968 *Geo-Ecology of the Mountainous Regions of the Tropical Americas*. Dümmler in Kommission, Bonn.

Tryon, Christian A. and Rick Potts
2006 Approaches for Understanding Flake Production in the African Acheulian. Paper presented at the 71st Annual Meeting of the Society for American Archaeology, San Juan, Puerto Rico. http://www.saa.org/meetings/esymposium/197/10.pdf

Tschopik Jr., Harry
1946 The Aymara. In *Handbook of South American Indians*, edited by Julian H. Steward, pp. 501-573. vol. 2. Smithsonian Institution, Bureau of Ethnology, Washington, D.C.

Tukey, John W.
1977 *Exploratory Data Analysis*. Addison Wesley, Reading, MA.

Uhle, Max
1909 Peruvian Throwing-Sticks. *American Anthropologist* 11(4): 624-627.

Ulloa Mogollón, J. d.
1965 [1586] Relación De La Provincia De Los Collaguas Para La Descripción De Las Indias Que Su Magestad Manda Hacer. In *Relaciones Geográficas De Indias*, edited by M. Jimenez de la Espada, pp. 326-333. vol. 1. 3 vols. Ediciones Atlas, Madrid.

Upham, Steadman (editor)
1990 *The Evolution of Political Systems: Sociopolitics in Small-Scale Sedentary Societies*. Cambridge University Press, New York.

Valensi, Lucette
1981 Economic Anthropology and History: The Work of Karl Polanyi. *Research in Economic Anthropology* 4: 3-11.

Valli, Eric and Diane Summers
1994 *Caravans of the Himalaya*. National Geographic Society, Washington, D.C.

Van Buren, G. E.
1974 *Arrowheads and Projectile Points: With a Classification Guide for Lithic Artifacts*. Arrowhead Publishing, Garden Grove, Calif.

Van Buren, Mary
1996 Rethinking the Vertical Archipelago: Ethnicity, Exchange, and History in the South Central Andes. *American Anthropologist* 96(2): 338-351.

Van Buren, Mary and Barbara H. Mills
2005 Huayrachinas and Tocochimbos: Traditional Smelting Technology of the Southern Andes. *Latin American Antiquity* 16(1): 3-25.

Van Leusen, Pieter Martijn
2002 *Methodological Investigations into the Formation and Interpretation of Spatial Patterns in Archaeological Landscapes.* Ph.D., Rijksuniversiteit.

Varese, Stefano
2002 *Salt of the Mountain: Campa Asháninka History and Resistance in the Peruvian Jungle*. University of Oklahoma Press, Norman.

Vaughn, Kevin J.
2005a Exchange of Quispisisa Obsidian in the Nasca Region: New Evidence from Marcaya. *Andean Past* 7.

2005b Household Approaches to Ethnicity on the South Coast of Peru: The Domestic Architecture of Early Nasca Society. In *Us and Them: Archaeology and Ethnicity in the Andes,* edited by Richard M. Reycraft, pp. 86-103. Cotsen Institute of Archaeology, University of California, Los Angeles.

Volcano Hazards Program, USGS
2000 *Obsidian*. United States Geological Survey. http://volcanoes.usgs.gov/Products/Pglossary/obsidian.html

Ward, Michael, James S. Milledge and John B. West
2000 *High Altitude Medicine and Physiology*. 3rd ed. Oxford University Press, New York.

Webster, Steven S.
1973 Native Pastoralism in the South Andes. *Ethnology* 12: 115-33.

Weiner, Annette B.
1976 *Women of Value, Men of Renown: New Perspectives in Trobriand Exchange*. University of Texas Press, Austin.

Wernke, Steven A.
2003 *An Archaeo-History of Andean Community and Landscape: The Late Prehispanic and Early Colonial Colca Valley, Peru.* Ph.D. Dissertation, University of Wisconsin, Madison.

West, John B.
1996 Prediction of Barometric Pressures at High Altitudes with the Use of Model Atmospheres. *Journal of Applied Physiology* 81(4): 1850-1854.

West, Terry L.
1981a Llama Caravans of the Andes. *Natural history* 90(12): 62-73.

1981b *Sufriendo Nos Vamos: From a Subsistence to a Market Economy in an Aymara Community of Bolivia.* Ph.D. Dissertation, New School for Social Research.

Wheatley, David
1995 Cumulative Viewshed Analysis: A Gis-Based Method for Investigating Intervisibility and Its Archaeological Application. In *Archaeology and Gis: A European Perspective*, edited by G. Lock and Z. Stancic. Routlege, London.

Wheeler, Jane
1983 On the Origin and Early Development of Camelid Pastoralism in the Andes. In *Animals and Archaeology*, edited by J. Clutton-Brock and C. Grigson. B.A.R., Oxford, England.

Wheeler, Jane C., A. J. F. Russel and Hilary Redden
1995 Llamas and Alpacas: Pre-Conquest Breeds and Post-Conquest Hybrids. *Journal of Archaeological Science* 22(6): 833-840.

Whittaker, John C.
1994 *Flintknapping: Making and Understanding Stone Tools*. 1st ed. University of Texas Press, Austin.

