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Obsidian Networks and Imperial Processes: Sourcing Obsidian from the Capital of the Wari Empire, Peru (AD 600 – 1000)

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by

Jessica Doyle Kaplan

Committee in charge:

Professor Emerita Katharina Schreiber, Chair

Professor Gregory D. Wilson

Professor Stuart Tyson Smith

June 2018

The dissertation of Jessica Doyle Kaplan is approved.

Stuart Tyson Smith

Gregory D. Wilson

Katharina Schreiber, Committee Chair

June 2018

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VITA OF JESSICA DOYLE KAPLAN

June 2018

EDUCATION

2018 Ph.D., Anthropology, University of California, Santa Barbara
2012 M.A., Anthropology, University of California, Santa Barbara
2009 B.A., Anthropology, Vassar College

RESEARCH INTERESTS

Imperialism and Imperial Processes, Political Economy, Craft Production
Resources and Strategies of Control, Obsidian Sourcing, X-Ray Fluorescence Analyses
Andean Archaeology, The Wari Empire

RESEARCH GRANTS AND FELLOWSHIPS

2010–2017 Tuition Fellowship/Fee Fellowship, UCSB Anthropology
2015 Archaeology Graduate Student Research Grant, UCSB Anthropology
2015 Humanities and Social Sciences Research Grant, UCSB
2008 Undergraduate Research Symposium Institute Fellow, Vassar College

AWARDS AND HONORS

2014 Outstanding Teaching Award (nominated), UCSB Academic Senate
2013 Excellence in Teaching Award (nominated), UCSB Graduate Student Association
2012 High Pass on M.A. Comprehensive Exams, UCSB Anthropology
2009 Nomination to Sigma Xi, Vassar College

PRESENTATIONS, LECTURES, PUBLICATIONS

2017 The Origins of Food Production, Social Complexity and Settled Life. Guest Lecture, Introduction to Archaeology, Department of Anthropology, UCSB

2017 Animal and Plant Domestication. Guest Lecture, Introduction to Archaeology, Department of Anthropology, UCSB

2017 Obsidian in the Wari Empire: Sourcing Material from the Capital Using PXRF. Paper Presentation, Society for American Archaeology 82nd Annual Meeting, Vancouver, BC.

2016 Análisis elemental de obsidiana: usando fluorescencia de rayos-x portátil. Lecture, Universidad Nacional de San Cristóbal de Huamanga, Ayacucho, Peru.

2016 The Use of Quispisisa Obsidian in the Wari Empire. Paper Presentation, Society for American Archaeology 81st Annual Meeting, Orlando, Florida.

2016 Visible Identities: An Archaeological Approach to Sacred Landscapes on the South Coast of Peru. Paper Presentation, Second Graduate Conference on Religion: Sacred Sites and Sacred Landscapes, UCLA Center for the Study of Religion.

2015 Imperial Strategies and Resource Control: Tracing the Production, Distribution and Consumption of Quispisisa obsidian in the Middle Horizon, Peru. Dissertation Proposal Defense, Department of Anthropology, UCSB.

2013 The Ski Minne Rockshelter, Shawangunk Ridge, New York. Published Paper, *The Bulletin: Journal of the New York State Archaeological Association*: 2013.

2012 Seeing the Sacred: Investigating Early Andean Ritual Practice Using Visibility Analysis. Paper Presentation, Society for American Archaeology 77th Annual Meeting, Memphis, Tennessee.

2012 Entanglement and Ideologies of Landscape: Responses to a Wari Presence in Nasca, Peru. Paper Presentation, Constructing Worlds: Making and Breaking Order, Department of Visual Studies, UC Irvine.

2010 Cusco: An Inca City. Guest Lecture, Andean Art History, Department of Art History, UCSB.

2009 Analysis of the Ski Minne Rockshelter, Shawangunk Ridge. Paper Presentation, New York State Archaeological Association, Rochester, New York.

TEACHING EXPERIENCE

Introduction to Archaeology, Teaching Assistant, Department of Anthropology, UCSB: Spring 2011, Spring 2013, Spring 2014, Spring 2015, Spring 2016, Spring 2017

Introduction to Cultural Anthropology, Teaching Assistant, Department of Anthropology, UCSB; Fall 2010, Winter 2012, Fall 2014, Winter 2014, Fall 2015, Winter 2015, Winter 2016, Fall 2017

The Inca Empire, Teaching Assistant, Department of Anthropology, UCSB: Winter 2014

North American Indians, Teaching Assistant, Department of Anthropology, UCSB: Fall 2012, Winter 2014

Introduction to Sociology, Teaching Assistant, Department of Sociology, UCSB: Fall 2013

FIELD AND LABORATORY APPOINTMENTS

Primary Investigator, Quispisisa Obsidian and the Wari Empire Project, Ayacucho, Peru 2013–2016

Field Archaeologist, Quispisisa Obsidian Source Project, Directors Nicholas Tripcevich and Daniel Contreras, Department of Ayacucho, Peru, 2012

Laboratory Assistant, Central Coast Information Center, Director Lynn Gamble, UCSB, 2012

Field Archaeologist, Mina Primavera Project, Directors Kevin Vaughn and Hendrik VanGijseghem, Department of Ica, Peru, 2011

Field Archaeologist, Santa Cruz Island Project, Director Lynn Gamble, Channel Islands, California, 2011

Field Archaeologist, Proyecto Arqueológico Nasca *Tardio*, Directors Kevin Vaughn and Verity Whalen, Department of Ica, Peru 2010

Curatorial Assistant, Hispanic Society of America, Director Daniel Silva, New York, 2009–2010

Laboratory Assistant, Vassar College Archaeology Laboratory, Director Lucille Lewis Johnson, New York, 2007–2009

Field Archaeologist, Shawangunk Mountains Project, Director Lucille Lewis Johnson, New York, 2008

Exhibition Intern, Museo Pumapungo, Banco Central del Ecuador, Cuenca, Ecuador, Director Andres Abad, 2008

Undergraduate Supervisor, Undergraduate Research Symposium Institute, Vassar College, New York, 2008

Collections Intern, American Museum of Natural History, Director Paul Beelitz, New York, 2007

SERVICE

Faculty and Staff Representative, Anthropology Graduate Student Association, UCSB, 2014–2015

Co-Chair, Anthropology Graduate Student Association, UCSB, 2013–2014

Brown Bag Lecture Chair, Anthropology Graduate Student Association, UCSB 2012–2013

Undergraduate Liaison, Vassar College Anthropology Department, New York, 2008–2009

PROFESSIONAL MEMBERSHIPS AND AFFILIATIONS

Society for American Archaeology (SAA)
Sigma Xi

REFERENCES

Dr. Katharina Schreiber
Department of Anthropology
University of California
Santa Barbara, CA 93016
kschreiber@umail.ucsb.edu

Dr. Gregory D. Wilson
Department of Anthropology
University of California
Santa Barbara, CA 93016
gdwilson@anth.ucsb.edu

Dr. Stuart Tyson Smith
Department of Anthropology
University of California
Santa Barbara, CA 93106
stsmith@umail.ucsb.edu

ABSTRACT

Obsidian Networks and Imperial Processes: Sourcing Obsidian from the Capital of the Wari Empire, Peru (AD 600 – 1000)

by

Jessica Doyle Kaplan

This dissertation explores results from portable x-ray fluorescence and lithic analyses of obsidian artifacts from the sector of Vegachayuq Moqo, site of Huari, in the Ayacucho highlands of Peru. The site of Huari is the capital of the eponymous Wari Empire, whose territory extended over the central Andes during the Middle Horizon, AD 600–1000. Throughout prehistory, obsidian in the Andes was generally obtained from three primary obsidian source locations (Quispisisa, Alca and Chivay) as well as six additional smaller, local, sources (Puzolana, Jampatilla, Potreropampa, Lisahuacho, Macusani and Aconcagua). Previous obsidian sourcing studies conducted throughout the central Andes, primarily focused on elemental and geographical identification of the sources themselves, suggest that during the Middle Horizon the Wari Empire became invested in the distribution of obsidian from the Quispisisa obsidian source in the Ayacucho highlands (Burger et al. 2000). During the Middle Horizon, the distribution of Quispisisa obsidian reaches its greatest extent, often coinciding with the presence of other Wari imperial media in the region (e.g., ceramic iconography, architecture). While it has been assumed that Wari may have controlled the

distribution of obsidian during the Middle Horizon, little work has been done to explore this hypothesis. This dissertation tests the assumption that the Wari Empire played a fundamental role in the distribution of obsidian from the Quispisisa obsidian source to hinterland territories within the empire, consequently ushering in new obsidian production and consumption practices during the Middle Horizon.

The data for this dissertation derive from the 2012 excavation season at the site of Huari, conducted by Dr. Jose Ochatoma Paravicino, Licenciada Martha Cabrera and Licenciado Carlos Mancilla Rojas from the Universidad Nacional de San Cristóbal de Huamanga (UNSCH) in Ayacucho. X-ray fluorescence analyses were conducted using a Bruker Tracer III from the Anthropology Department at the University of California Santa Barbara. Lithic analysis was conducted at the UNSCH archaeology lab during the summer field season, 2016. The results presented in this dissertation confirm previous assumptions regarding the presence of Quispisisa obsidian in hinterland territories, while uniquely focusing on the consumption of obsidian in the Wari capital. This dissertation suggests that Wari imperial control of obsidian was not based upon a radical new program, but instead upon a co-option, or formalization, of pre-existing obsidian production, distribution and consumption networks built upon thousands of years of obsidian exploitation in the Andes. At the site of Huari, obsidian production and consumption patterns were established during the Early Intermediate Period, Huarpa occupation (AD 1–500), and continue through the Middle Horizon, Wari occupation. This continuation of obsidian exploitation and use confirms the Wari Empire's flexible political, economic and social strategies in co-opting, or adapting upon, pre-existing infrastructure, and local social, political and economic organization, to administer control over a territorially dispersed empire.

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CHAPTER 1

INTRODUCTION

This dissertation explores the role of obsidian as a resource within the political economy of the first known empire in the Andes, the Wari Empire (AD 600–1000), Peru. The Wari expanded, through a flexible strategy of imperialism that co-opted (when available) pre-existing local sociopolitical and economic organization, to control a territory that covered the extent of present-day Peru. In addition to territorial expansion, the empire relied on and imported resources from hinterland regions into the capital and beyond, such as cotton and coca from the Peruvian coast, spondylus from Ecuador, and feathers from the amazon. Another resource that has been suggested to have operated within a Wari political economy is obsidian. Obsidian is a volcanic glass with one of the sharpest naturally occurring edges, making the material ideal for stone tool production. In addition, obsidian is an easy medium to work due to its conchoidal fracture pattern. Its aesthetic qualities ranging from translucency to varying hues, have made it a popular medium for ritual and/or prestige goods throughout the world. Furthermore, obsidian is limited in its availability. Because obsidian is produced during singular volcanic events, it is only encountered at high-elevations in tectonically active regions, and high-quality obsidian comes from volcanic events younger than 10 million years.

In the central and southern Andes, there are nine commonly used obsidian sources, including three high-quality sources (Quispisisa, Alca and Chivay). This dissertation explores the nature of obsidian use in the Wari Empire through an analysis of 628 obsidian artifacts from the capital of the empire, the site of Huari located in highlands of Ayacucho, Peru.

Lithic and portable X-Ray fluorescence analyses were conducted to explore the nature of obsidian production and consumption at the site of Huari, and to examine distribution networks from varying obsidian sources during the Middle Horizon to explore the nature of Wari control and/or investment in obsidian and obsidian distribution networks. The results of the data suggest that the site of Huari was relying on obsidian from three obsidian sources: Quispisisa, Alca and Puzolana. Prior to the Middle Horizon, the Ayacucho valley relied exclusively on obsidian from Quispisisa and Puzolana, both local sources. The importation of Alca obsidian into the Ayacucho Valley (from over 500km to the south) during the Middle Horizon reveals extended interregional interactions and connections likely facilitated by Wari imperialism. The presence of Alca obsidian at the site of Huari attests to the cosmopolitan nature of the capital, and the site as symbolic of a wider imperial agenda. The data suggest that the use of obsidian at Huari from different sources is a practice that originated in the Early Intermediate Period Huarpa occupation of the site. The Huarpa relied predominantly on obsidian from Quispisisa, as did most of the central highlands obsidian network.

While the Wari Empire appears to have mostly formalized pre-existing obsidian networks, they did manage to extend and manipulate the borders of these networks for imperial purposes. Results from the lithic analyses also suggest that individuals at Huari were not producing their own bifacial or formal tools at the site itself. The material produced in-situ was expedient in nature, and produced by individual, non-skilled craftsmen. Formal material that was consumed at the site was likely produced elsewhere and brought into Huari as a completed tool. This production/consumption pattern also pre-dates the Wari occupation of the site, and suggests that Huarpa obsidian use forms the basis for obsidian use by the Wari Empire. Because the Wari were known to have adapted their imperial strategies to account for local, pre-existing infrastructure and/or social and political systems, it follows that they also would have done so for the use and acquisition of resources. This dissertation reveals this particular imperial process through a focus on obsidian networks and production and consumption processes.

Outline of the Dissertation

Chapter 2 explores the history of imperial studies within the discipline of archaeology and its application in this dissertation. While early theoretical focuses on empires (World Systems Theory, Neo-evolutionary models) sought to develop defining features, or universal traits, of empire, more recent approaches (power dynamics, imperial processes, entanglement) have begun to focus on the fluid and dynamic aspects of the act of "doing" empire. In this dissertation, empire is defined as "a territorially expansive and incorporative kind of state, involving relationships in which one state exercises control over other sociopolitical entities (e.g., states, chiefdoms, non-stratified societies" (Sinopoli 1994: 159)). In addition, this dissertation focuses on the process of empire by exploring relationships of power. And because the Wari Empire has no written history, one of the best ways to study relationships of power is through quantifiable, material "things" (Smith 2003). And while relationships of power within and across empires are difficult to identify, this dissertation follows Stein (1998) in suggesting that one such way to identify power is through a regional analysis of the political economy and variation in the differential/asymmetric movement of resources within the empire. In other words, the movement of obsidian from the source, to the production, consumption and and finally discard location, may reveal one facet of Wari's political economic strategy.

Chapter 3 traces the prehistory of the Wari Empire, from its origins in the Huarpa occupation in the Ayacucho Valley to influences from Nasca and the state of Tiwanaku to the south. The Wari Empire (AD 600–1000) likely developed from the Early Intermediate Period (EIP) Huarpa occupation of the Ayacucho Valley. During the EIP, the Huarpa began to intensify agricultural production and move into more settled, nucleated settlements—one of which was the foundation for the capital of the Wari Empire. By the end of the EIP, influence from the Southern Nasca Region (largely in the form of ceramic polychrome pottery) began to make its way into the Ayacucho highlands and by the beginning of the Middle Horizon, Wari iconography shared many features with Nasca ceramics. Concurrent with the Wari development in central Peru, the Tiwanaku state was arising in the Titicaca Basin near the border of present-day Peru and Bolivia. Although sharing similar iconographic motifs, it appears that the two states were distinct entities, with interaction occurring with more intensity in the southern hinterlands of the Empire (i.e., Moquegua). In addition to the contextual development of the empire, Chapter 3 addresses the interaction networks present within the Wari Empire, including the heartland (the site of Conchopata) and the surrounding regions (Sondondo, Apurímac, and Southern Nasca Region) as well as hinterland expressions of empire in Cusco and Moquegua. Through exploring the circumstances within which the empire developed, and subsequently the expansion and consolidation of the empire, it is possible to begin to contextualize obsidian networks within a Wari political economy, which follows in Chapter 4.

Chapter 4 addresses the history of political economy and craft production studies within archaeology. In this dissertation, political economy is defined broadly as the organization of economic systems as they intersect with power and political and social systems. By defining political economy in this manner, this dissertation attempts to follow Hirth (1999) in focusing on four key principles to the study of political economy in archaeology: 1) the accumulation of resources; 2) the where and how of resource accumulation; 3) the position of elites at nexuses of control; and 4) the role of ideology in the control over these nexuses and resources (Hirth 1999: 4). And while it is acknowledged that a full understanding of political economy necessitates a focus on multiple resources across all levels of society, this dissertation begins by tracing obsidian from its source location, through to its production and consumption, and final discard at the Wari capital. It compiles these results with comparative data from other studies to address regional, social and temporal differences in the production and consumption of obsidian within the Wari Empire. In order to do so, Chapter 4 also addresses studies of craft production, as way to bring materiality to political economy. Craft production is defined as the study of technologies, human agents and organizing principles, with the goal of explaining historically specific production systems and cross-cultural regularities and variability within those systems (Costin 2005). Costin (much like Hirth) suggests that archaeological approaches focus on six key features of a craft production system: 1) producers—specialization, labor, compensation, and skill; 2) means of production—raw materials, tools, and knowledge; 3) organization—spatial, social production, and temporality; 4) objects—function and use; 5) distribution—transportation and oversight; and 6) consumers—use and reuse (Costin 1991: 190-191). In sum, this chapter presents an argument for focusing on the role of resources (in this case obsidian) as one vehicle for understanding the institutionalization of power within and across the empire.

Chapter 5 addresses obsidian throughout the prehistory of the Andes as well as during the Middle Horizon. The chapter provides a brief discussion of obsidian as a material, and its use as both a functional as well as an aesthetic (of course often overlapping) resource both in the Andes and worldwide, and follows with a discussion of obsidian sources, and the material aspects of obsidian that make it an ideal candidate for x-ray fluorescence applications. More important to a discussion of political economy and craft production, Chapter 5 traces the history of the use and acquisition of obsidian from the first people of the Andes through to the Middle Horizon, exploring the lengths that people traveled to obtain obsidian as well as the type of products and the nature of production. Ultimately, obsidian was a highly used resource that required complex interaction networks long before the emergence of the first state or empire in the Andes. A more in-depth focus on obsidian in the Middle Horizon is also presented, which explores regional differences in the consumption and acquisition of obsidian in the Wari heartland and Wari hinterland, which provides context for interpretation of the analyses and results of this dissertation.

Chapter 6 presents a description of the methods used for data collection and sampling strategy as well as the history and use of x-ray fluorescence for archaeological research. An in-depth discussion is provided on the parameters used for the portable x-ray fluorescence (PXRF) analysis. Following this, Chapters 7 and 8 present the results of the data. Chapter 7 presents the results from basic lithic attribute analyses (including context information, artifact type, lithic debitage traits, etc.). The results are presented using chi-square tests to explore the relationship between different variables (such as context and artifact type), and results are preliminarily compared with data from the neighboring Wari site of Conchopata. Chapter 8 presents the results form the PXRF analyses, and sources the artifacts to their obsidian source with the help of a comparative collection acquired from Archaeological Research Facility at the University of California Berkeley. The source results are then placed alongside the results from lithic attribute analyses to explore source variation in different production and consumption processes at the site of Huari. Again, these results are preliminarily compared with the site of Conchopata and previous research done at the site of Huari itself.

The results confirm the use of three different obsidian sources at the site (Quispisisa, Alca and Chivay) as well as suggest an expedient nature to the production of obsidian at the site. The ubiquity of obsidian as a resource at the site may have led to something akin to “cavalier crafting” (Klarich et al. 2017). In general, obsidian production and use at the site of Huari follows a pattern that pre-dates the Middle Horizon, suggesting that the Wari Empire merely formalized, facilitated, or built upon pre-existing obsidian production and consumption processes established during the earlier Huarpa occupation. The only change brought about by Wari imperialism was the presence of Alca obsidian, signaling increased interregional interaction networks and a widened flow of resources from and between different regions of the empire, likely organized or enabled by Wari imperial processes.

Chapter 9 places the results from the previous chapters in context with prior obsidian research conducted by scholars in varying hinterland regions of the empire. Chapter 9 illuminates the nature of obsidian consumption and use prior to the Middle Horizon, as two general obsidian networks within the central Andes—one focused on the exploitation of the Quispisisa source in the central highlands (encompassing Ayacucho, the Southern Nasca Region and parts of Apurímac), and the other focused on the exploitation of the Alca and Chivay sources in the south (encompassing Cusco, Moquegua, and the Titicaca Basin). The results of this dissertation suggest that during the Middle Horizon, the Wari Empire had a political economic strategy that focused on capitalizing on the pre-existing obsidian networks within the Andes, changing and formalizing where necessary. For example, while most networks continue to operate as they did prior to the Middle Horizon, Cusco is incorporated into the central highlands network, likely indicating the (need for a) greater connection between Cusco and Ayacucho. Lithic attribute analyses focus on the production and consumption of obsidian, and a comparison between the capital of Huari and the neighboring imperial site of Conchopata suggests limited in-situ bifacial production and instead the expedient production of tools from a ubiquitous obsidian source. Chapter 9 discusses these results and attempts to provide insight into Wari political economy through a focus on obsidian.

In sum, this dissertation attempts to bring together aspects of political economy and craft production, with a history of the Wari Empire, to explore in-depth how one resource is experienced within the capital of the empire. By tracing the connections between not only the data acquired for this dissertation, but by combining it with research collected by other scholars, it is possible to begin to see patterns in the use of a resource throughout time and space, and how imperial processes both changed and formalized those patterns.

CHAPTER 2

IMPERIAL STUDIES: HISTORY AND APPLICATION

The study of empires and imperial processes has long been of interest to social theorists, historians and archaeologists alike. Definitions of what constitutes an empire are, therefore, quite varied in relation to not only specific historical, environmental and contextual circumstances, but also in relation to dominant theoretical models and paradigm shifts. In this chapter, I trace the development of archaeological approaches to empire, from the systems models and universal typologies of the 1960s to 1980s, to the historically-specific and agent-centered approaches gaining popularity in the 2010s. Early archaeological approaches to empire began with the desire to produce universal generalizations that could be used to define and study social and political evolution. World Systems Theory (Wallerstein 1974), the Metrocentric-Pericentric-Systemic model (Doyle 1986) and the Territorial-Hegemonic model (Luttwak 1976; Hassig 1985) paved the way for systems approaches, and sought to identify and define the key components of imperial societies. As a direct response to what was seen as the limitation of typologies and neo-evolutionary models, archaeologists began to focus on strategies of control and the material manifestations of power (Schreiber 1987; DeMarrais et al. 1996; Mann 1986; D'Altroy and Earle 1985). More recently, a shift in archaeological theory away from models (a shift largely influenced by post-processual and post-modern theoretical movements), scholars have begun to approach empires by looking at the agency of individual actors and groups as opposed to top-down systemic processes (Dietler 2010; Stein 2002; Khatchadourian 2016). After exploring the theoretical foundations for archaeological studies of empire, I close this chapter by positioning my own approach to imperial studies within these theoretical frameworks.

I. Defining Empire

Definitions of what constitutes an empire can be difficult to formulate, as defining characteristics vary by a scholar's regional and topical interest. Some scholars prioritize geographic characteristics of empire (Morrison 2001), some economy (Costin and Earle 1989; Smith 2001; D'Altroy 1992; Smith and Berdan 1992), while others focus on the political (Stanish 1997), ideological (DeMarrais et al. 1996; Bray 2003; Lucero 2003) and/or militaristic components of imperial strategies (Sinopoli 1995; Woolf 1992; Mann 1986). Another difficulty in defining empire is the actual variability of empires themselves, and the complexity of comparing a diversity of sources (archaeological vs. historical), and both old world and new world and archaic and "modern" examples. The word "empire" is used to refer to all of the above cases synonymously, although each case is much more complex than a single word would suggest. This dissertation focuses on what Katharina Schreiber (1992) refers to as a more "archaic form of empire", meaning those empires in prehistory that rose to power, and subsequently lost it, long before globalization and the emergence of the Nation-State. This dissertation will follow the definition of empire set forward by Carla Sinopoli, in which an empire is defined as a "territorially expansive and incorporative kind of state, involving relationships in which one state exercises control over other sociopolitical entities (e.g., states, chiefdoms, non-stratified societies) (Sinopoli 1994: 159)." In addition, empires are understood to encompass a "diversity of localized communities and ethnic groups, each contributing its unique history and social, economic, religious and political traditions" (Sinopoli 1994: 159).

II. Early Systems Models of Empire (1970s – 1990s)

Definitions and conceptualizations of empire have always been heavily linked to theories of social evolution. Empires were understood as the natural end point following a long trajectory of development from simple societies, progressing to chiefdoms and states, and finally culminating in empires. Following the theoretical framework of social evolutionism, empires were subject (as were societies of all levels of complexity) to intense classification and typology, with very little room given for any variability across time or space (Khatchadourian 2016). Archaeological studies of empire became increasingly popular following the emergence of New Archaeology in the 1960s. Scholars began to show interest in models, and in a departure from previous cultural historical approaches, sought to compare and universalize patterns of behavior in the archaeological record in an attempt to understand general human behavior from social, ecological and political perspectives.

World Systems Theory

The work of Emanuel Wallerstein fit perfectly. In 1974, Emanuel Wallerstein proposed that his model, originally intended to facilitate understanding of western Europe after the 16th century, could, in fact, be applied to archaic empires. Wallerstein's World Systems Theory emphasized the exploitation of marginalized or peripheral areas by an empowered core, as central to the definition of empire. At the very cornerstone of the model was an inverse relationship between development in the capital/core and underdevelopment in the periphery (something echoed in concurrent Marxist studies on class divisions). Ultimately, this distinction between core and periphery was picked up by archaeologists and used in subsequent world systems approaches to social and political evolution. For example, Ekholm and Friedman (1979), developed one of the first archaeological models for imperialism based on World Systems Theory. They focused on the economic marginalization of the periphery as the singular goal of imperial societies, resulting from a desire to accumulate capital in the imperial core. This emphasis on economic motivation was something that was seen as parallel between both modern and archaic empires. Another beneficial aspect of World Systems Theory was its acknowledgment that an empire could not be understood without looking at both the core and the periphery (Cusick 1998).

More recently, World Systems Theory as a model for archaeological studies has been heavily problematized, due in large part to the model's emphasis on the unidirectional motivation from core to periphery. The binary of the dynamic core/static periphery was seen as limiting the value of the model by denying agency and social identity to the individuals and groups participating in these systems of interaction in both the periphery and the core (Dietler 2005; Stein 2002). World Systems Theory became so unpopular that in 1994, Marshall Sahlins felt that it had become "the superstructural expression of the very imperialism it despises" (Sahlins 1994: 412-413). More recently, scholars have shown that there is no predictable drop-off rate of underdevelopment with distance from an imperial capital and that the reality of imperial interactions both in the core and periphery is much more nuanced and even more importantly, historically, environmentally, and culturally contextual (Sinopoli 1995).

Metrocentric-Pericentric-Systemic Model

As World Systems Theory began to fall out of favor in the late 1970s to 1980s, new models emerged that specifically addressed a more archaic and archaeologically relevant understanding of empire. The Metrocentric-Pericentric-Systemic model was proposed by Michael Doyle in 1986 and focused on motivations (or pressures) for imperial expansion. This model postulated that imperial expansion operated predominantly through one of three frameworks: 1) metrocentric; 2) pericentric; or 3) systemic. Metrocentric expansion was seen as the result of pressures/motivations originating in the core, metropolis or center of the empire and thus, was the framework most similar in nature to World Systems Theory. Pericentric expansion originated from pressures/motivations in the periphery, yet imperial expansion was still often addressed in terms of benefits to the core. For example, a periphery may have been part of a defensive strategy to secure borders, or to secure an economic benefit or advantage. These actions were understood as pressures felt in the periphery, but ultimately executed by the core (D'Altroy 1992). Systemic expansion was the result of pressures/motivations felt in both the core and periphery, and was often assumed to be rooted in competition over international power (Doyle 1986). For example, a core and periphery operating with a singular motivation in contrast to an "other" sociopolitical entity. Doyle made sure to stipulate that the model only worked through a combination of the above frameworks, and that "the existence of empire called for a combined explanation, one that took into account the apparently necessary roles of a metropole, a periphery, and a transnational connection" (Doyle 1986: 160). Despite the insistence on a combined explanation, many scholars still found that the model limited the variability inherent in imperial interactions (D'Altroy 1992; Sinopoli 1995).

Territorial-Hegemonic Model

The Territorial-Hegemonic model (Luttwak 1976; Hassig 1985) moved away from motivations/pressures for imperial expansion to a focus on the exertion and maintenance of control as experienced by different imperial ventures and peripheries. Hassig (1985) proposed the model operated along a continuum, from more indirect hegemonic control to more direct territorial control. The hegemonic end of the spectrum emphasized the role of core polities and client polities (a hold-over from core-periphery models), and focused on the purpose of empire as a means of extracting and securing resources, but often without much investment or continued maintenance in the periphery. Hegemonic empires did not necessarily have fixed boundaries, and most commonly ruled or maintained control over areas through a system of "rewards and punishments" (Sinopoli 1995: 6). The territorial end of the spectrum emphasized militarism, occupation and a more direct governance by taking a more active role in establishing and maintaining order in the periphery. Aspects of the Territorial-Hegemonic model would be echoed in Michael Mann's (1986) treatise on the sources of social power, calling the two ends of the continuum "integrated territorial empires" and "empires of domination", respectively. While the Territorial-Hegemonic model was still rooted in the binary dynamics of core-periphery models, many scholars felt it was more appropriate, as it accounted for the effect of space and geography on relationships of power (D'Altroy 1992).

III. Current Approaches (1990s – present)

In the last few decades, new ways of understanding empire have been put forth, largely in an attempt to widen the understanding of archaic empires by acknowledging context, variability, and the agency of regional or hinterland (previously periphery) areas in imperial interactions (Smith 1998; Schreiber 2005; Sinopoli 1995; Stanish 1997; Stein 1992). The desire to move away from earlier models is summarized by Sinopoli, who states that "defining an empire as being either patrimonial or bureaucratic, or hegemonic or territorial, can obscure the significant variability that exists within individual empires in the nature and extent of imperial control and in relations between imperial centers and outlying areas" (Sinopoli 1995: 6). As archaeological theories began to move past the overly-generalizing World Systems, Metrocentric-Pericentric-Systemic and Territorial-Hegemonic models, so too did definitions of empire come to embody variation and adaptability. In turn, definitions of empires began to encompass the diverse sets of communities, histories, and social, economic, and political trajectories of a multitude of populations, all of whom were participating in imperial interactions (Sinopoli 1994). Local and regional populations were given back the ability to affect change and influence on the empire. At its fundamental core, however, the definition of empire was still inextricably linked to a recognition of power and inequality, and an emphasis placed on defining empire focused on the process or action of empire—imperialism. Imperialism is "an ideology or discourse that motivates and legitimizes practices of expansionary domination by one society over another" and is the "projection of power across space" (Dietler 2010: 15). Imperialism was understood as operating over three phases: 1) expansion; 2) consolidation; and 3) collapse (Dietler 2010; Ho 2004; Sinopoli 1994).

Expansion, at its most basic definition, refers to the initial emergence of a high population density in a central city/metropolis followed by the creation of new geographic and/or demographic spaces (Sinopoli 1994). The reasons and methods through which an empire chooses to expand are varied (e.g., resource control, labor extraction, tribute/tariffs, secure borders) and an empire may even, in fact, undergo multiple expansions (possibly for different purposes) throughout the duration of its existence. Re-expansion into the same area may also happen, as rebellions and resistance are often cyclical in nature (Sinopoli 1994). For empires whose expansion is documented in written records, attention is often given to individual rulers (e.g., Sargon of Akkad; Augustus of Rome; Pachakuti of Cusco), whose leadership in war, and/or eloquence in speech making, elevate them to the forefront of imperial progress (Parker 2003). However, for prehistoric empires with no record of distinct individuals nor their actions, research often focuses on the more systemic aspects of imperial expansion. For example, the construction of roadways, outposts, population growth, and the intensification of agriculture are often archaeological markers of imperial exploits.

Consolidation refers to the institutionalization and maintenance of new infrastructure and administrative structures (including administrative, economic, ideological and social institutions). The consolidation of empires is inextricably linked to politics and administrative strategies of control, and the relationship between imperial and local elites established within a well-defined and strategized geographical and social hierarchy. Maintaining an empire also involves economic control. This control is experienced in a multitude of ways which will be explored in greater depth in Chapter 4. Economic consolidation may involve tribute or tax (or a complex system of both), forced or corvée labor, and the access to, regulation, and control of valuable resources. Ideological control is also important to consolidation strategies, established through the co-option of pre-existing religions, beliefs, and worldviews, or through the creation and enforcement of new ones.

And finally, after expansion and consolidation, empires collapse. There is much debate on the usefulness or correctness of using the world "collapse" to define this last phase of imperial process (Yoffee 1988; Tainter 1988; McAnany and Yoffee 2009). The word itself is problematic in that it connotes a complete abandonment or catastrophic and rapid disappearance of populations and political systems. The ways through which empires come to no longer "be" are, in reality, varied. "Collapse" can be quick or prolonged in nature, can leave empty sociopolitical vacancies in the region, and can even cause reemergence or redevelopment and the beginning of a new cycles of imperial process (Schwartz and Nichols 2010). Collapse can be caused by many factors, not least of which are environmental conditions (such as drought, crop failure, etc.), and social and political unrest and instability.

Archaic empires may not be documented by historical sources or written texts. Therefore, much of what is known about archaic empires is thus derived from the archaeological record and the archaeological evidence for empires appears in a relatively predictable way: large-scale architecture, road systems, urban centers, temples, elaborate prestige goods and settlement patterns that often reveal a centralized core and a hinterland periphery. Each specific empire may not have all of the above, or even manifest the same imperial structures in similar ways. For example, regional settlements in hinterland areas may vary according to levels of control exerted by the empire based on a variety of factors such as distance from the imperial center, the pre-existing political conditions in the region, the level of resistance encountered and the presence of valuable resources in the region (Schreiber 1992: 17-32; Smith 1998). Regions experiencing more direct control will show significant imperial impact, and formal imperial styles and features, while regions with relatively indirect control may have limited or even emulated imperial styles.

IV. Imperial Strategies of Control

Strategies of control are the political, economic and ideological sources of power by which empires expand and legitimize their domination (DeMarrais et al. 1996). These strategies reflect not only the organization and worldview of the empire, but also the pre-existing structures, organization and ideologies of local subject populations (Schreiber 1987). Control is often exerted in both relatively indirect and relatively direct ways (Schreiber 1987; Stanish 1997). Indirect and direct control operate as ends of a continuum, with indirect control generally involving minimal change at the local level, and direct control generally requiring increasing levels of structural and organizational investment. This is complicated by pre-existing local sociopolitical organizations. For example, if a region lacks centralized authority the empire would need to create infrastructure and political organization. Conversely, if an area already has a strong political organization, the empire may only need to send an authority to govern or collect tribute (Schreiber 1987: 266). Imperial strategies of control are often discussed in relation to sources of power. Michael Mann (1986) provided the foundational study on sources of power and described sources of social power as being ideological, economic, militaristic and/or political in nature.

Types of Social Power

Social power is the ability of an actor to carry out his/her will, even in the event of resistance. Social power is often difficult to resist, as it inhibits collective action on the part of the marginalized through organizational deficiencies. Mann (1986: 6-9) identifies several descriptive categories of social power: a) distributive/collective power; b) extensive/intensive power; and c) authoritative/diffused power. Distributive power describes a unidirectional flow of power from actor A over actor B, while collective power represents a collaborative effort of multiple actors to increase their power over additional parties (Mann 1986: 6). Collective power may become institutionalized at the state or imperial level, whereby laws, values and/or societal norms serve to reinforce this power. Extensive power is the ability to organize large numbers of people across expansive territories, sometimes at the cost of internal stability, while intensive power is the ability to organize participants at a higher social/political/economic level, regardless of spatial extent (Mann 1986: 7). A final way to approach social power is to examine the distinction between authoritative and diffused power. Authoritative power is brought about directly by groups or institutions, while diffused power is not explicitly commanded (Mann 1986: 8). For example, collective power may at first be authoritative, but over time cultural norms and values and religions and/or ideology may institutionalize this power, in which case it may become diffused in nature. While all of the above categories of social power are interchangeable, they have been used as heuristic devices by archaeologists to draw broad comparisons across empires both worldwide and throughout history.

Ideological Power

In addition to outlining the above types of social power, Mann (1986: 22-28) identifies four sources of this power: a) ideological; b) economic; c) militaristic; and d) political. Ideological sources of social power are linked to the ways in which human beings make sense of their world, and to the norms and values that regulate and influence behavior, often performed through aesthetic and ritual practices (Mann 1986: 22). Ideological power may be *transcendent* or *immanent morale*. Transcendent ideology rises above mundane institutions and finds its roots in the sacred, following the sacred-profane dichotomy outlined by Emile Durkheim (1915). Transcendent ideological power is often a form of diffused power, in that it is not dictated from a ruler to a populace, but as a mandate from a higher and often intangible realm. Immanent morale ideology takes the form of a norm or value that attempts to foster social cohesion of a group (Mann 1986: 24). Often, immanent morale ideological power is institutionalized as a continuation and/or a promotion of pre-existing group cohesion.

DeMarrais et al. (1996) see ideology as fundamental to social power and propose looking at the "materialization of ideology" as the vehicle for its application in archaeology. Ideology, they argue, is materialized through symbolic objects, monuments, writing and even shared values and beliefs. It is ideology materialized that allows widespread values and beliefs to be shared widely within and between groups and to have influence over large territorial or social organizations. For example, an elite individual or group with social power can extend the range of its power through ideology, materialized in products that can outcompete those who do not have the resources (DeMarrais et al. 1996). In other words, ideology provides an avenue for "ambitious people to modify the worldviews and codes of social behavior" to justify regulations of that behavior (DeMarrais et al. 1996: 31). For example, the distribution of iconographic motifs, the construction of monumental architecture, and even feasting may be an imperial or state ideology of power, materialized. Of course, empires are themselves subject to their own ideologies, meaning that ideologies are always linked to cultural and historical contexts (Stanish 1997). Archaeologists often approach ideological power through a lens of ritual (Leach 1966; Lucero 2003), because through ritual, "beliefs about the universe come to be acquired, reinforced, and eventually changed" (Kertzer 1988: 9).

Economic Power

Economic sources of power are found in the production, distribution, exchange, consumption, reuse and discard of resources. Mann (1986: 25) refers to the concept "circuits of praxis", to define two ends of a spectrum of economic organization; on one end, workers laboring and expressing themselves through the conquest of nature and on the other, circuits of exchange into which millions may be locked by natural forces. Mann's "circuits of praxis" is built upon the the work of Karl Marx and 19^{th} and 20^{th} century conceptions of capitalist economic and social organization, and relies on the relationship between the degree and type of economic organization and the "organizing power of class and class struggle" (Mann 1986: 25). While limiting in its applicability to archaeological studies of prehistoric economies, "circuits of praxis" does illuminate a fundamental aspect of economic power—differential access to resources and goods. Differential access to goods, both resulting in and from economic strategies of control, can serve to reinforce economic power relations and legitimate the political and economic organization of a dominant power (Costin and Earle

1989). Costin and Earle (1989) see emergent complexity and state-level control as fundamentally linked to finance (both staple and wealth) that is intimately controlled by a governing institution. In fact, a defining characteristic of empire, accordingly, is the ability to extract tribute or taxes from subject populations (Schreiber 2001). Political economy and craft production as a strategies of control will be discussed in more detail in Chapter 4.

In early discussions of states and empires, economic power was often understood within a dichotomous system of finance, with wealth finance on one end of the spectrum and staple finance on the other (D'Altroy and Earle 1985). Broadly understood, staple finance involves heavy investment by the empire in resources such as grain and livestock and requires tribute and labor from subject populations. Staple finance systems are relatively straightforward, with subject families working to provide a portion of their own staple products to the empire. Conversely, staple finance systems are difficult to maintain, as it is difficult to move goods over long distances, and an empire needs heavy political organization in the hinterlands in order to effectively collect tribute from subject populations. Wealth finance, on the other end of the spectrum, is the production and exchange of special value products and resources, that are often exchanged among more high status and elite members of the empire, including local elites or leaders. Wealth finance is particularly lucrative for territorially extensive empires, in that wealth finance systems require minimal investment in transportation and do not require infrastructure to operate effectively. The downside to finance systems is that the resources that operate within wealth finance systems are limited, and often need to be converted for the general populace, which often results in a loss of associated power (D'Altroy and Earle 1985).