Wiessner, Polly
1982 Risk, Reciprocity and Social Influences On !Kung San Economics. In *Politics and History in Band Societies*, edited by E. Leacock and R. B. Lee, pp. 61-84. Cambridge University Press, Cambridge.

1996 Leveling the Hunter: Constraints on the Status Quest in Foraging Societies. In *Food and the Status Quest: An Interdisciplinary Perspective*, edited by Polly Wiessner and Wulf Schiefenhövel, pp. 171-191. Berghahn Books, Providence.

2002 The Vines of Complexity. *Current Anthropology* 43(2): 233-269.

Wilk, Richard R.
1996 *Economies and Cultures: Foundations of Economic Anthropology*. WestviewPress, Boulder, Colo.

Willey, Gordon Randolph and Jeremy A. Sabloff
1974 *A History of American Archaeology*. W. H. Freeman, San Francisco.

Williams, Patrick Ryan
2001 Cerro Baúl: A Wari Center on the Tiwanaku Frontier. *Latin American Antiquity* 12(1): 67-83.

Wing, Elizabeth
1986 Domestication of Andean Camelids. In *High Altitude Tropical Biogeography*, edited by François Vuilleumier and Maximina Monasterio, pp. 246-264. Oxford University Press, New York.

Winter, Marcus C. and Jane W. Pires-Ferreira
1976 Distribution of Obsidian among Households in Two Oaxacan Villages. In *The Early Mesoamerican Village*, edited by Kent V. Flannery, pp. 306-311. Studies in Archeology. Academic Press, New York.

Winterhalder, Bruce
1997 Gifts Given, Gifts Taken: The Behavioral Ecology of Nonmarket, Intragroup Exchange. *Journal of Archaeological Research* 5(2): 121-168.

Winterhalder, Bruce and Eric Alden Smith
2000 Analyzing Adaptive Strategies: Human Behavioral Ecology at Twenty-Five. *Evolutionary Anthropology*: 51-73.

Winterhalder, Bruce and R. Brooke Thomas
1978 *Geoecology of Southern Highland Peru: A Human Adaptation Perspective*. University of Colorado Institute of Arctic and Alpine Research, Boulder.

Wirrmann, Denis and Philippe Mourguiart
1995 Late Quaternary Spatio-Temporal Limnological Variations in the Altiplano of Bolivia and Peru. *Quaternary Research* 43(3): 344-354.

Wirrmann, Denis, J.P. Ybert and Philippe Mourguiart
1992 A 20,000 Year Paleohydrological Record from Lake Titicaca. In *Lake Titicaca: A Synthesis of Limnological Knowledge*, edited by Claude Dejoux and A. Iltis, pp. 40-48. vol. 68. Kluwer Academic Publishers, Dordrecht.

WMO, World Meteorological Organization
2006 *Weather Information for Arequipa*

Wobst, H. Martin
1978 The Archaeo-Ethnology of Hunter-Gatherers or the Tyranny of the Ethnographic Record in Archaeology. *American Antiquity* 43(2): 303-309.

Wright, Gary A.
1969 *Obsidian Analyses and Prehistoric near Eastern Trade: 7500 to 3500 B.C.* University of Michigan, Ann Arbor.

1970 On Trade and Culture Process in Prehistory. *Current Anthropology* 11(2): 172-173.

Wright, Gary A. and Adon A. Grodus
1969 Distribution and Utilization of Obsidian from Lake Van Sources between 7500 and 3500 B.C. *American Journal of Archaeology* 73(1): 75-77.

Yacobaccio, Hugo D., Patricia S. Escola, Fernando X. Pereyra, Marisa Lazzari and Michael D. Glascock
2004 Quest for Ancient Routes: Obsidian Sourcing Research in Northwestern Argentina. *Journal of Archaeological Science* 31: 193-204.

Yacobaccio, Hugo D., Patricia S. Escola, Marisa Lazzari and Fernando X. Pereyra
2002 Long-Distance Obsidian Traffic in Northwestern Argentina. In *Geochemical Evidence for Long-Distance Exchange*, edited by M. D. Glascock, pp. 167-203. Bergin and Garvey, Westport, CN.

Zahm, John A. (pseudonym of H.J. Mozans)
1911 *Along the Andes and Down the Amazon*. D. Appleton, New York.

Zeidler, James A.
1977 Primitive Exchange, Prehistoric Trade, and the Problem of a Mesoamerican-South American Connection. *Journal of the Steward Anthropological Society* 9(1): 7-39.

Zeitlin, Robert N.
1978 Long-Distance Exchange and the Growth of a Regional Center on the Southern Isthmus of Tehuantepec, Mexico. In *Prehistoric Coastal Adaptations*, pp. 183-210. Academic Press, New York.

1982 Towards a More Comprehensive Model of Interregional Commodity Distribution: Political Variables and Prehistoric Obsidian Procurement in Mesoamerica. *American Antiquity* 47(2): 260-275.

Zeitlin, Robert N. and R. C. Heimbuch
1978 Trace Element Analysis and the Archaeoogical Study of Obsidian Procurement in Precolumbian Mesoamerica. In *Lithics and Subsistence: The Analysis of Stone Tool Use in Prehistoric Economies*, edited by D. D. Davis. Vanderbuilt University Publications in Anthropology. vol. 20. Vanderbuilt, Nashville, TN.