Coercive Power

Coercive power is linked to physical displays and acts of power (both defensive and offensive) and is the most concentrated form of social power, as it "mobilizes violence" (Mann 1986: 26). Many scholars propose that military power is a defining characteristic of empires (Mann 1986; Sinopoli 1995). This concentration of force can also be sustained beyond the battlefield and used to procure or concentrate labor, whether forced or coerced, slave or corvée. However, while military power is the most concentrated form of social power, it is not always the most useful for empires operating with dispersed power. For example, military power is not effective in controlling the investment and participation in agriculture, industry and/or trade, where discrete knowledge or skill is required. Military power is therefore more useful for states and empires where power is concentrated, intensive and authoritative in nature.

Political Power

Political power is related to and inseparable from social, economic and military power, and is often understood as the organizational force behind sources of social power. Mann (1986: 26) restricts the definition of political power to only apply to state or imperial societies. It is a governing or organizing form of power. Mann (1986) sees political power as unique to the core polity, in contrast to the other three sources of power, which can be multi-directionally present in all regions of a state or empire. In archaeological studies of political power, it is usually subsumed within the other three sources (e.g., political ideology, political economy) to refer the organization of, for example, economic practices within a discussion of imperial political power. It is neither simple, nor the intent of studies of imperial strategies of control, to separate, identify and only study one source of social power. While scholars may focus more directly on one source of power, each source is always inextricably linked to the others. For example, Charles Stanish focuses on "changes in organizational structure, specifically changes in the political organization of economic processes and the ideological legitimization of that organization" (Stanish 1997: 197). For Lucero (2003), it is through ritual that political actors can operate within political agendas. Lucero (2003) sees ritual not as a source of political power, like economy or the military, but as an avenue through which political power can be expressed. It is important to acknowledge the variability of sources of control and their expression in different states and empires, and to recognize that these combinations of strategies may not always manifest in similar ways across time and space (Morrison and Sinopoli 1992).

V. Critical Approaches to Empire (2000s – present)

Archaeological research on empires has come a long way since the early 1970s, from a focus on systems models and categorical typologies to thinking in terms of imperial strategies and the materialization of power and control. More recently, scholars have begun to problematize the uncritical use of categories and definitions of empire (Dietler 2010) and the heavy reliance placed on objects over individuals (Khatchadourian 2016). In her recent dissertation work on ancient Persia, Lori Khatchadourian (2016) provides a critique of previous archaeological studies of empire and their over-reliance on flawed typologies (e.g., World Systems Theory, Territorial-Hegemonic model). "Early attempts [at definitions of empire] left to archaeology the somewhat marginal task of illustrating 'on the ground' strategies of imperial control", something that Khatchadourian (2016: 28) sees as unnecessary, due to the large amount of historical and ethnohistorical data that already addresses these components. While Khatchadourian (2016) does correctly illuminate the almost pedantic nature of early attempts to categorize and define imperial societies, her critique gives priority and privilege to historic empires (predominantly in the "Old World"). As Smith (2003: 167-168) addresses, "the integration of text and archaeology" — the ethnohistorical and the material — can illuminate complicated dynamics within imperial systems, even for "Old World" empires. If archaeologists are to move forward in understanding imperial relationships, perhaps the avenue is not through a definition of empire as a bounded and discrete sociopolitical entity.

Interregional Interaction

Definitions of empire often result in a static view of individuals and their interactions, limiting the value of the model and denying agency and social identity to the individual participants in imperial systems (Dietler 2005; Stein 2002). Gil Stein provides a new paradigm for looking at interregional interaction, in which "the recursive relationship between social structure and strategic actions of individuals or small groups plays a major role in reproducing and changing the social organization of complex societies" (Stein 2002: 905). Interregional interaction is not as far from World Systems theory as might be expected, stemming from the Distance-Parity model that suggests that the core's ability to exercise power over the periphery decays with distance, thereby distant peripheries have a more equal relationship with the core. While this understanding is still too narrow, interregional interactions account for actions and processes being both directed by and experienced by populations in both the core and periphery, both in relation to each other and independently. Looking at interregional interaction instead of empire as a bounded ideal provides a more dynamic and mutable approach to understanding imperial relationships. While looking at interregional interaction may seem too large of a concept for focusing on empire, it actually makes the approach easier to digest. Instead of focusing on material and patterns in the archaeological record as they apply to features of empire, the focus can be placed back upon the actors. It is important for studies of empire moving forward to acknowledge the active processes that are in play by individuals and social groups, and how these processes are embedded in a myriad of economic, political and cultural perceptions (Dietler 1998).

Entanglement

Another approach to focusing on imperial relationships is through a focus on entanglement, or "the complex webs of economic, political, social and cultural linkages that can result, often inadvertently, from the consumption of alien material culture" (Dieter 2010: 53). The process of entanglement is linked to the actions and choices of the individual and the "dynamic relationship between agency and structure" (Dietler 1998: 291). Interregional interactions, especially those that are imperial in nature, may best be approached as complex processes that entangle individuals and ideologies *across* regions, and not as unique *instances* leaving a unidirectional impact on the periphery. Entanglement can be a way for material resources to reflect changing identities and negotiations of power within imperial processes (Buzon et al. 2016). Often the concept of entanglement is used in archaeological research on colonialism and culture contact, in an effort to decolonize the traditional narrative which gives power and agency to the conquering society (Silliman 2005). Perhaps then, focusing on entanglement for empires can help us to do the same thing. It may appear that focusing on interregional interaction and entanglement is just giving a new name to an old concept. And perhaps this is the case. But as Dietler (2010) suggests, this re-branding may be necessary for archaeological studies of empire in order to move forward. While stuck in a circular discussion of the definition of empire, perhaps we are missing the more nuanced perspective on individual and group identities and relationships.

VI. Concluding Remarks

My archaeological approach to the study of empire emphasizes objects and resources as fundamental to relationships of power. At the same time, I attempt to move away from categorizing these relationships of power as they pertain to empires as strict sociopolitical entities. My approach is built upon the concepts of entanglement and interregional interaction, which have primarily preferenced the hinterland or periphery in an effort to illuminate marginalized and/or forgotten areas of colonial, imperial, and other forms of culture contact. However, while building off of this theoretical approach, I aim to focus on the capital of the Wari Empire and its relationship with regions within the core (less than 100km from the capital) and in the hinterlands. I propose that focusing on entanglement is as useful for studies of an imperial capital as it is for the hinterlands. No capital is distinctly uniform, felt, expressed and understood equally among all individuals living there or passing through that space. It is just as important to view individuals and groups in the core as actors in imperial relationships as it is to acknowledge those populations engaging in imperial and non-imperial relationships at greater distances.

Despite critiques (Khatchadourian 2016) that political economic approaches reduce empires to things and objects instead of relationships between people, an approach to archaic empires, particularly those empires for which we have no written records, an archaeological approach must be, fundamentally, based in quantifiable, material "things" (Smith 2003). Privilege is often accorded to societies with written histories (even those for whom history is written by the colonial power), and different approaches must be taken for societies without written histories. Research on relationships of power can be difficult to identify in the archaeological record, and Stein (1998: 26) proposes two avenues to account for this difficulty: 1) to integrate textual/iconographic evidence with archaeological data; and 2) to look at regional analysis of political economy and map variation in "nodes of power" across a geographic or even social/political landscape. Stein (1998) suggests that differential/asymmetric movements of labor, goods, and the like within an empire provides some of the clearest evidence for power relationships. It is important to engage not only with things and objects, but with the human actors who ultimately give meaning to, and bring to life these objects. This study approaches the Wari Empire through this lens, of entanglements, complex relationships, and the social, political and economic power of resources.

CHAPTER 3

THE WARI EMPIRE (AD 600–1000)

The Wari Empire (AD 600–1000) was the first prehispanic empire in South America, and at its height covered the extent of present-day Peru, spanning roughly 1,300km from north to south and 400km from east to west (Schreiber 2013). While the Inca Empire (AD1400–1533) has captured the attention of the general public, largely due to elaborate stone masonry and history with Spanish colonization, the Wari Empire, in fact, paved the way for much of the infrastructure (terracing, road networks, etc.) used by the Inca. Originally considered to be part of the Tiwanaku religious cult originating in the Lake Titicaca Basin, with a ceramic style first identified as "Coast Tiwanaku", Wari was largely understood as operating within a Tiwanaku interaction network. This changed in the first half of the 20th century, when Peruvian archaeologist Julio C. Tello began to develop the first interpretation of Wari as not only the source of the "Coast Tiwanaku" style, but as the geographic and cultural origin for the entire iconographic suite, including all of its manifestations from masonry to textiles and ceramics. While Tello was one of the first to conceptualize of Wari as an empire, he was, unfortunately, never able to publish his findings before his death in 1947.

In 1946, John Rowe from the University of California Berkeley, Donald Collier from the Field Museum of Natural History and Gordon Willey from Harvard, traveled to the Ayacucho Valley to identify the architectural and ceramic styles at the Wari capital with the eponymous name of Huari. This dissertation follows Isbell (1991) in differentiating between the empire, Wari, and the capital, Huari. During this trip, Rowe, Collier and Willey saw similarities between architecture at Huari and at the now-identified Wari administrative centers of Pikillacta in Cusco and Viracochapampa in Huamachuco. In the early 1960s, John Rowe and his student Dorothy Menzel, who had begun the pivotal ceramic seriation sequence on the South Coast, went on to seriate ceramics from both the coast and the highlands, and coined the term "Middle Horizon" to designate the widespread appearance of Wari iconography. This foundational chronology is still more or less widely accepted and utilized today (Menzel 1964; Bergh and Jennings 2013).

The Wari Empire is known for its infrastructural projects (including roadways, agricultural terracing, administrative systems, etc.), iconographic ceramics and fine stone masonry. Wari architecture, epitomized at the capital of Huari and seen at other important hinterland sites, is characterized by orthogonal patio-group compounds, or tightly clustered rectangular room blocks. Buildings were constructed to have one to three stories, and rooms were connected by narrow hallways and carefully arranged in organized and often unidirectional pathways. Often rooms, particularly those at the rear of a building, were accessible from only one or two entrance points. Wari architecture was coursed-wall with field stone masonry, and often contained characteristic niched walls (Schreiber 1992; Isbell 1991). Another hallmark of Wari architecture was D-shaped ritual or ceremonial structures, with the largest at Huari measuring 30m in diameter.

In this chapter, I address the geographic, cultural and temporal contexts that led to the rise of the Wari Empire, as well as discuss the capital city of Huari and its role within the larger Wari imperial process. I continue by discussing imperial interaction networks within the Ayacucho Valley, Apurímac and Sondondo regions, and further Nasca and Cusco regions, setting up the geographic and cultural stage for a discussion on the movement of obsidian in Chapter 5. While these regions do not reflect the only interaction networks that were existent within the Wari Empire, they do reflect those in closest geographic proximity to the capital, and represent those populations from whom the Wari were drawing their most important resources, such as agricultural products, camelid herding, cotton, and obsidian.

I. Geographical Context: The Ayacucho Valley

The Wari Empire developed within the Ayacucho Valley of Peru, in the south central Andes (Figure 3.1). The Andes mountains are the longest, and second highest, mountain range in the world. The mountains divide the western half of South America into three ecological zones (this is especially prominent in Peru where the slope of the mountains reach their highest gradient): the coast (*la costa*), the highlands (*la sierra*), and the jungle (*la selva*). The height of the Andes, and the steepness of the slope, cause these three ecological zones to lie in incredibly close proximity to each other. For example, in some areas within Peru it is less than 200km from the coast to the jungle (Bergh and Jennings 2013). Within each ecological zone are micro-ecozones linked to elevation, with different flora, fauna, and resources that prehistoric and present-day communities have learned how to rely on with incredible efficiency. In 1972, John Murra studied the close relationship between Andean populations and the resources found within the different ecozones, and referred to the practice of exploiting from different ecozones as vertical ecology, or vertical archipelagos (Murra 1972). Vertical archipelagos refer to the practice of autonomous groups communally controlling ecologically diverse valleys, in order to exploit the resources from each ecozone within. Verticality could also be practiced through extended migrations or by political conquest (seen in later Wari and Inca Empires) (Brush 1982: 23).

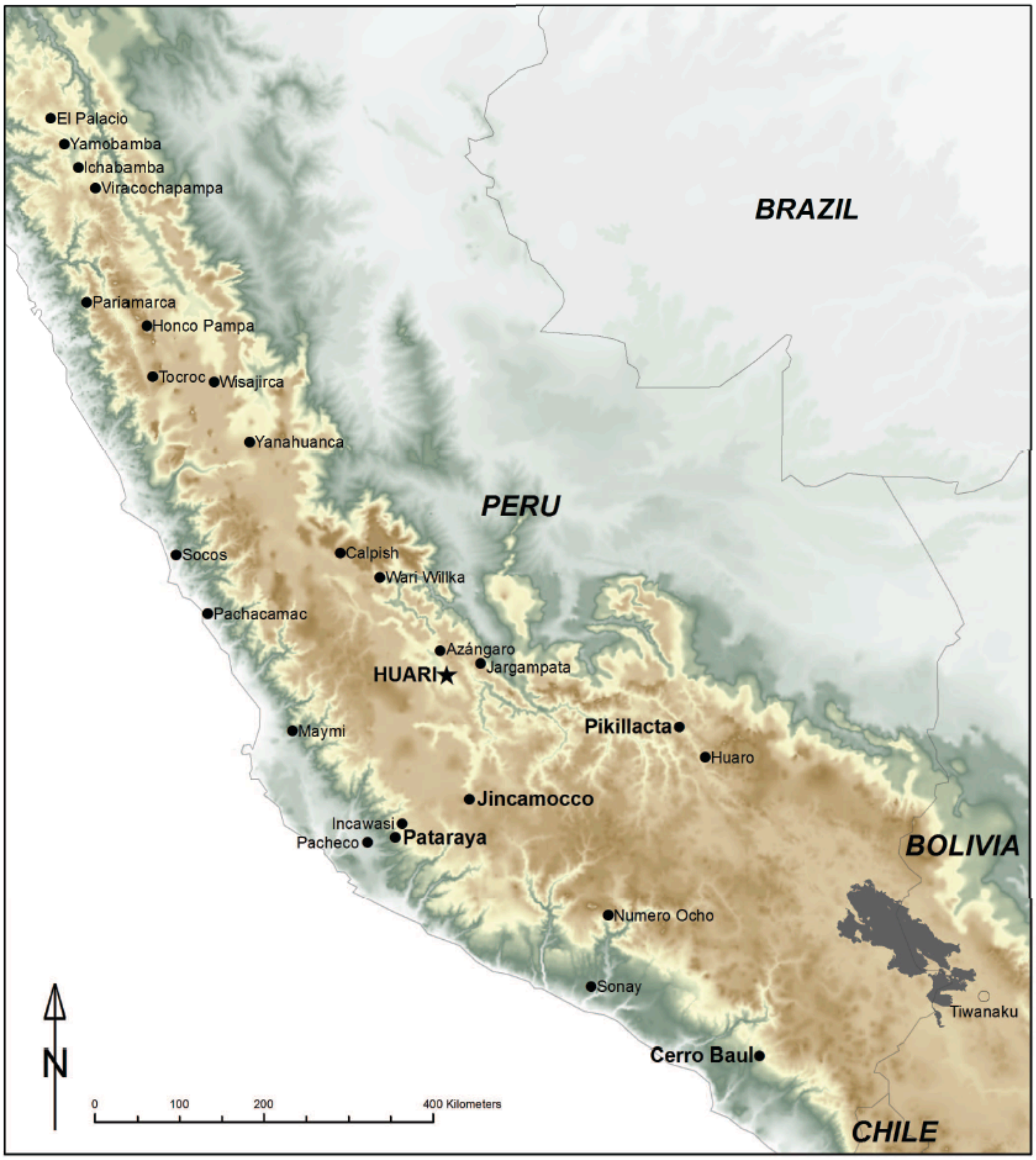


Figure 3.1. Map of the major Wari Empire. Showing major sites throughout the central Andes. Map courtesy of Matthew Edwards (2010: 21).

Populations within the Ayacucho Valley would have been able to access and exploit resources from the coast and the jungle at further distances, and to rely more dependently on products from the three highland ecozones: *quechua*, *suni*, and *puna*. The *quechua* ecozone (2,500–3,500 meters above sea level, or masl), is a relatively warmer mountainous ecozone, and is ideally suited for intensive maize agriculture, as maize requires consistently warmer temperatures than much of the high Andes provides. The *suni* ecozone (3,500–3,800 masl), has increasingly cooler temperatures than found in the lower elevation *quechua* zone, and is used primarily for the cultivation of tubers and quinua. The *puna* ecozone (3,800–4,500 masl) is the coldest zone, and has limited or no agricultural potential, with a landscape dominated by *ichu* shrubs and brush. The *puna*, traditionally and at present, is primarily utilized for camelid pastoralism. The Ayacucho Valley largely falls within the *quechua* ecozone and would have been an ideal region for the development of maize agriculture, and archaeological evidence suggests that it was, in fact, a regional center for the development of maize agriculture and subsequent terracing for intensive exploitation (Leoni 2004).

The Ayacucho Valley, with the present-day capital of Huamanga, or Ayacucho, was not a prehistoric capital or city. In fact, Huamanga was a result of early efforts at urban planning by the Spanish, an attempt to restructure and resettle the populations of the Ayacucho region in the 16th century. In prehistory, the heart or cultural center of the valley was centered geographically around the confluence of the Huarpa and Pongora rivers and their southern tributaries. One of the earliest known sites in the region, the cave of Pikimachay (12,000BC), is located in this central area and has a vantage point to the site of Huari that would occupy the region some 13,000 years later (MacNeish et al. 1981). The site of Huari itself, located at 2,800 masl is in the heart of the Ayacucho Valley and was ideally suited for both a large-scale urban population and the intensive and extensive production of maize and tubers. This connection between the earliest evidence of people in the central highlands at Pikimachay and the first Andean Empire at Huari, signals an ecological potential for the Ayacucho Valley that was largely capitalized upon by people from the first populations in the region through to the present-day.

II. Cultural and Temporal Context

Before beginning a discussion on the Wari Empire, it is important to understand the historical and cultural contexts for development. Cultural antecedents in the Ayacucho Valley and in the Southern Nasca Region played a pivotal role in the establishment and development of Wari imperial identity and practices. Concurrent with Wari expansion, the polity of Tiwanaku in the Lake Titicaca Basin contained an iconographic suite that was so similar to that of the Wari that for the longest time scholars understood the two societies to be one culture. No society or empire arises in a vacuum.

The Ayacucho Valley

Fundamental to a discussion of the Wari Empire is an understanding of the preceding occupations of the Ayacucho valley during the Early Horizon (1200–200BC) and the Early Intermediate Period (200BC–AD600). During the Early Horizon, the Chavín culture, originating in the north central Andes, influenced a wide expanse of the Andes through ceramic iconography and ritual motifs. In the Ayacucho valley, this influence was felt through the construction of ceremonial centers containing platform mounds, like the site of Chupas at the far southern end of the valley. Other sites of Wichqana, Waychaupampa, Jargampata de Huamanga and Aya Orqo were constructed with U-shaped temples (Cabrera

1998; Ochatoma 1992; Ochatoma 1998; Leoni 2010). During this period, populations lived in small sedentary communities subsiding on agriculture or pastoralism, and likely came together at the U-shaped or otherwise, ceremonial or ritual centers (Isbell 2001; Lumbreras 1974; Leoni 2004).

By the Early Intermediate Period (EIP), the Ayacucho Valley was undergoing a demographic change, characterized by population growth and the movement of populations into larger, nucleated communities. The Huarpa, originally identified through a diagnostic ceramic style, were an agricultural population that lived in nucleated settlements, possibly chiefdoms, and began to intensify agricultural production beginning around AD100–300. In the final moments of the EIP, the Huarpa began to adopt elements (largely stylistic) from Nasca potters from the Southern Nasca Region (Knobloch 1976; Leoni 2004; Isbell 2001). This cultural interchange, coupled with the continued intensification of maize agriculture and rising population densities, are considered to be the preeminent catalysts for the eventual polity that would become the Wari state.

Huarpa Ancestry

Huarpa was first identified as a ceramic style through the seriation work of John Rowe and Dorothy Menzel (Rowe et al. 1950; Menzel 1964) and was interpreted as the local EIP pottery style of the Ayacucho valley. First seen in the archaeological record around 300–200BC (MacNeish et al. 1981), with some scholars pushing that date even earlier (Knobloch 1976), Huarpa ceramics were often matte white slip with red and black painting of geometric and linear designs: broad black bands, narrow black lines, and black and white checkerboard designs (Menzel 1964; Leoni 2010). Huarpa ceramics were the first to display the classic

Middle Horizon chevron design iconography that is so characteristic of Wari ceramics (Menzel 1964). Due in large part to interactions with the Nasca culture from the south coast of Peru, Huarpa ceramics continued to evolve and increase in complexity, primarily adopting elements from Nasca fine polychrome ceramic style (Leoni 2010; Menzel 1964; Knobloch 1976).

Early archaeological survey work conducted in the Ayacucho valley by the Universidad Nacional de San Cristóbal de Huamanga (Benavides 1976) and by the Ayacucho-Huanta Archaeological-Botanic Project (MacNeish et al. 1981) identified over 100 Huarpa phase sites. This is a relatively large number of sites for the region, and is possibly the result of population growth, supplemented by the sites' locations close to water sources, extensive terracing on hillsides for agriculture, and the emergent use of irrigation methods (Leoni 2010). The sociopolitical nature of Huarpa was more complex than previous Ayacucho valley occupations, and early studies of the Huarpa (Lumbreras 1974, Lumbreras 1981), largely building on world systems models and social evolutionary theories of the 1960s, considered Huarpa to be a state-level society, a classification that was absolutely necessary in order for the Wari to be considered an empire. However, further systematic and regional studies of the Ayacucho valley contrasted this view, and put forward the notion that the Huarpa were a collection of small-scale polities, or chieftaincies (Schreiber 1992; Isbell and Schreiber 1978). Isbell (1984) suggested that the Huarpa were perhaps best understood as a series of nucleated chiefdoms, clustered around several regions within the valley. One cluster, the Ñawinpukyo cluster, contained the sites of Ñawinpukyo, Conchopata and Acuchimay. Another cluster, the Huari cluster, would have been centered around the site of Huari and included several other small and nearby sites (Isbell 1984). This idea was further supported by the survey conducted by MacNeish et al. (1981), who noted the presence of an "administrative village" in the Huari area during the Huarpa phase. Interestingly, Isbell (1984) noted that in each proposed cluster of sites, only one site in each would have been continuously utilized by the Wari. For example, the site of Conchopata in the Ñawinpukyo cluster, and the site of Huari in the Huari cluster. However, recent research by Leoni (2010), confirms that the site of Ñawinpukyo was also occupied continuously through the Middle Horizon, and slightly undermines the one site, one cluster proposition.

The site of Ñawinpukyo, situated less than six kilometers from the present-day city of Ayacucho, is the best studied site pertaining to the Huarpa occupation the valley (Leoni 2010; Leoni 2004; Finucane 2008; Finucane 2009; Ochatoma et al. 2015). Ñawinpukyo lies in the *quechua* ecozone at 3,000 masl, an ideal location for maize agriculture (MacNeish et al. 1981; Lumbreras 1974). The site was occupied by the Huarpa during the EIP from AD 400–700 and subsequently by the Wari from AD 700–1050. Ñawinpukyo is notable for having been a center for public, communal rituals and displaying signs of emergent social differentiation (Leoni 2010; Finucane 2008). The largest archaeological remains at the site are on the hilltop, with agricultural terraces occupying the lower parts of the hill (Leoni 2010). The hilltop was the center of the EIP occupation of the site, with ceremonial buildings and a walled compound that was both ceremonial as well as defensive (Leoni 2010). Residential compounds immediately surrounded the ceremonial plaza and were likely elite residences with rectilinear rooms, patios, and elongated halls echoing later Middle Horizon patio group architecture (Leoni 2010). The East Plaza at the site consisted of a series of three concentric stone circles with a door opening to the snow-capped peak of Rasuwillka, the highest mountain visible in the region (Leoni 2010). Disarticulated camelid bones and round stone tools provide evidence of feasting, and consequently, Leoni (2010) interprets the plaza as a location for the practice of a possible mountain cult. Some of these masonry walls at the site were physically incorporated into later Wari room blocks. While the residential areas were repurposed or continuously used and/or modified by the Wari during the Middle Horizon, the ceremonial spaces of Ñawinpukyo were not.

The reuse of EIP Huarpa sites by the Wari during the Middle Horizon is now well-documented. At the site of Huari, Bennett's stratigraphic excavations in the 1950s identified (although incorrectly at the time) a Huarpa occupation at the lowest layers of the stratigraphy. Ochatoma et al. (2015) have confidently identified a Huarpa occupation under the Middle Horizon occupation within the Monqachayuq and Vegachayuq Moqo sectors at Huari. Ochatoma et al. (2015) found that Huarpa architecture is found, in relative abundance, beneath Huari material culture and architecture, and always under a layer of sand (usually red) that is not local to the area. This suggests that construction over Huarpa architecture contained some level of symbolic significance for Wari populations. Furthermore, the pattern of building Wari structures over preexisting Huarpa remains is also seen at the sites of Conchopata, Acuchimay and Chakipampa (Isbell 1984).

Influence from Nasca

The influence from Nasca polychrome ceramics on Huarpa style is frequently discussed in the literature on both the Huarpa and the Wari Empire (Menzel 1964; Vaughn 2006; Knobloch 1976; Conlee 2010). Dorothy Menzel's (1964) foundational south coast ceramic seriation identified burgeoning Nasca influence on Huarpa ceramics at the end of the Early Intermediate Period (Late Nasca ceramic style), around AD 500. This influence extends through the beginning of Middle Horizon. Chakipampa ceramics (a widespread highland tradition) and Ocros ceramics (possibly a local highland tradition) also have strong influences from Late Nasca phase pottery. Even "fancy" Chakipampa ceramics, strongly associated with the Wari Empire, bear a striking resemblance to Late Nasca ceramic style (Menzel 1964). While Nasca phase pottery began to influence Huarpa potters during the EIP, it wasn't until the Middle Horizon that highland styles began to influence Nasca and south-coast ceramic styles.

The nature of the relationship between Late Nasca populations and the Ayacucho valley may be illuminated by examining the iconographic features of Nasca ceramics. Towards the end of the Middle Nasca and beginning of Late Nasca style, iconography began to transition from early naturalistic and supernatural themes to images of violence and military exploitations in a more abstract or "proliferous" style (Proulx 2001; Schreiber and Rojas 2005) and is coeval with the cessation of construction at the Early Nasca ceremonial center at Cahuachi (Silverman 1994; Vaughn 2006). Around AD 540–560, a drought plagued the Southern Nasca Region, and perhaps marked a defining moment in the relationship between the highlands and coastal areas. Populations in the region began to shift to fewer, more densely settled sites, and it is at this time that Nasca influence appears on Huarpa ceramics (Schreiber 1999).

The connection between the Southern Nasca Region and the Ayacucho valley at the beginning of the Middle Horizon is so strong that scholars have even suggested that Nasca may have occupied a "special" place within the Wari Empire, possibly even influencing its expansion (Menzel 1964; Edwards 2010; Conlee 2010; Vaughn 2006). While it is still unclear whether the first occurrences of shared stylistic features during the EIP were due to interregional interaction, trade, vertical ecology, migration, or imitation (Vaughn 2006), it is clear that there was a shared or similar belief system held between the two regions and exchange of ceramic styles, foodstuffs, obsidian, and other resources.

Middle Horizon Contemporaries: Tiwanaku

Tiwanaku culture (AD 550–1000) was first connected to discussions of the Wari Empire due to a perceived similar iconographic style, and the two polities were considered a singular entity linked by a religious following represented by a staff god iconographic figure. By the 1950s, John Rowe and Dorothy Menzel's ceramic seriation confidently identified the Wari Empire as the source for the Wari, or Middle Horizon ceramic style, not Tiwanaku. Apart from similar and/or shared iconography, Wari and Tiwanaku have very different styles of monumental architecture. While Tiwanaku monumentality focuses on sunken courts and raised mounds, with megalithic gateways and intricate masonry adornments, Wari monumentality was focused on grand masonry compounds with high walls and multistory interiors with complex and intricately connected galleries (Williams 2001). Similar to the Wari, Tiwanaku is also suggested to be the result of a consolidation of three different ethnic groups living in the Titicaca basin prior to the Middle Horizon (Uru, Aymara and Pukina) (Kolata 1993; Janusek 2004). Both Tiwanaku and Wari practiced land modifications. The Wari constructed extensive terracing programs and Tiwanaku erected intensive raised-fields for agricultural production.

Tiwanaku first rose to prominence around AD 550 in the Lake Titicaca Basin and the nature of the Tiwanaku polity has been much contested over the last several decades. It has been promoted as an expansionist state or imperial power (Ponce 1957), a religious phenomenon, a trade center (Browman 1978) and an interaction network (Janusek 2004; Knudson 2008). More recently, it has been interpreted as an incorporative (rather than transformative) state (Janusek 2004; Goldstein 2005; Vaughn 2006; Stanish 2002). This definition is built on the models presented in Chapter 2, and refers to a state-level practice of incorporating diverse groups and populations into a system, rather than "forcing" them into a monolithic state program (Vaughn 2006). This transformation in archaeological perceptions of Tiwanaku has had lasting implications on the ways that scholars explore issues of craft production (for further discussion on craft production see Chapter 4). Paul Goldstein (2005) suggests that Tiwanaku-associated communities are best understood as belonging to a "diaspora" of trade and socioeconomic relationships, rather than as colonies of the state. Some regions, possibly selected for resource availability, were selectively incorporated into the Tiwanaku polity (Stanish 2002), leading some scholars to view productive regions, and migrant populations existing within them, as an "archipelago" of Tiwanaku interaction (Goldstein 2000). Through this system, Tiwanaku rulers were able to establish "political hegemony" in the Lake Titicaca region, incorporating pre-existing organization and populations into new institutions for state power (Janusek 1999). This is consistent with settlement patterns studies that show a relatively discontinuous application of Tiwanaku state power over different regions within the Titicaca Basin (Janusek 2004).

The center of the Tiwanaku state was the city of Tiwanaku, located at 3800 masl and covering an extent of six square kilometers by AD 800. The population growth in the city of Tiwanaku was coeval with an increase in population in the nearby hinterlands and an emergent organization of a four-tiered settlement hierarchy, similar to the process for consolidation at Huari (Janusek 2004). The city of Tiwanaku had great displays of power

(Kolata 1993; Janusek 2004) and a built landscape that used ideological concepts to materialize hierarchical social order (Janusek 2004; Kolata 1993; Janusek 2006). Iconographic themes that once showed deified personas connected to the water and the earth, shifted upon consolidation at Tiwanaku, to portray elite personas with prestigious resources connected to celestial beings and the sun (Janusek 2006).

III. The Wari Capital and Imperial Power

Capitals vs. Cities

As discussed in Chapter 2, much archaeological research on empires has focused on either the capital or on the periphery or hinterland. While this dissertation problematizes this dichotomous approach, it also acknowledges the very specific interactions that happen within an imperial capital, and nowhere else within the empire. Most research on capitals is founded upon World Systems Theory, emphasizing the push and pull influences from capital cores not regional peripheries. More recently, work emerging from post-processual critiques of systems approaches has focused on the more nuanced relationship between all participants within an empire. Amos Rapoport's work (1993) approaches the study of capitals in direct contrast from what they are not – cities. Rapoport argues that capitals are strong and enduring administrative and economic centers at the top of a regional settlement hierarchy. More importantly, they are characterized by high levels of investment in symbols of national or imperial identity (Rapoport 1993). For example, imagine any capital city today and they are represented by iconic symbols that both inhabitants of the capital, and outsiders alike, can recall and associate with that specific empire or nation.

Rapoport (1993) outlines three aspects that are considered unique to capitals: 1) they are centers for control (coercive, economic and political); 2) they have wide interests or scope when compared with other cities; and 3) they play a primary role in the organization of a territory. While focusing on the local and mutually affecting relationships between the capital and the hinterland is important, it cannot be done by ignoring the very real fact that a capital plays a very different, unique and fundamental role within an empire. Carla Sinopoli (1994: 293) acknowledges the benefit of focusing on the capital in archaeological research due to the fact that a capital can be studied as an "artifact" of empire, as a locus for control, and as a tangible, concrete location with measurable features. Because a capital contains the most direct access to the seat of imperial power, its archaeological material is a reflection of this proximity, and by proxy, a direct line into imperial power and process: "a capital is thus a center of symbolism, of culture-specific expression, of grandeur, elaboration, sacredness, [and] resources invested, etc." (Rapoport 1993: 33).

Huari, the Capital of the Wari Empire

The capital of the Wari Empire was a large city located in the highlands of the Ayacucho valley approximately 20km north of the present-day city of Ayacucho (Figure 1.2). As previously discussed, Huari lies at 2,800 masl and lies within the maize-growing *quechua* ecozone, where access to maize would have been readily available. Relying on vertical ecology, the Wari would have also had access to potatoes and other tubers and camelid pasturelands at higher elevations (Schreiber 2013). The entire site covered approximately 15 square kilometers and consisted of a dense urban population, elite palaces, ceremonial centers, craft production zones and mausoleums (Isbell 1997; Schreiber 2001;

Tung 2012; Ochatoma et al. 2015). What archaeologists know about Huari comes from less than 10% of the site, and the surface has poor visibility due to the expansive *tuna,* or prickly-pear cactus, growing through the porous soil created by archaeological remains.

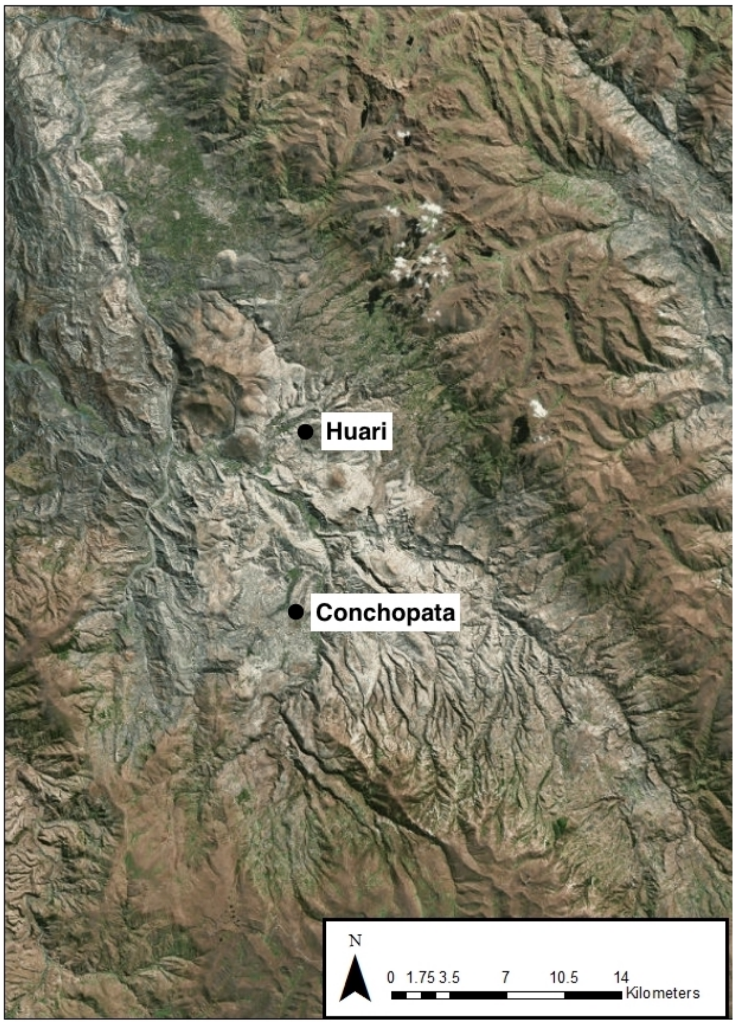


Figure 3.2. Map of the Ayacucho Valley. Showing Wari sites of Huari and Conchopata.

The site of Huari has been divided by archaeologists into sectors, largely based on geographic delimitations and functional characteristics. The sectors of Vegachayuq Moqo (from which the data for this dissertation was derived) and Monqachayuq contain large architectural groups and ceremonial structures, including the well-known D-shaped structure that spans 30m in diameter (Bragayrac 1991) that has been interpreted as a Wari temple

(Ochatoma et al. 2015). In addition, these sectors include a mortuary complex with elaborate stone masonry (Isbell 1997; Ochatoma et al. 2015). The level of detail given to mausoleums is also echoed at the sector of Cheqo Wasi, which was constructed during the height of Wari expansion (Wolf 2012), and considered to be an elite burial location (Ochatoma et al. 2015). The site of Huari appears divided by socioeconomic or other identifying markers of class or status, based in large part on the quality of stone masonry within the sector. The sector of Moraduchayuq, perhaps with the best representation of Wari-style compounds, as well as Cheqo Wasi and Robles Moqo, were sectors of the site reserved for elite personages. Robles Moqo is separated from the rest of Huari by a large standing wall and contains walls of structures standing over eight meters in height (Ochatoma et al. 2015; Lumbreras 2007), and may have been utilized by the highest level elites, or "kingly" individuals (Ochatoma et al. 2015). In contrast, the sector of Waripampa, suggests a more densely clustered area with residential compounds for a more "common" population (Ochatoma et al. 2015).

IV. Wari Hinterlands

As discussed in Chapter 2, understanding imperial strategies of control is dependent upon a full understanding of the relationships both within and between the capital and the outlying, or hinterland, regions. The Wari adapted their strategies of control by region, administering control through a combination of relatively indirect or relatively direct control, largely depending upon the pre-existing sociopolitical organization, infrastructure and resources available within a region (Schreiber 1987, 1992). Therefore, it is important to examine Wari presence in hinterland regions. As mentioned at the beginning of this chapter, the regions discussed here do not reflect the full geographic or administrative extent of the empire, but instead represent several of the regions in geographic and material proximity to Wari through the road network, and the movement of populations and resources. A map of the regions and sites discussed in this section can be seen in Figure 3.3.

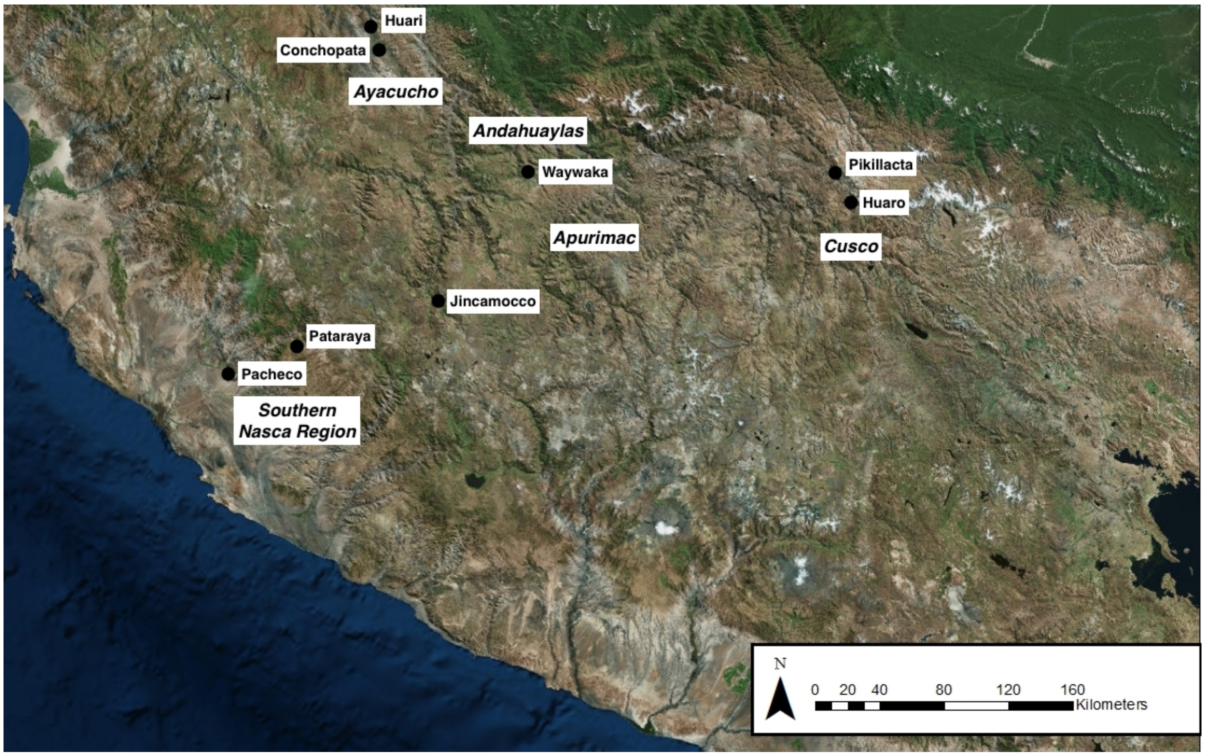


Figure 3.3. Map of sites and regions discussed in Chapter 3.

Ayacucho Valley

The site of Conchopata, located approximately 10km south of the capital at Huari, lies at 2,700 masl on a flat mesa within the present-day city of Ayacucho. At its height during the second half of the Middle Horizon, the site covered an area of approximately 20 to 40 hectares. First identified in 1942 by Julio C. Tello, the site is known for its elaborately decorated and oversized ceramic urns, buried in offering deposits throughout the site. The vessels depict mythological and ideological images of the staff god, or front faced deity, an iconography that was shared with the neighboring regions of Nasca and Tiwanaku. The shape and size of the urns suggest that they had been used to contain liquids, perhaps large quantities of *chicha* used for feasting purposes (Isbell 1984; Burger et al. 2016; Knobloch 2000). Further excavations at the site, led by Luis Lumbreras (1974; Pozzi-Escot 1985), also found evidence of a community of ceramic specialists (Burger et al. 2016). Apart from traditionally identified potting tools, the dense orthogonal architecture at the site contained evidence for the first kilns identified archaeologically in the region (Leoni 1999; Wolf 2012).

More recent research at Conchopata has led Isbell (2004) to consider the site a "second city" to the capital at Huari, consisting of a dense urban core, plazas and patios, and a possible perimeter wall. In addition to possessing architectural features diagnostic of an urban core, Isbell (2004) also identified burials at Conchopata containing markers of wealth, something that a strictly middle-class community of potters would not have had. The site of Conchopata also has the large patio groups, mortuary features and D-shaped ritual structures characteristic of other Wari imperial sites. The D-shaped structure at Conchopata measures 12m in diameter (compared to the 30m diameter at Huari), and was erected at the height of Wari expansion (Wolf 2012). The site of Conchopata, previously thought to have been abandoned in the earlier part of the late Middle Horizon, was, in fact, occupied until the end of the Middle Horizon, as late as AD 1000.

Central Highlands

Around 100km from the capital of Huari, lies the Andahuaylas region, located in the Department of Apurímac. Wari imperial presence was first noted in the region by John Rowe in 1956, and subsequently confirmed by excavations led by Joel Grossman (1972) and Frank

Meddens (1985). Further work continues to illuminate the nature of Wari involvement in the region (Bauer and Kellett 2010; Kurin 2016; Bauer et al. 2010). Andahuaylas is the name given to the valley containing the Chumbao River on the eastern slopes of the Chumbao mountain range, and is recognized as one of the most productive agricultural zones in the region, containing both the *quechua* and *puna* ecozones. Andahuaylas has a rich history of mineral extraction, including salt mines and copper veins (Kurin 2012; Burger et al. 2006), and the Potreropampa obsidian source (discussed in Chapter 5) is located 75km to the south. In addition, the region contains the earliest evidence for gold-working toolkits in the Andes at the site of Waywaka, dating to around 1,500 BC (Grossman 1972). In addition to rich lands for agriculture and camelid herding and extensive mineral resources, Andahuaylas was also along a natural corridor (and Wari road) from Huari to the Cusco region, as well as to the administrative center of Jincamocco in the Sondondo valley and subsequently Nasca and the South Coast (Kurin 2012). It is not surprising, therefore, that Andahuaylas is considered to be one of the first regions that was drawn into to the Wari hegemony (Grossman 1983).

The emergence and expansion of the Wari empire appeared to only minimally change the ceramic, architectural and economic structure of the Andahuaylas region (Bauer and Kellett 2010; Kurin 2012; Grossman 1983). Middle Horizon settlements in Andahuaylas continued to be located in areas of agricultural fertility, with only a marginal shift to greater population density and fewer sites (Bauer et al. 2010). Agricultural practices continued as they did the Early Intermediate Period, and surprisingly no new terraces were established during the Middle Horizon (even in one of the richest agricultural valleys), leading scholars to suggest that Andahuaylas was successfully “assimilated” into the empire instead of conquered or occupied (Bauer and Kellett 2010).

There is also no evidence of a Wari administrative center in the region, unlike in other neighboring regions (such as Sondondo). The relationship between Andahuaylas and the Wari Empire is perhaps most notable in the exchange of iconographic motifs and ceramics (largely acknowledged as unidirectionally flowing from Wari to Andahuaylas, and not the other way around). Wari ceramics (even "fancy" Wari ceramics) are present at many sites within the Andahuaylas region (Bauer et al. 2010), and there are even examples of ceramic sherds with distinctively Wari pastes, but with unmistakably local Qasawirka designs (Grossman 1983). This interplay suggests not only the transfer of iconography between regions, but perhaps also people and knowledge. However, this exchange is not easy to identify. It also appears that local individuals were responsible for the economic extraction of resources from the region. Danielle Kurin's bioarchaeological research identified zero individuals from the Ayacucho Valley living within Andahuaylas (Kurin 2012). Instead, the individuals extracting salt from the mines at Cachi and agricultural products from Turpo (products thought to be consumed by the Empire) were locally-born Andahuaylan individuals, all of whom were buried in association with Wari imperial symbols and products (Kurin 2012).

Following the collapse of the Wari Empire at the end of the Middle Horizon, the Andahuaylas region saw a dramatic upturn in violent aggression. Over 400 sites were abandoned, there was a sudden disappearance of Qasawirka and Wari ceramics, and new occupations were placed on hilltops and mountain ridges (Bauer and Kellett 2010). As Kurin (2012) states, the presence of Wari in the Andahuaylas region, while perhaps not uniformly felt, caused a definite aftershock in Andahuaylas that was "uniformly tumultuous" (Kurin 2012). The Late Intermediate Period in the region is marked by increasing levels of violence and interpersonal conflict between perceived ethnic groups created in the empty vacuum left by the disappearance of Wari political power. The complete abandonment of Qasawirka and Wari sites and ceramic styles may represent a decision on behalf of the Andahuaylan people to forget and disassociate from the fallen-down empire (Kurin 2012). This practice of site abandonment is also echoed in the Nasca region following Wari collapse (Edwards 2010).

The Sondondo valley, is located approximately 150km south from the capital at Huari, roughly a six-day journey on foot (Schreiber 1987). Prior to the Middle Horizon, Early Intermediate Period sites in the Sondondo Valley were located between 2,800 and 3,800 masl, mostly within the higher *suni* ecozone corresponding to tuber production (Schreiber 1987). Some of the higher elevation *puna* areas in the valley would have likely been used for camelid herding, and several EIP villages located on the border between the *suni* and *puna* ecozones, were likely located to take advantage of both tuber production and access to camelid pasturelands (Schreiber 1987). The Wari occupation of the Sondondo Valley began around AD 600, and was characterized by extensive restructuring of the agricultural potential of the valley, including the relocation of sites to elevations below 3,300 masl (to areas capable of intensive maize production), and the construction of bench terracing in the lower valley (below 3,300 masl) to artificially increase the agricultural potential of the land (Schreiber and Edwards 2014).

The largest Wari facility in the Sondondo Valley is the administrative center of Jincamocco. Jincamocco is an architecturally Wari-style compound erected over an earlier local site, and when initially constructed, covered an area of approximately 3.4 hectares. Jincamocco was later expanded by the Wari to cover an additional 15 hectares (Schreiber 1987). This is the only known Wari administrative center (apart from Pikillacta in Cusco) to have been expanded by the Wari after its initial construction, suggesting that whatever the function of Jincamocco, it may have changed or gained increasing importance in later phases of imperial consolidation. At Jincamocco, archaeological excavation and survey showed evidence of agriculture, food preparation, craft production of textiles, and possible storage facilities, suggesting that the site likely functioned as a generalized administrative center for the empire (Schreiber 1987).

The Sondondo Valley also contains (apart from Jincamocco) an additional three compounds with Wari-style architecture. These compounds are much smaller than Jincamocco, but still contain exclusively Middle Horizon period ceramics, and were possibly used as storage facilities, or habitations for important Wari families (Schreiber 1987). In addition, these compounds may have been important in regulating access and passage through the Sondondo Valley, as one compound is located where the Wari road enters the valley from the north, most likely a route to the capital (Schreiber 1987). Unlike Andahuaylas, the Sondondo Valley contain the remnants of four intrusive Wari settlements, while Andahuaylas has no evidence of direct infrastructural investment. This may be due to the differing resources of each region. While Andahuaylas contained mines for salt and metal (transportable objects with easily controlled extractive sources), Sondondo was utilized for intensive maize production (difficult to transport and requiring high levels of oversight and investment).

Southern Nasca Region

As previously discussed, the Nasca region continues to play a fundamental role in the Wari Empire during the Middle Horizon. The administrative outposts of Pataraya, Pacheco and Incawasi were all established along the Wari road connecting the Southern Nasca Region to the Wari administrative center of Jincamocco in the Sondondo Valley. Each of the three administrative centers (a relatively high number of centers in comparison to other Wari-controlled regions) had distinctive Wari architecture, differentiating them from locally occupied sites. The highest elevation site (the first you would encounter on the road from Jincamocco to the Southern Nasca Region) was Incawasi (2,700 masl), which due to present-day agricultural disturbance has produced very little contextual data. Incawasi was the largest of the three Wari sites in the region, measuring approximately 400 square meters in area (Edwards 2010). The next site encountered on the road to the coast is the outpost of Pataraya (1,350 masl), likely a location for textile manufacture and the acquisition and transshipment of coastal cotton into the highlands (Edwards 2010; Edwards et al. 2008). Smaller than Incawasi, Pataraya spanned an area of 250 square meters, and was established on previously unused land and was occupied for its duration by non-local, Wari individuals (Edwards 2017).

The remaining Wari site in the Southern Nasca Region, Pacheco (375 masl), has been suggested to have been a site for religious offerings, in contrast to the more economically-oriented site of Pataraya. Deliberately broken vessels interred in adobe chambers at Pacheco are similar to offering deposits found at Conchopata (Menzel 1964; Conlee 2010; Tello 2009). In addition, these vessels (some of which depicted the Wari staff god), were uniformly broken by blows to the chest or face of the figure, leading to interpretations of the vessels as either ritual, and/or evidence of a Nasca "resistance" to Wari hegemony (Schreiber 2005). The location of Pacheco is also important and it is positioned just up the valley from the Nasca ceremonial site of Cahuachi. Cahuachi functioned as not only a pilgrimage center for south coast populations in the Early Intermediate Period, but was also located on top of the clay source used for all of Nasca fine polychrome ceramics (Vaughn and Neff 2000). The placement of Pacheco up valley from Cahuachi did not stop the use of the site, as cemeteries were constructed through the end of the Middle Horizon, but most likely controlled access to the important economic and spiritual location (Schreiber, pers. comm.).

The collapse of the Wari Empire was felt heavily in the Southern Nasca Region. The collapse appears to have occurred during a relatively short period of time, but was not sudden. Instead, Edwards (2010) proposes that Wari abandonment of the region was a purposeful and methodical removal. Excavations at Pataraya show that the site had been ritually closed, with the Wari symbolically walling up sections, performing closing rituals, and cleaning the space as they left (Edwards 2010). Similar to the response in Andahuaylas, the collapse of Wari in the region prompted a “dark ages”, resulting in the abandonment of previously occupied habitations and cemeteries, and the movement of populations up into defensive locations (Conlee 2003).

Cusco

Within the entire Cusco region, the Lucre and Huaro basins have the greatest evidence for Wari presence in the region, at the Wari sites of Pikillacta and Huaro, respectively. The Lucre and Huaro basins may have been heavily utilized by the Wari due to their close proximity to both the Andean highlands and the upper Amazon drainage (Skidmore 2012). In addition, lower elevations in the Cusco region were similar geographically to the Ayacucho area (i.e., suitable for maize agriculture), and would have been familiar to the Wari (Schreiber 1992; Skidmore 2012). Prior to the Middle Horizon and

Wari investment in the region, the Early Intermediate Period in Cusco was marked by population growth and the movement of settlements into lower elevations of the basin, likely to capitalize on burgeoning maize agriculture (Covey et al. 2013). However, prior to the Middle Horizon, there was no evidence of landscape modification (terracing, irrigation, etc.) (Skidmore 2012).

Perhaps one of the best-studied Wari sites in the Cusco region is the administrative center of Pikillacta, located in the Lucre Basin at 3,250 masl, approximately 30km southeast of Cusco. The site measures approximately 500 square meters and lies on a ridge above Lake Huacarpay, and was built in a characteristically Wari-style orthogonal pattern consisting of multiple compounds (Covey et al. 2013; Glowacki and Malpass 2003). Despite being the largest architectural structure in the Cusco region prior to the Inca Empire of the Late Horizon, Pikillacta had minimal surface remains and has therefore been difficult to reconstruct archaeologically. One sector of the site was originally suggested to have been a storage facility based on its location and architecture, however direct evidence of storage has not yet been identified (McEwan 1996). McEwan (1996) suggests that Pikillacta more likely operated as a provincial or regional capital of the Wari empire, due to its location within a maize producing region and along the Wari road network, connected to Huari through Andahuaylas. In addition, Pikillacta was the largest site in the region during the Middle Horizon, and must have been an impressive symbol of Wari power. Lastly, the presence of fine polychrome ceramic, shell and spondylus from the coast as well as other elite and prestige goods (including feasting vessels) suggest that the site was an administrative or regional site for Wari elite personnel (McEwan 1996).

Despite the fact that McEwan (2005) estimated that construction of Pikillacta took approximately several million worker-days, some sectors of the site were never completed before it was abandoned at the end of the Middle Horizon (Covey et al. 2013). Similar to Pataraya, the abandonment of the site was orderly and consisted of elaborate closing rituals, including the blocking of doorways, removing of valuables and other goods from rooms, and deliberately filling and closing rooms with clay. McEwan (1996) suggests that this may mean that the Wari intended to return to Pikillacta—but this never happened. Some time after the Wari left, the site was purposefully burned, likely by local and possibly rebellious populations (McEwan 1996).

The Huaro Basin, also occupied by the Wari during the Middle Horizon, was home to the Wari-style residential center of Huaro. Huaro was less carefully planned, which has been interpreted as perhaps a softer form of direct control than that experienced in the Lucre Basin (Skidmore 2012; Covey et al. 2013). Huaro was constructed by the Wari during the Middle Horizon, but the residential sector of Hatun Cotuyoc at the site suggests that those living there lived similarly to other residential sites in the Ayacucho valley, with the exception of increased access to exotic resources, trade goods, and symbols of the Wari Empire (Skidmore 2012). Skidmore (2012) suggests that the similarity in domestic activities at Hatun Cotuyoc and other Ayacucho valley sites suggests that residents at Huaro were colonists from the Wari heartland.

V. Concluding Remarks

This chapter explored the ecological, temporal and cultural contexts in which the Wari Empire developed, consolidated and maintained power, over a wide expanse of the Andes. The Wari Empire employed a strategy for resource control in hinterland regions, using vertical ecology to capitalize on naturally occurring resources spread out over different ecological niches within in the central highlands. In the Ayacucho valley, maize agriculture spurred population growth and the development of the Huari capital. Andahuaylas served as an important hub on the Wari road network connecting to Cusco. And although the region was rich in salt, copper, and other minerals that were heavily utilized by the Wari, there was no known administrative center. The Sondondo Valley was heavily restructured to maximize production of maize agriculture, and the administrative center of Jincamocco was a pivotal stop on the way to the Southern Nasca Region. Nasca (along with the administrative site of Pataraya) supplied cotton, coca and iconographic inspiration from the south coast to the Wari highlands. Cusco's Pikillacta dominated the landscape in the region, and also facilitated intensive restructuring for maize agriculture. Understanding the intersecting relationships between regions and resources as managed through culturally, historically and regionally specific populations is the theme of this dissertation and will be explored in greater detail through a theoretical discussion of political economy in Chapter 4, and the distribution of obsidian in Chapter 5.

CHAPTER 4

POLITICAL ECONOMY AND CRAFT PRODUTION

Political economy, broadly defined as the organization of economic systems as they intersect with power and political and social systems, is heavily informed by theoretical frameworks developed by Adam Smith and Karl Marx in the late 18^{th} and early 19^{th} centuries. Smith and Marx explored burgeoning capitalist concepts of rent, labor, capital, profit, exchange, production, and distribution, as structured by complex webs of political, social and economic factors. Studies of political economy within archaeological contexts are, in most applications, focused on systems and societies far removed from more present-day capitalist systems. However, the acknowledgement of the inherent power differential existent within capitalist systems was seen as paralleling the power differentials universally present within all state-level societies, and therefore political economy became a universalizing approach to understanding material surplus and the use of labor to create and maintain political institutions, with an emphasis on social and political evolution (Wells 2006). Archaeological research utilizing a political economic perspective has historically focused on the development of social and political hierarchies, on political evolution, or on the maintenance and systemic integration of power in state-level societies (Hirth 1996; Vaughn 2006; Stanish 1992; Earle 1994).

I. Political Economy, Political Complexity and Social Evolution

Scholars who focus on the development of political and social complexity often turn to political economic approaches to explain the rise of chiefly power and institutionalized hierarchy (Stanish 1992; Vaughn 2006; Adams 1966). A primary focus for theses studies is the role of surplus and/or prestige goods in the development of social and political leaders and the subsequent institutionalization of power within chiefdoms and states (Childe 1950). Elmann Service even went so far as to state that "one of the most striking things about the evolution of culture is the rapid improvement in the products of craft specialization at the point of the rise of chiefdoms" (Service 1962: 148). This perspective, however limiting and typological, was quickly incorporated into processual models of social evolution. Managerial models saw redistribution as fundamental to the development of emergent leadership (Sahlins 1972; Service 1962), while finance models explored the manufacture or procurement of products and resources in exchange for service or patronage (Friedman and Rowlands 1977; Chase and Chase 2001). Debt models addressed elite self-interest and the establishment of relationships built upon unequal exchange, debt, or contractual relationships between patrons and clients. And world systems models (previously addressed in Chapter 2), focused on the universal relationship between cores and peripheries that dictated the directionality of exchange and consumption (Wells 2006).

Ultimately, however, the different foci of these models highlights the incredible variability present within political economic systems, and consequently, the inadequacy of a single model to represent the totality of power relationships and political, social and economic practices within a society. For example, Timothy Earle's (1987) foundational study of Hawaiian chiefdoms explored not only the role of chiefs in the distribution of subsistence plots in exchange for corvée or indentured labor, but also how chiefs relied on surplus (managerial model) from corvée labor to "pay" for elite support and infrastructure (finance model). Simultaneously, Hawaiian society allowed for warriors to rise to chiefly status through an ideology favoring exploits in war, further complicating models by the fact that these wars were ultimately battles over chiefly-organized land and the rights to extract surplus and labor (Earle 1987). The complexities inherent in all political economic systems require a more nuanced approach than simply following the delimitations of a single model.

Cross-cutting the models presented above was a focus within archaeological studies on social evolution and the way in which elites began to control power through the regulation of prestige goods, also known as the "prestige goods theory" (Dupre and Rey 1973; Ekholm 1972; Costin and Earle 1989). In this theory, power is considered to ultimately derive from control over the labor and resources to produce limited quantities of high-value goods. The value of these goods can fall into a myriad of categories: religion, ritual practice, gift-giving, rarity, and many more. The theory posits that elites become patrons of special crafts and raw materials that carry symbolic, economic, and political value (or any combination of the above) as well as, or in addition to, objects that require high levels of knowledge and skill to quarry, produce, and/or utilize (Urban and Schortman 2004). Often goods that fall within the rubric of a prestige good are made from non-local raw resources, are difficult to fake or reproduce through skilled labor, and are only accessible through limited channels (Ekholm 1972). Ultimately, typologies and ideal models, while important in that they have informed all subsequent studies of political economy and social evolution, tend to simplify the complexities of political economic systems as they focus more on defining stages in a social evolutionary sequence instead of focusing on the the political and economic processes themselves as the end goal (Earle 2011).

II. Political Economy and Power

From the 1950s to the 1970s, much of economic anthropology was focused on defining and debating the differences between formalist, substantivist and marxist economic theories. Formalist and marxist theories drew no distinctions between the capitalist economies (within which these theories developed) and the non-capitalist economies of prehistory (Smith 2004; Dalton 1990). The leading proponent of the substantivist models, Karl Polanyi, proposed that non-capitalist economic systems operated around reciprocity and redistribution and were incomparable to capitalist economies (1968). Polanyi's substantivist model became increasing popular among economic anthropologists during the processual archaeology of the 1960s to 1980s, however, the assertion that non-capitalist societies lacked the same economic rationality and were so far removed from other types of economic systems, has been considered a detriment by some (Smith 2004).

Beginning in the early 1990s, two different approaches to economic anthropology emerged that linked power to political economy: adaptationist and political. In adaptationist approaches, economic practices were seen as adaptational responses from a society to its environment (Sanders et al. 1979). Adaptationist approaches asserted that (when environmentally beneficial) political elites intervened in the economy through mechanisms of redistribution, reciprocity, centralized decision making and sponsored trade (Service 1962; Sahlins 1958). For example, specialization and redistributive economic practices emerged in in areas of high resource diversity and resource instability (Brumfiel and Earle 1987). In contrast, the political model assumed that political elites employ specialization and exchange to create and maintain social inequality through monopolies, coercive power, and control (over materials, labor, and distribution) (Brumfiel and Earle 1987). The political model focused on elite expropriation of resources from and through a broader population, either through labor and/or distribution (Wells 2006).

One of the more foundational political models was advanced by Elizabeth Brumfiel and Timothy Earle (1987) and outlines how political elites fostered, and capitalized off of, specialization and exchange to encourage and maintain social inequalities, to strengthen political coalitions, and to establish widespread institutional control. "Political economy is the material foundation upon which complex social institutions are constructed, and is the mechanism by which elites support the institutions on which their power, control and legitimacy rest" (Earle 1994; Earle 1991). This model has provided a starting point for most discussions on power relations in state-level societies. The political model, and this dissertation, both begin from the assumption that the political economy of a society is not only the basis for which power and control is institutionalized and maintained, but also a material and patterned reflection of these intersections. Scholars have sought to illuminate the processes by which power and control are institutionalized within political economies. Earle's (1977) division between two principle forms of economic interaction (staple finance and wealth finance) within state-level societies has formed the basis for much of the subsequent research on the subject.

Staple Finance

Staple finance is the political economic system characterized by state-sponsored control over staple products, such as grains, livestock, clothing, and other necessary goods (Earle 1994). In a staple finance system, the state owns all lands—and the products subsumed within—and allows subject populations to use the land for subsistence, in exchange for the production of goods for the state (as a tax or through a system of corvée labor). Or it may also involve the subject population performing labor on a part-time or seasonal basis (D'Altroy and Earle 1985). Staple finance systems are relatively straightforward; they rely on the mobilization of labor and the state-controlled redistribution of land, products and resources to the subject population (Earle 1977; Smelser 1959). This form of labor mobilization, also known as assigned production, separates land from its typical context—the household (Hirth 1996). This system excels because it collects from its population not only subsistence resources, but also generally necessary household goods, and then redistributes them back to the subject population (D'Altroy and Earle 1985).

Despite the fact that staple finance systems are relatively straightforward in theory, they are logistically difficult to execute, particularly over a large territorial empire. The main disadvantage is that the system relies on the production and mobilization of bulk products that require storage and are often too heavy to be transported over long distances (D'Altroy and Earle 1985). This makes staple finance systems more suitable for small agrarian states or for empires capable of regional-level resource mobilization and control (D'Altroy and Earle 1985). For larger states or empires, the political economy is usually decentralized, meaning that much of the power and influence exerted over the management and regulation of land-use and production outside of the heartland is done so at great physical as well as political and economic distance from the capital (Earle 1994). In addition, instead of moving resources or goods produced in a province to the capital, they are mobilized and redistributed in the same region in which they were produced. This makes maintaining the power and control in the capital an increasingly more difficult endeavor as it requires managerial investment either of imperial officers outside of the physical control of the capital, or the promotion of local elites to positions of power over their local populations. The more decentralized a staple finance system becomes, the less control can be exerted by the capital, or imperial center. Wealth finance systems are often a solution to this managerial dilemma.

Wealth Finance

Wealth finance systems are political economies that are characterized by the manufacture and distribution of special objects (such as personal adornments, status markers, currency, prestige goods, etc.) that operate as a form of political or social payment and as a way for elites to foster and maintain relationships and obligations with necessary personnel (Dalton 1977; D'Altroy and Earle 1985). Special objects within a wealth finance system usually have an established relative value when compared to other special objects, but are not necessarily linked to subsistence goods as they would be in a form of market exchange (D'Altroy and Earle 1985). The value of a special object is largely symbolic, but must still be agreed upon by all individuals within the system. The giving of a special object within a wealth finance system is only one aspect of this political economic model. The objects themselves are usually produced from non-local (i.e., rare) raw materials, involve higher levels of skilled production, and have tightly controlled distribution channels. Some special objects are produced as corvée labor (discussed above), in exchange for subsistence use of the land, or can be more regulated and produced by craft specialists (hired or indentured). The control achieved over special goods that operate within a wealth finance system can be limited to one phase of the production or distribution sequence or all of them, depending on the level of control necessary (Urban and Schortman 2004). This can be further complicated in that different objects may have or require different levels of control, even as they operate within the same wealth finance system. Items that operate as wealth objects may also not always intersect obviously with status, and may be multipurpose or utilitarian tools that are often ignored during archaeological analyses (Cobb 1996). While easier in that wealth finance systems do not require the storage requirements of staple finance systems, the primary disadvantage to wealth finance systems is that they are, by nature, limited in that the value of wealth objects must be converted to subsistence goods if they are to operate on a level outside of elite exchange (D'Altroy and Earle 1985).

Although originally dichotomized as two independent systems, staple and wealth finance are rarely independent from each other in complex societies (D'Altroy and Earle 1985; Smith 1998). For example, in the Hawaiian chiefdoms studied by Earle (1987), staple goods mobilized from the labor of subject populations are used to support craft specialists who produce wealth items for elite personages. This cyclical arrangement is seen in the Inca Empire as well. In addition, objects that operate as wealth items may not be prestigious, but may be highly useful utilitarian items that are difficult to procure or produce (D'Altroy and Earle 1985). Most scholars now approach staple and wealth finance as different systems that can be present within a political economy in varying permutations, and that context- and object-specific analyses are required for each society (Smith 1998). An example is presented below of the intersections of staple and wealth finance in the Inca Empire.

Staple and Wealth Finance in the Inca Empire

The Inca Empire provides a good example for approaching the co-operation of staple and wealth finance systems within the Andes, particularly due to the ethnohistoric accounts from Spanish conquistadors, a level of historical information that is lacking for the earlier Wari Empire. The Inca relied heavily on corvée labor, a form of indentured labor, in which labor was exacted in exchange for subject populations having access to land and resources for subsistence. Corvée labor as a form of obligation between the subject population and the state was not unique to the Inca Empire, and evidence suggests the practice developed from a local pre-state Andean system of *ayllu* exchange, a form of reciprocal exchange between households along kinship lines and different ecological zones (see Chapter 3) (Wachtel 1977; D'Altroy and Earle 1985). Laborers for the Inca Empire largely did not provide staple products directly from the household, but instead served the state apparatus on a part-time basis and produced resources (grain, textiles, etc.) from state-owned lands or locations (D'Altroy and Earle 1985). The pre-hispanic Andes had no known system of market exchange (Stanish 1992), and so communities produced goods for the empire, or gave labor to the military, mines, infrastructural projects, etc. in exchange for the ability to subsist off of state-owned land (Earle and D'Altroy 1982).

Within the Inca Empire, wealth finance objects operated to link and integrate managerial personnel from the capital to the far-flung hinterlands (D'Altroy and Earle. 1985). Furthermore, the practice of exchanging or gifting special value or prestige goods pre-dated the emergence of the empire. Prior to the Inca Empire, Andean populations circulated special products such as spondylus, obsidian, precious stones and metals, and feathers from elaborately colored Amazonian birds, to name a few (Vaughn 2006). Within the Inca Empire, wealth finance objects were mobilized in two ways: 1) gifts between local elites and the state; and 2) conversion of staples goods into objects produced by craft specialists (both resources and labor) (D'Altroy and Earle 1985). A regional example of the wealth finance system was documented in the Mantaro Valley where the beginning of the Inca Empire corresponded to increased silver production by regional communities, but decreased consumption of silver by those same communities (D'Altroy and Earle 1985; VanBuren and Presta 2010). A similar pattern was seen in the production and consumption of maize (a staple resource) by hinterland populations (Hastorf 1990). In other words, the empire employed a process of labor taxation upon the Mantaro communities to produce a special object (silver) that was intended not for redistribution back to the community, but for mobilization within a wealth finance system directed by the state.

Further complicating the staple and wealth finance dichotomy are the ways in which economic organization exists outside of the capital within the Inca Empire. According to ethnohistoric documents, local lords would receive tribute taxes or payments from local populations, consisting of textiles, beads, metalwork, and specialized agricultural products (such as coca). These products would be redistributed as gifts within local political hierarchies to establish obligations as well as to purchase other products. In addition to this system, there were merchant intermediaries who bought and sold special objects both from and to local elites. And it appears that the intersections of these different systems were dependent upon pre-existing regional political and economic systems that pre-dated the emergence of the empire (D'Altroy and Earle 1985). Schreiber (1992) suggests that the Wari Empire would have practiced the same regionally flexible model of political economy, making our understanding of Wari political economy dependent not only upon the specialized product, but on the local and regional political and economic systems that intersect the larger imperial agenda.

III. Recent Approaches to Political Economy

More recent approaches to political economy have begun to move away from a singular focus on resources and finance, to a focus on individuals, ideology, and social control as inextricably linked to political economy (Bourdieu 1979; Giddens 1984; Brumfiel 1992; Urban and Schortman 2004). Studies of political economic systems have, consequently, begun to focus on craft production and the individuals (most often non-elite) who “actively [participated] in fashioning the social and cultural worlds they inhabited” (Urban and Schortman 2004: 186). Crafts and goods can show evidence of the crafter’s identity, including gender, rank, status, kinship, etc. (Wells 2006; Inomata 2001; Janusek 1999). Ultimately, it comes down to the fact that political economic systems reliant on the purely symbolic value of goods do not succeed unless those objects have a recognized and agreed upon value by all within the system (Giddens 1984; DeMarrais et al. 1996; Demarest 2013). Therefore, scholars have begun to focus on the materialization of ideology, or how objects themselves can carry symbols of ideology, to explain how symbols of imperial control come to be incorporated within subject populations. However, at the same time scholars still recognize that symbols, and the objects that contain them, can carry multiple interpretations, with different meanings attributed to the object by different populations, similar to the idea of religious syncretism (Bourdieu 1979; Schortman et al. 2001; Loren 2001; Silliman 2009; Appadurai 1986). For example, in the Andes, indigenous populations continued to celebrate their own traditions and gods through the pantheon of saints and holidays of Catholicism, the double meaning of which was often hidden to the Spanish priests. In analogy, objects can contain the same double meanings, hidden to some members of the population. As Arjun Appadurai (1986: 5) suggests, it is "things-in-motion" that can illuminate hidden social contexts and meanings. As Wells states, "consumption can be viewed as politico-symbolic drama that provides an arena for highly condensed symbolic representations of social relations" (Wells 2006: 282; Cohen 1974).

Studies of political economy have attempted to move past this dichotomous approach focused on typologies and binaries (substantivist vs. political; staple finance vs. wealth finance) and to acknowledge that production, exchange and all other phases of a *chaine operatoire* are "two sides of the same political coin… used together by elites to accumulate resources and exercise control over their respective populations" (Hirth 1996: 206). Hirth (1999: 4) suggests that political economy needs to be studied archaeologically through a focus on four guiding principles: 1) the accumulation of resources; 2) the where and how of resource accumulation; 3) the position of elites at nexuses of control; and 4) the role of ideology in the control over these nexuses and resources (Demarest 2013). In addition, all studies of political economies benefit from a focus on the diversity of resource mobilization strategies and the common mechanisms used across all societies (Hirth 1996: 206). It is both the recognition of micro-level diversity as well as the orientation of macro-level systems that comprise a complete understanding of political economy in archaeology.

IV. Craft Production

Studies of political economies have begun to place a renewed focus on the materiality of objects and their role within society and turned to craft specialization and production as a way to address the social, political and economic actions of individuals, groups, and societies. Craft production is the study of technologies, human agents, and organizing principles, with the goal of explaining historically specific production systems and cross-cultural regularities and variabilities within and between those systems (Costin 2005). Craft production has been linked to studies of sociopolitical organization through three research avenues: 1) the role of craft production in the creation and maintenance of hierarchies; 2) the organization of the production process and its affects on the social and the political; and 3) the function and meaning of objects within social and political structures (Costin 2001: 273-274). Primarily in studies of state-level societies there is a focus not only on craft production (which all communities do), but more specifically on craft specialization, or "fashioning items at volumes above and beyond the needs of the individual or group for exchange [through a variety of different mechanisms]" (Schortman and Urban 2004: 187). Craft specialization studies pay attention to fabrication, distribution, and use, as well as political centralization, social differentiation, ideological factors, and inequality (Schortman and Urban 2004: 187).

A focus on craft production has also illuminated the need to approach the variability present not only across different craft materials but also within the *chaine operatoire* of each individual product (Lemmonier 1992; Leroi-Gourhan 1964). The *chaine operatoire*, or the operational sequence, consists of every phase in the life-cycle of an object and the decision-making strategies involved in each: resource collection, manufacturing, production, time, distribution, consumption, reuse, and discard (Schortman and Urban 2004). While the *chaine operatoire* was popularized within archaeology to study the "rules" that govern technological behavior, more recent approaches have focused on agency and social identity in reference to the producers (Dobres 1999). The benefit of looking at the *chaine operatoire* is that it can link "tangible and intangible dimensions of technological practice" as well as "make it possible to link the archaeological record… to the dynamic social milieus in which they were practiced" (Dobres 1999: 129).

In order for craft production to be relevant to archaeological research studies and comparable across larger social evolutionary theories and studies of political economies, scholars tend to focus on exploring general aspects of the production process along different phases of the *chaine operatoire*. Costin suggests a focus on six dominant features of any craft production system: 1) producers—specialization, labor, compensation, and skill; 2) means of production—raw materials, tools, and knowledge; 3) organization—spatial, social production, and temporality; 4) objects—function and use; 5) distribution—transportation and oversight; and 6) consumers—use and reuse (Costin 1991: 190-191).

Production Systems

Production systems include the level of specialization of the object, the labor involved, the compensation [of varying forms], and the technological knowledge of the producer. When a craft object is specialized it means it is the product of alienable goods produced by one segment of the population for consumption by others (Inomata 2001; Clark and Parry 1990). Other definitions of specialization link it directly to institutional control and hierarchy (Costin 1991). This alienation of both resources and labor (important to look at both) often results in information regarding institutionalized power and production systems, rather than the craft product itself. In studying the specialization of a production system it is important to account for 1) the affiliation of the specialists (independent/attached), 2) the product, 3) the intensity of specialization (part-time/full-time), 4) the scale (individual, household, workshop, village, etc.), and 5) the volume of output (Brumfiel and Earle 1987: 5).

One of the primary ways that scholars have approached the study of specialization is through a scalar approach to independent vs. attached specialization systems (Earle 1981). Independent specialists produce goods and services for an unspecified population while attached specialists produce for a patron or social/political elite and/or governing institution (Brumfiel and Earle 1987). Simply put, independent specialists hold rights of alienation over their products, while attached specialists do not (Inomata 2001). Both independent and attached specialists, or a combination thereof, can be present within a single political economic system. Another scale for examining specialization categorizes production on a continuum between household production and large-scale industry (van der Leeuw 1977). It is important to remember, however, that specialization occurs in *degrees,* not in discrete categories (Costin 1991). A downside to the plethora of models for specialization is that cross-cultural work is difficult and the abundance of different terms to describe similar phenomena obscure comparisons. Ultimately, however, studies should focus on the context, scale, and intensity of specialization instead of typologies in order to eliminate these problems (Costin 1991).

In addition to studying the specialization of a production system it is important to address the means of production, or the raw materials, tools, and technical skill and knowledge necessary to produce a craft product. The organization of the means of production are one of the most readily studied pathways to inequality and institutionalization of power. Alienation of workers from their own labor and from the products they create is not only a key tenet of capitalist systems, but more generally speaking is a hallmark of social and political inequality. Furthermore, the organization of production, including how long it takes to produce an item, where it is produced (regionally, centrally, etc.) and the individuals responsible for production are essential elements for understanding craft production systems. After products are made, they are distributed, used, reused, and discarded in a wide variety of permutations.

Recent Approaches to Craft Production

Included within recent studies of craft production, largely drawing from practice theory (Bourdieu 1979; Giddens 1984), is the understanding that technology is a meaningful engagement of social actors with the material conditions of their existence (Dobres and Hoffman 1994), and that archaeological patterns represent collective production of material culture by a community of practice who share a worldview (Peelo 2011). Instead of looking at objects as representative of identities, it may be useful to see them as a medium for the construction of identities (Peelo 2011). The objects themselves carry significant weight in understanding their own production systems. The function, use, and symbolic meaning attached to objects is paramount in understanding their consumption. The theoretical concept of object agency asserts that objects are not only reflections of human action, but also that they themselves structure the lives of human actors (Gell 1998; Gosden 2005; Latour 2005). While some studies of object agency take the concept into the realm of abstractionism, it is important to acknowledge the role of the object itself *within* the production system, not external to it. Despite the fact that studies of production processes discuss the alienability of objects from their producers, object agency asserts that objects are not, in fact, alienable. They may be removed from the physical possession of the producer, but the formal, stylistic, and other choices made by the producer are inalienable to the object itself (Thomas 1991).

V. Political Economies of the Wari Empire

In the Andes, most discussions on political economies are focused on the rise of elite populations and middle-range societies (Vaughn 2006; Stanish 1992; Levine et al. 2013; Costin 1991; D'Altroy and Earle 1985). Prehistorically, Andean political economy was centered around the household and organized within larger kin-groups, forming an *ayllu* (Stanish 1992). Each *ayllu* participated in a system of vertical exchange, using the ecology of the Andes to take advantage of different resources from different ecozones determined by elevation (see Chapter 3). The exchange of resources, including reciprocity and redistribution, was dependent upon systems of extended kinship. Unlike in Mesoamerica, there is no archaeological evidence of "markets" or market exchange in the Andes (La Lone 1982; Stanish 1997). While there are architectural features (such as large plazas), that are associated with market systems in other regions, Andean scholars (and ethnohistoric sources) do not believe that markets were in operation in the Andes, either prehistorically or during the Inca Empire (Earle 1985; Stanish 1997).

The Andes does, however, have a long history of the production and exchange of crafts and craft products. For example, metals, unlike in other areas of the world, were first used in the Andes as prestige objects (e.g., jewelry, ornaments, figurines) (Vaughn 2006; Lechtman 1984). As early as 1,200 BC, the first widespread temporal horizon centered around the ceremonial site of Chavín de Huantar. The site became a hub for the distribution of iconography and was a pilgrimage location for offerings of ceramics, lithics, and other craft products such as spondylus and precious stones from distant regions (Vaughn 2006). By the Early Intermediate Period on the south coast, polychrome pottery and textiles became the dominant vehicles for symbolic imagery and ideology, mediums that were picked up and brought into the developing Wari iconographic canon.

While most information scholars have on political economies in the Andes relies on analogy with the Inca Empire, it was the Wari Empire who first paved the way for state-level political organization in the wider region. However, understanding the political economy of the Wari Empire is difficult due to the lack of historical or ethnohistorical information. An examination of the products more popularly exchanged within the empire can provide a starting point for understanding the intersection between commodities, products, production, exchange, consumption, and the institutionalization of power.

Textiles

Most of what scholars know of Wari textiles comes from Wari occupations on the South Coast, where the dry climate preserves the highly organic and fragile material. Wari textiles utilized both cotton and camelid fiber on the same loom, and the use of cotton helps explain why the site of Pataraya was so important, as the lower elevation zones on the south coast were ideal for cotton production (Edwards et al. 2008). Pataraya was a Wari colonial outpost in the Nasca region, and was occupied by non-local Wari individuals (Edwards 2010). The site of Pataraya has evidence of spinning (as do other Wari imperial sites like Jincamocco), and spindle whorls were found at the site in contexts associated with domestic activities, such as food preparation. Wari weavers wove mantles, headbands, and most commonly the tunic (Bergh 2013). Wari tunics are perhaps the most documented of the products that use textile as a medium. Tunics measured approximately 204 by 111 cm and were often placed in Wari burials with minimal evidence of use-wear, a feature characteristic of ceremonial garments (Stone-Miller and McEwan 1991). In addition, the iconography on many textiles depicting supernatural figures adds to this interpretation of the tunics use in ceremonial arenas. After death and in burial, the tunic served as a cover for the false-headed mummy bundle that was present in many Middle Horizon burials (Stone-Miller and McEwan 1991). Stone-Miller and McEwan (1991) see the Wari textiles operating as vehicles for state values in life, and as connected to the supernatural realm in death. As such, these tunics were likely reserved for elite or state-affiliated individuals during the Middle Horizon.

Wari tunics were intricate and detailed, including multiple production choices for the weavers: elements of composition, coloring, format, imagery, etc. Fibers used included camelid and cotton, and the selection was followed by spinning, plying and dying of the fibers with precious colorants and in multiple combinations. Likely worn by individuals important to the state or given as gifts, the use of the sleeved tunic may have been adopted by the Wari from the Moche (Bergh 2013). “These tunics imply that to a very great degree Wari elites’ authority derived from trust in their privileged access to the sacred realm and its denizens. Indeed, by donning such tunics Wari lords may have identified themselves with or even transformed into these figures" (Bergh 2013: 188).

The weft and warp of the tunic are such that the spinners and weavers likely possessed a great deal of technical skill in order to produce such tightly woven cloth (Stone-Miller and McEwan 1991; Rehl 2000). It has been predicted that due to the amount of labor involved in production, it likely took two to four individuals to complete a singular tunic within a workshop setting (Stone-Miller and McEwan 1991). In addition, the high thread count of each tunic would have meant that producers spent a considerable amount of time and energy on each individual piece. Stone-Miller and McEwan (1991) suggest that each weaver made choices to produce a tunic with a unique combination of shapes and colors, while following basic rules of repetition. In other words, craft producers were able to make choices along each step of the *chaine operatoire.* In addition, many of the Wari tunics had "mistakes", or errors in the formal rules, primarily in terms of color, and even more specifically in relation to blues and greens. Since these choices were not quick decisions, but would have required considerable investment to make, they are more likely the intentional introduction of deviance (Stone-Miller and McEwan 1991). In fact, the abundance of textiles with errors or deviations suggests that it was possibly the rule to "break the rule" (Stone-Miller and McEwan 1991). The deviation in blue and green hues may also relate to a paucity of dyes of a blue color in Wari regions, while blue is more prevalent in Tiwanaku-style ceramics (Oakland 2000). Perhaps color represented something of a symbolic nature. The freedom given to the craft producers to change and manipulate color choice and other aspects of textile production suggest that it may have been high-status individuals both producing and wearing the tunics.

Another known Wari textile is the tie-dyed tunic, which involved weaving, disassembly, tie-dying and then re-assembly (Rowe 2013). The function and use of tie-dyed tunics is known to scholars primarily through depictions of tie-dyed textiles on ceramics. Iconography from the early half of the Middle Horizon depicts tie-dyed tunics among scenes of perceived ritual or religious importance. For example, in one scene of a kneeling figure carrying a bow and arrow and a shield shows the man wearing a tie-dyed tunic. His kneeling position, and the fact that the vessel was found in the Tiwanaku region, suggested to scholars that the individual represented was possibly an important Wari religious figure, or even an individual responsible for spreading Wari religion to distant regions (Cook 1996). By the later Middle Horizon, this figure no long wears a tie-dyed tunic but a striped tunic and a four-cornered hat (Rowe 2013). This change in regalia alludes to the fluid and dynamic nature of tunics as "materialized ideology". Images of tie-dyed tunics are also found on the face neck jars that were ritually smashed at both Conchopata and at Pacheco (Rowe 2013). The smashed vessels have been interpreted as offerings to the gods, and so the importance of the tie-dyed tunics on these face neck jars seems paramount. Due to the level of detail and time involved in the process of making tie-dyed tunics and their iconographic restriction to contexts and scenes of religious importance, suggests that the tie-dyed tunic may also have been restricted in its consumption.

In sum, the high level of skill and time associated with textile production, coupled with the limited availability of cotton and imported dyes, and the portrayal of state-affiliated and/or supernatural content, suggests that textiles were a highly restricted medium both in production, consumption, and discard (through burial). The use/consumption of the textile likely served a myriad of purposes (clothing, symbol, ritual object, etc.). Rehl (2000) explored the order of images on Wari textiles from different contexts and discovered that Wari-style symbols were presented with a higher object-order (dominance and clarity of the image when looked at) for areas in which Wari presence may have been more contentious. For example, Wari-style symbols were blended and developed from south coast imagery, while more pronounced or emphasized on tunics from the north-coast (Rehl 2000: 13). Wari-style textiles could also signal differences in comparison with the complex polity of Tiwanaku to the south. Differing four-cornered hat styles, as well as different pigment preferences may have served as signals of identity (Oakland 2000). And while most scholars suggest that dyed tunics were reserved for elite individuals, they may have also been used within a wealth-finance model or as gifts for state-service.

Ceramics

Ceramics are the most durable medium created by the Wari, and therefore, one of the most well-studied craft products. Polychrome and iconographic pottery is often found in Wari ceremonial and burial contexts, while plainware sherds and other utilitarian products are commonly found in household or midden contexts. Wari-style ceramics are found as far south as the Titicaca Basin, leading to the original misclassification of Wari as part of the Tiwanaku interaction sphere. Some of the largest ceramics within the Wari Empire were ceremonial urns, feasting vessels and large, deity effigy vessels. Some of the greatest examples of these ceramics are found at the site of Conchopata in Ayacucho and at Pacheco in the South Coast.

Pottery was the most "accessible and expedient means of distributing the symbols of [Wari] authority" (Knobloch 2013). Wari pottery likely spread through a combination of migration, trade, and military conquest (Knobloch 2013) and was also a highly valued object frequently used in offerings (Glowacki 2013). The Wari practiced a ceremonial ritual in which large oversized urns and vessels were smashed, and the deposits of these smashed vessels have been found at the Wari sites of Pikillacta in Cusco, Pacheco in Nasca, and at Conchopata in Ayacucho (all imperial Wari sites). At Conchopata, the numerous ritual ceramic deposits contain vessels and urns depicting deities and mythological figures. The large size and shape of the smashed urns has led scholars to suggest that they may have been used to contain liquids, the most likely candidate being *chicha,* a type of fermented beverage used for feasting events (Isbell 1984; Knobloch 2000). Another ceramic deposit at Conchopata contained five smashed urns and a face neck jar, buried in association with five young women (Glowacki 2013). The vessels were prepared explicitly for ritual use as they showed no evidence of wear caused by repeated use (Glowacki 2013). At Pacheco, a ritual deposit of smashed urns depicted images of deities and agricultural products (such as potato, *olluco*, etc.) (Knobloch 2000). Also at Pacheco, all of the vessels had been smashed by blows to the face and neck, leading to several interpretations of the vessels as either ritual deposits by the Wari, or perhaps a rebellion by local Nasca populations at the decline of the empire (Schreiber 2005).

Within archaeological material recovered from Wari imperial sites, the ceramic assemblages can be studied within the context of state-sponsored feasting, a part of the Wari political economy that operates to redistribute food and beverages to a labor force or to gain favor among other elite members. This usually operates within a staple-finance model of political economy, where protection and the right to live within Wari territory is granted in exchange for labor or specialized production (D'Altroy and Earle 1985). Within a ceramic assemblage, a relatively high percentage of serving vessels (in comparison to cooking/production vessels) is characteristic of feasting practices (Cook and Glowacki 2002). This is common at many Wari imperial sites. For example, the site of Jargampata (east of Huari in the Ayacucho region) had a ceramic assemblage that contained over 50% serving vessels (Isbell 1988). At Azángaro (west of Huari in the Ayacucho region), serving vessels comprised 68% of the ceramic assemblage (Anders 1991). At the site of Pikillacta in Cusco, patio groups with ceramic assemblages produced 70% serving vessels (Glowacki 1996). And at the site of Huaro in Cusco, serving vessels made up 80% of the ceramic assemblage.

Within Wari imperial sites the percentage of serving vessels is uniformly high, however, the relative ratio of the type of serving vessel (bowl vs. cup) varies between sites. This variation in vessel type is likely due to the nature of the feasting activity. A higher bowl to cup ratio is indicative of administrative-labor feasting, while a higher cup to bowl ratio suggests a more elite-oriented feasting practice (Cook and Glowacki 2002). Jargampata, Azángaro, Pikillacta and Huaro all contained higher bowl to cup ratios, indicating that these sites were possible locations for state-sponsored administrative-labor feasting events. However, Huaro contained a higher percentage of cups than that found at Pikillacta (Glowacki 1998), suggesting some variability in feasting events across Wari imperial sites (Cook and Glowacki 2002). Because Huaro was not the predominant imperial administrative site within the Cuzco valley, it may have been a location for either Wari and/or local elites to feast together, the higher prevalence of cups suggesting a more elite-oriented feasting practice.

Despite the abundance of Wari pottery in the archaeological record, there is limited evidence for pottery production facilities. The largest known ceramic production workshop is at the site of Conchopata in the Ayacucho valley itself. Lumbreras (1974) and Pozzi-Escot (1985) found evidence at Conchopata for a dense community of ceramic specialists due to the frequency of tools and ceramic waste found during excavations. In addition, Conchopata is also the location of the first-identified kiln in the region, dating back to the Middle Horizon (Leoni 1999; Wolf 2012). Burials at Conchopata suggest that this large city neighboring Wari also contained a high degree of wealth, something that would have been previously unexpected for a pottery producing community (Isbell 2004). Perhaps the potting community was more important to the Wari Empire than previously assumed, or perhaps Conchopata was both an elite community and an adjoining pottery production facility. A second Wari pottery production facility has also been identified at the site of Maymi in the Pisco valley in the South Coast (Anders 1990).

The lack of production facilities for imperial polychrome pottery suggests that the production may have been tightly controlled, always produced and consumed within imperial (and elite) settings. Ultimately, polychrome ceramics served as a main vehicle for the transportation and display of Wari iconography throughout the empire. Much of the Wari iconographic style developed from a close association with Nasca potting communities on the south coast as well as with Tiwanaku staff-god imagery. These images were then publicly displayed during the consumption of *chicha* at feasting events among elites for alliance building or social solidarity, and for state-sponsored labor. The images of supernatural deities presented on feasting vessels would have linked Wari individuals with a supernatural power through public display.

Other Products

The most common Wari metal products were made from gold, silver and copper. Common metalwork included plumes (meant to be worn or to adorn a headdress), figurines, and jewelry (Bergh 2013). While the Wari possessed the ability to craft and forge metals, they did not create weapons or utilitarian products from these materials. Metals were reserved for elite, ceremonial, or ritual contexts. While metal workshops have not been identified in the archaeological record, the neighboring region of Andahuaylas contains the first evidence for gold-working, dating to around 1500 BC (Grossman 1972). This history of metal working at the region's copper veins also point to Andahuaylas as a possible region for Wari metal extraction and production (Kurin 2012). Metal was a relatively high-labor resource to extract, requiring high investment with minimal returns – aspects commonly associated with prestige or wealth items. Metal is also easily transported and difficult to reproduce given a lack of technical knowledge or access to extraction zones. It would have been an easily controllable resource, and entrances to mines are often narrow and easily guarded. This is not difficult to imagine as mines for precious metals and stones are some of the most highly contentious locations in the world today.

In addition to metals, the Wari political economy also included products made of precious stones, including lapis lazuli, serpentine, turquoise, and chrysocolla. These stone are often found in ritual or elite contexts, in offerings, or in burial deposits. Production locations for objects made from these materials have not yet been identified, although the source locations for these materials come from a diverse ecological range. One of the most distant materials found within the Wari ritual deposit assemblage is spondylus, a mussel from the ocean which shines with iridescent colors. Spondylus is found on the coast of Ecuador and would have been brought to Wari sites at great effort. While not much is known about the production locations of metals and other precious stones and materials, their deposit in Wari elite and ceremonial contexts speaks volumes about the value placed on exotic material within the empire and the empire's ability to mobilize and to restrict or allow access to these resources within their territory.

VI. Concluding Remarks

The political economy of the Wari Empire intersects with not only the materials produced (encompassing processes of extraction, production, distribution, and consumption), but also the social and political networks at play within the empire and between its populations. While agricultural resources like cotton (used in textile production) and maize were intensively cultivated, the empire was relatively dispersed, and the agricultural products may have been mobilized and consumed within their territories of production. The Wari does, however, appear to capitalize on and fetishize regional resources with restricted and limited access. For example, spondylus from Ecuador, brightly colored feathers from the Amazon, coca from the coast, and metal and other precious stones and dyes found in distant reaches of the empire. This preference for objects of limited extractive access appears to highlight interaction networks within the empire built on the acquisition of these resources and the display of objects signaling rarity and value (e.g., tunics made from blue dye, obsidian from Alca, a spondylus necklace from Ecuador or a metal tupu from Andahuaylas). At the site of Huari, the fill layer overlaying the previous Huarpa occupation and ushering in the new Wari Empire, is a layer of imported red sand, likely from the coast over 150km away. Perhaps operating as items in a wealth or prestige economy, or perhaps serving an important ritual or symbolic function, resources from across the empire play a fundamental role in the Wari political economy.

The research for this dissertation, therefore, focuses on the role of resources (and the products that can be made from them) as one vehicle for the institutionalization of power within the Wari Empire. Because the Wari drew resources from all corners of their far-reaching empire, the political economy inherently involves those distant regions and individuals and communities within them, not just those within the Wari capital. By following the *chaine operatoire* of a resource, not only in terms of its technological journey but also its social and economic one, this dissertation seeks to understand the intersections present within the life-cycle of an object, and what these can illuminate about the Wari political economy. The following chapter will address obsidian as one such resource through which to approach Wari political economy and the institutionalization of power and relationships.

CHAPTER 5

OBSIDIAN IN THE CENTRAL ANDES

Obsidian, a naturally occurring volcanic glass, is one of the most utilized resources in prehistory, not just in the Andes but worldwide. It is one of the most easily knappable materials due to its predictable conchoidal fracture pattern, and its edges are some of the sharpest in existence, making it a highly sought after and utilized resource for hunting, warfare and other cutting and scraping activities. In addition to obsidian's more "functional" qualities, its appearance, usually black and translucent with occasional hues of red, blue, and gray, have made it a commonly used prestige or high-value resource linked to aesthetic and symbolic values (Saunders 2001). While commonly utilized in prehistory, obsidian is not ubiquitous. Obsidian occurs only in regions of volcanic activity, and because it can decompose over time, high-quality obsidian is from eruption events younger than 10 million years (Ogburn 2011). For all of these reasons, obsidian is relatively limited in its occurrence (Chia et al. 2008). Its use in widespread archaeological assemblages is the result of human transport—through seasonal transhumance, trade, exchange, and other economic, political and social avenues. Because obsidian is a homogenous material, due to the fact that it is produced through individual volcanic events occurring in specific geographical locations, archaeologists can study the trace elements within an obsidian artifact and determine its original source location. The fact that obsidian can be accurately sourced means that it is possible to study prehistoric movements, and economic, political and social systems as they are linked to obsidian as a resource. This chapter explores obsidian as a resource, and its use (production, distribution, and exchange) in the Andes and during the Middle Horizon.

I. Obsidian

Obsidian, a type of rhyolitic silica, is a naturally-occurring volcanic glass (igneous rock with a glassy texture), that is formed during the rapid cooling process of volcanic lava. During a volcanic event, viscous lava that moves slowly enough either on the surface or at a shallow depth, under high pressure and temperature (1000 degrees Celsius), will not crystalize as it cools (Burger and Asaro 1977; Ericson et al. 1975). This lack of crystallization is what results in obsidian having the properties of a glass, or super-cooled liquid. Shackley refers to obsidian as a "liquid in all its properties except in its ability to flow easily" (Shackley 2005: 10). Because obsidian is a glass, it has no predetermined direction of fracture, but does have a conchoidal fracture pattern. Conchoidal fracture patterns are similar to those seen on broken window glass, (e.g., a curved breakage pattern develops as the energy moves away from the point of contact through the material). In other words, because obsidian is a volcanic glass it can fracture in any direction, and with a predictable and consistent fracture pattern, making it one of the easiest and most predictable materials to manipulate and flintknapp (Andrefsky 2005).

In addition to obsidian's fracture properties, its formation also results in a relatively homogenous material. Due to obsidian's formation within a singular volcanic event, it has a unique elemental signature that is directly correlated with its location of origin. As the lava cools, the melting and crystallization process changes the composition of elements within the lava. As lava cools it changes from a liquid to a solid state, and there are some elements that are incompatible with the solid phase of the material. These incompatible elements disperse at different rates due the speed at which the lava cools (solidifies), and eventually settle into a unique element ratio that is specific to the exact historical moment and location at the which the lava cooled and moved from a liquid to a solid state (Shackley 2005). Because these incompatible elements make up less than 1% of the material, they are called trace elements, and the study of them, trace element analysis. This process and the final ratio of incompatible elements is what allows archaeologists to source obsidian.

Another important feature of obsidian results from its natural devitrification process, whereby it slowly begins to crystalize, and therefore lose its glassy properties and conchoidal fracturing capabilities (Burger and Asaro 1977). For this reason, obsidian used for artifact production in prehistory is generally young (25 million years old or younger), with the most high-quality obsidian resulting form volcanic events that are younger than 10 million years (Ogburn 2011). Furthermore, obsidian is generally rare, occurring predominantly within the circumpacific tectonic belt near fault lines and other areas of high volcanic activity (Ericson et al. 1975). The Andes is rich in volcanic activity, particularly the south-central highlands (present-day central and southern Peru, northern Chile, and Bolivia), but much of the regions' obsidian is older than ideal, with only three major obsidian sources (Chivay, Alca and Quispisisa) and five secondary sources, utilized in prehistory for their superior quality.

II. Function of Obsidian in the Andes

Obsidian is still a relatively understudied material in the Andes. Studies of obsidian in the Andes have generally followed one of two approaches. The first examines obsidian tools in relation to functional activities of hunting and subsistence behavior in the Preceramic period (Quilter 1991; MacNeish et al. 1980). The second approach focuses on obsidian sourcing and quarrying activities (Burger and Glascock 2000; Burger et al. 2000; Vaughn 2006; Jennings and Glascock 2002; Tripcevich 2007). While generally perceived as a functional tool, obsidian is, in reality, a much more complex material resource that often operates simultaneously in both utilitarian and prestige/ritual arenas. Many scholars have noted that this variability has limited research, as obsidian has fallen victim to an overly simplified utilitarian/ritual dichotomy (Tripcevich 2007). As noted by Arjun Appadurai, "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 homogenous, bulk item of extremely limited semantic range can become very different in the course of distribution and consumption" (Appadurai 1986: 40-41). Limiting obsidian to operating only in one arena limits our understanding of its use in prehistory.

Despite acknowledging the limitations of a utilitarian/ritual binary, most prior studies of obsidian still categorize its use along these divisions. Obsidian was used for projectile points, hafted onto spears and arrow shafts, and for knives, mounted onto wood or bone handles (Tripcevich 2007). Its utility in hunting is, however, debated within the archaeological community. Due to obsidian's fragile composition, any missed shots would have resulted in the destruction of a point (Metraux 1946; Bennett 1946; Kidder 1956; Ellis 1997). It is argued that perhaps obsidian wasn't used in hunting behavior but for butchering, scraping, and shearing wild game and subsequently domesticated camelids (Tripcevich 2007).

By 15,000 years ago, concurrent with the first populations in South America, obsidian was used in the Andes (MacNeish et al. 1980; Quilter 1991). As early as the Preceramic period (11,105–9,850 BP) populations were using obsidian at archaeological sites at distances up to 130km away (four days travel) from where it was acquired at the source (Burger et al. 2000; Kellett et al. 2013). By the Late Archaic period (5,500–4,000 BP), projectile points had become smaller and more triangular, interpreted by some scholars as relating to the invention of the bow and arrow (Klink and Aldenderfer 2005; Vaughn 2006). Interestingly, the development of this new technology is coterminous with the domestication of camelids (Tripcevich 2007; Klink and Aldenderfer 2005). And despite the utilitarian purpose of early tools, the first known inclusion of obsidian as a burial good dates to approximately 5,500 BP, as early as the Late Archaic period. This is the same relative period in which bow-and-arrow technology develops and camelids are domesticated, highlighting the difficulty in differentiating between purely utilitarian and purely ritual uses of obsidian (Tripcevich 2007).

Ritual use of obsidian is often identified in the archaeological record through its inclusion in burial contexts and ritual deposits (associated with other known ritual objects), as well as its depiction in textile and ceramic iconography. For example, Paracas textiles from the south coast of Peru dating to the Ocucaje 8 period (2300–2000 BP) show representations of mythical figures taking trophy heads and holding obsidian knives, presumably used in the removal of trophy heads (Burger and Asaro 1977). Also on the south coast, an Early Nasca (AD 1–300) knife was found with an obsidian blade hafted onto a painted dolphin palate (Burger and Asaro 1977). The union of material from the mountains (obsidian) and from the ocean (dolphin palate) would have been of symbolic and ritual importance.

Obsidian was also used in medical procedures. Trephination, a medical process that involves removing a piece of the cranium to relieve cranial pressure, likely involved the use of obsidian blades due to their naturally sharp edges. Those archaeologists working with obsidian in the field know that a thin cut from the blade will heal almost instantly, without the use of stitches. Another less examined role of obsidian is its use as a mirror (Burger and Asaro 1977). The transparent quality of the material can produce a reflection if it catches the light at the right angle, and may have been seen as mediator between cosmological worlds (Giesso 2003). Obsidian mirrors have been found in Huancayo and at the capital of the Wari Empire (Ochatoma pers. comm.). In Mesoamerica, the Aztec considered obsidian to be a symbol of rulership and power. The deity *Tezcatlipoca*, "Lord of the Smoking Mirror", observed the world through his magical obsidian mirror (Saunders 2001). While the Andes surely had their own unique understanding of the importance and symbolism of obsidian, this example from Mesoamerica provides a possible framework.

Obsidian in the Middle Horizon

As little research has been done on lithics in the Andes, even less has focused on lithics in the Middle Horizon. Formal typologies have been established by Burger and Glascock (2000) and by Vining (2005). Burger et al.'s (2000) typology categorized Middle Horizon point styles as usually following one of three forms: 1) small, stemmed-and-barbed shaped; 2) small concave-based shape; and 3) and convex-sided point with a straight or slightly concave base (Figure 5.1). Vining's (2005: 59) typology is more expansive and identifies seven point types: 1) "Type A" – a small triangular body with concave base; 2) "Type B" – a lanceolate body with a concave base; 3) "Type C" – a triangular body with a straight base; 4) "Type D" – a lanceolate body with a straight base (also known as the Wari type); 5) "Type F" – an excurvate body with a convex base; 6) "Type G" – a triangular body with a stemmed base (also known as the Tiwanaku type); and 7) “Type J” – a possible bifacial preform (Figure 5.2).

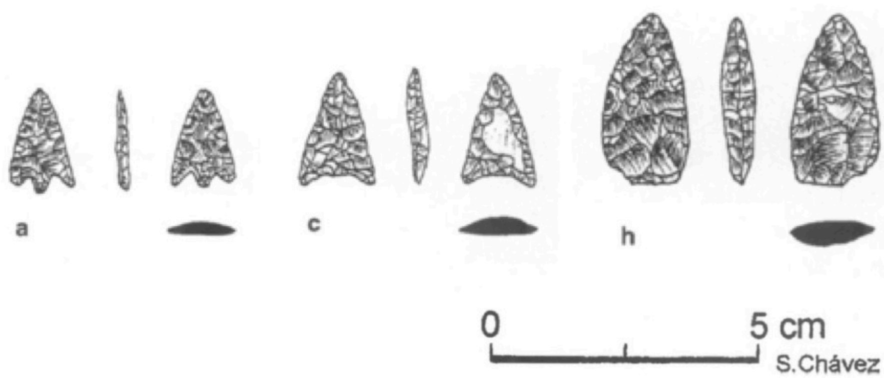


Figure 5.1. Burger et al.’s (2000) Typology of Middle Horizon Obsidian: a) small stemmed-and-barbed; c) small concave-based; h) convez sided point, straight/slightly concave base. Figure courtesy of Burger et al. (2000: 328).

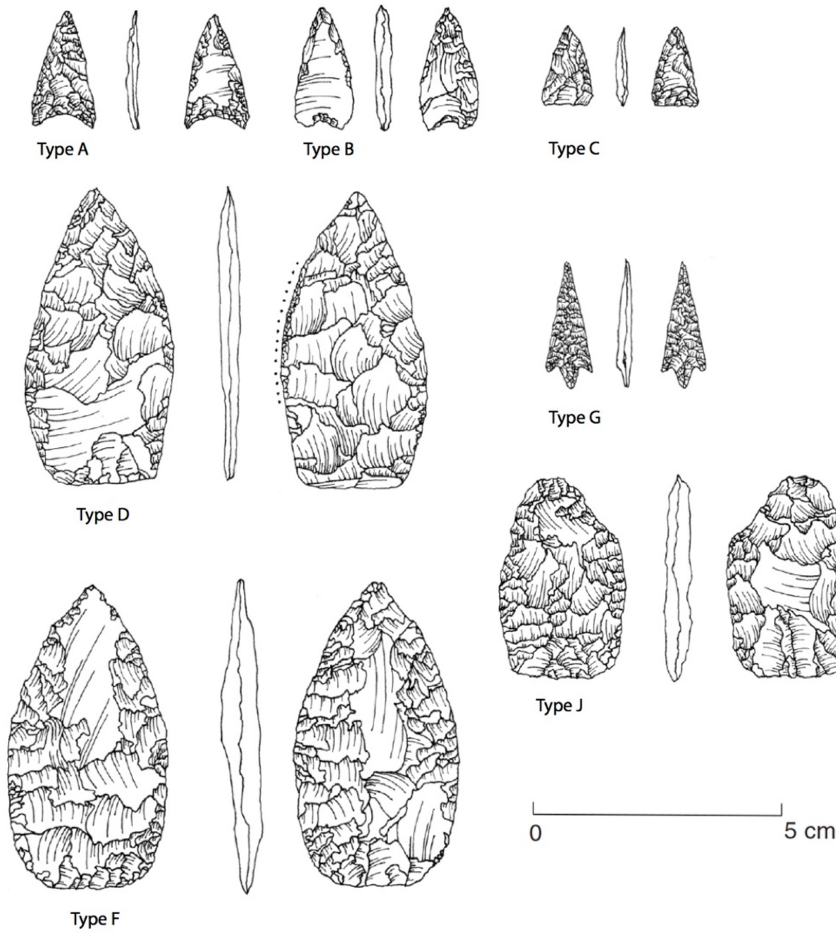


Figure 5.2. Vining's (2005) Typology of Middle Horizon obsidian: a) small, triangular body with concave base; b) lanceolate body with concave base; c) triangular body with straight base; d) lanceolate body with straight base (Wari); f) excurvate with concave base; g) triangular body with stemmed base (Tiwanaku); j) preform. Figure courtesy of Vining (2005: 52-58).

Most attention given to obsidian consumption has focused on the role of bifaces. Vining (2005) draws upon work by Gero (1989) to articulate the greater social, symbolic, political (and otherwise) content that is expected to be embedded in bifacial tools (over flakes or unifacial tools) due to the greater energy investment required for production. Therefore, while obsidian was used in prehistory for both expedient tools and for bifacially flaked tools (including points), most attention has been given to bifaces. However, as previously mentioned, often unassuming multipurpose objects (like scrapers and expedient flake tools), can carry with them important symbolic messages for both the consumer and the archaeologist. Following this, scholars have illuminated many multifaceted functions of obsidian in the Middle Horizon. Giesso (2003) identified obsidian as having both a social and ceremonial value at Tiwanaku. Giesso linked this to control over distribution and elite power at the site and regionally. Castillo (2000) found evidence of obsidian in ritual activities and offerings at San Jose de Moro and Nash (2002) found that not only did obsidian reflect elite status and ritual participation at Cerro Baul, but that it was found in close association with food preparation activities.

During the Middle Horizon, there does not appear to be a correlation between point form and obsidian source location. In other words, scholars have found that the same source can be used to produce a wide range of point styles, and that point styles can be produced by any obsidian source. What follows is that it was not important “where the obsidian came from, since the obsidian could not be distinguished visually, but rather that the tool was of obsidian (Burger et al. 2000: 296). However, this doesn’t account for the distribution patterns of obsidian during the Middle Horizon. If all that was important was obsidian as a material, then sites and communities would use obsidian from sources closest to them, as was done in many regions prior to the Middle Horizon. However, this pattern changes during the Middle Horizon, suggesting that social, political and/or economic mechanisms were present and active in the production, distribution and/or consumption of obsidian during this period.

III. Obsidian Sources

Early studies of obsidian sourcing in the Andes began in 1971, with the identification of three distinct obsidian sources using neutron activation analysis. By 1975, eight major obsidian source types had been differentiated, but were not yet linked to their geological locations (Burger et al. 2000). By 1977, scholars had matched five source types with their geological location. At present, ten obsidian source types have been identified both chemically and geologically (Burger et al. 2000). The nine most commonly utilized sources in the central Andes are: Quispisisa, Alca, Chivay, Jampatilla, Puzolana, Potreropampa, Lisahuacho, Aconcagua and Macusani (Figure 5.3). As previously discussed, each of theses sources has a unique elemental composition related to the ratio of incompatible elements. In the Andes, researchers focus on the ratios of rubidium (Rb), strontium (Sr) and manganese (Mn) within a sample, although titanium (Ti), iron (Fe), zinc (Zn), gallium (Ga), yttrium (Y), zirconium (Zr) and niobium (Nb) can also be used for source-type analyses.

Despite the incredibly similar composition of all obsidian (with the exception of minor incompatible trace elements), the phenotypic characteristics of obsidian can be different between each source; although these differences are not always apparent to the naked eye. For example, Quispisisa, Chivay and Alca produce relatively larger nodules (up to 30cm in maximum dimension) than those found at the other six sources (Tripcevich 2010). There is also variability in color, transparency and cortex (the exterior surface of the rock) between sources, although most material is visually indistinguishable. The prehistoric use of these sources is likely due to factors such as a populations' proximity to a source, the quality of the obsidian, the size of the nodule, other aesthetic qualities (such as color or transparency), as well as social, political and economic mechanisms (Burger et al. 2000).

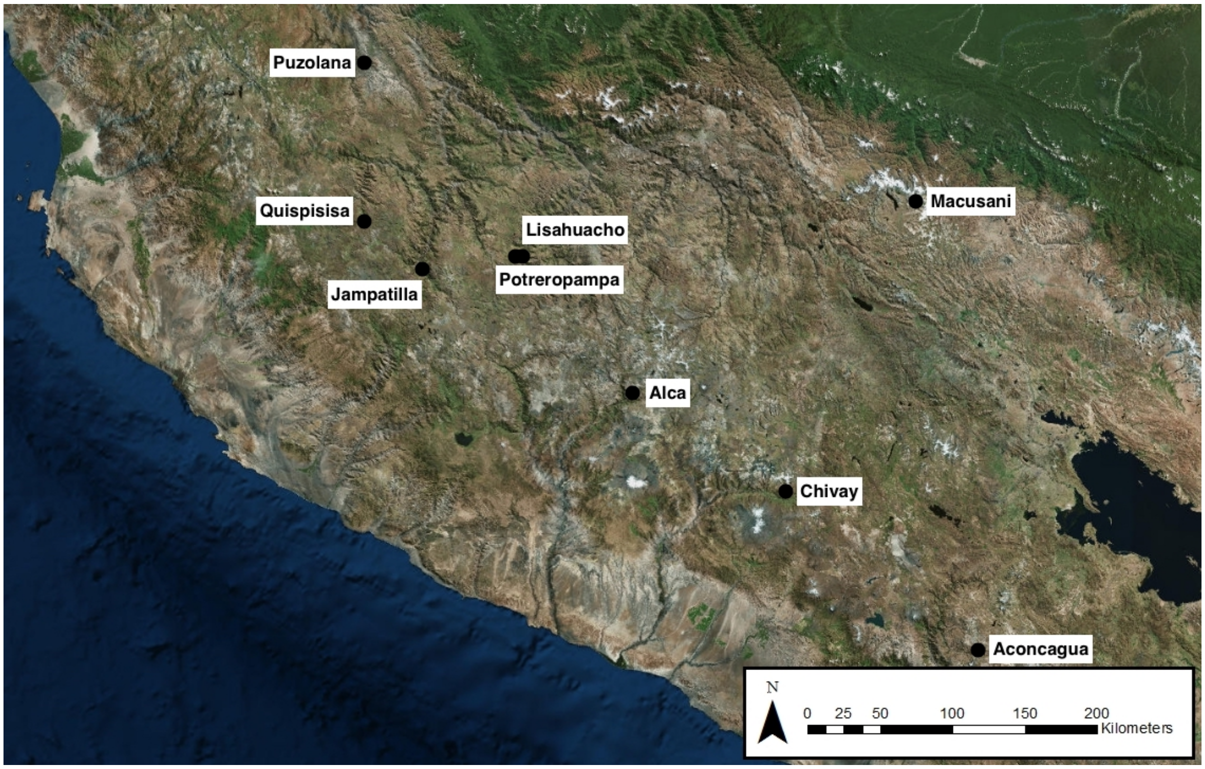


Figure 5.3. Map of Obsidian Sources in the Central Andes.

Quispisisa

The Quispisisa source, although originally thought to be located in the Department of Huancavelica, is located in the province of Huanca Sancos, approximately 100km south from the present-day city of Ayacucho, in the Department of Ayacucho (Burger and Asaro 1979; Burger and Glascock 2000). The word “Quispisisa” is derived from the Quechua word for “glassy (or crystal) stone”. The source itself is part of the Grupo Barroso formation dating to the Pleistocene epoch, approximately 2.5 million years ago. The formation is composed of lavas with volcanic breccia, a type of sedimentary rock composed of broken fragments of rocks and minerals formed during volcanic eruptions, and is overlying the Castrovirreyna formation dating to the Lower Miocene (Castillo et al. 1993; Tripcevich and Contreras 2011). The Grupo Barroso deposits in the region extend 19km north from the source location to the present-day town of Huanca Sancos. At this northern extent of the formation it is possible to find obsidian nodules, although they are usually smaller than 5cm at maximum dimension. The size of the nodules increases with proximity to the source, with nodules at the Jichja Parco quarry (located at the heart of the Quispisisa source) reaching up to 35cm in maximum dimension. Because nodule size is greatest at Jichja Parco, this quarry would have been the primary location from which to obtain obsidian for production (Tripcevich and Contreras 2011). The obsidian, while usually black in color, can occasionally have a red hue (Tripcevich 2007).

The quarry deposits at Jichja Parco have been identified by Tripcevich and Contreras (2013) as "doughnut quarries", characterized by their doughnut-like shape. "Doughnut quarries" are usually evidence of either 1) continuous, low-intensity quarrying activities conducted over a substantial period of time, or 2) coordinated, short-term, intensive exploitation (Tripcevich and Contreras 2013). In addition, within and around the Jichja Parco quarry, there is limited evidence for lithic reduction (Tripcevich and Contreras 2011). For Tripcevich and Contreras (2011), this suggests that obsidian nodules were selected from the quarry, minimally worked, and then transported to be further reduced and refined at another location. One possible zone of production, identified by Tripcevich and Contreras (2011) during their survey work and excavations in the region surrounding the quarry, is the town of Colcabamba, located 15km north of the source (just 4km south of Huanca Sancos). Despite lying within the Groupo Barroso formation, the quantity of obsidian within the present-day town and surrounding archaeological sites is more than natural accumulation. Colcabamba is located at an elevation of 3,350 masl, and is the closest region to Quispisisa that would have supported both herding and agricultural (maize, in particular) activities, and a sedentary population. The largest archaeological site in the area, Marcamarca, is characterized by an atypically large collection of obsidian from both surface and excavation contexts (Tripcevich and Contreras 2011).

Quispisisa-type obsidian was first identified through elemental studies at the Lawrence Berkeley Lab at the University of California Berkeley, and was found to account for approximately 90% of all obsidian (from the sampled material) from archaeological sites in central and northern Peru (Burger and Glascock 2000; Burger and Asaro 1978). Obsidian artifacts from Quispisisa have been documented at sites in the Ayacucho region and elsewhere as early as 15,000 BP, nearly contemporaneous with the peopling of South America (MacNeish et al. 1980). By 13,000 BP, Quispisisa obsidian was routinely traveling to sites at distances well-over 100km from the source. For example, Quispisisa obsidian has been found in the archaeological record at the Preceramic sites of Uchkumachay in the Jauja-Huancayo region (200km north) and Hacha in the Acari valley (156km southwest) (Burger and Glascock 2000; Tripcevich and Contreras 2011). By 6,500 BP, Quispisisa obsidian was traveling distances over 400km to sites like Paloma in the Chilca Valley (central coast), and San Nicolas in the Nasca region (south central coast) (Quilter 1989; Burger and Asaro 1978; Vaughn and Glascock 2005). By the Early Horizon, obsidian from Quispisisa was making its way to sites located at distances over 500km, at sites like the ceremonial and pilgrimage center of Chavín de Huantar (590km north) and Pacopampa (1,000km north) (Burger and Glascock 2000; Tripcevich and Contreras 2011; Burger and Mendieta 2002). Not only was obsidian from Quispisisa traveling such distances, but it was doing so in large quantities. At

Chavin, 95% of the obsidian found from the ritual center has been sourced to Quispisisa (Burger and Glascock 2000). By the Middle Horizon, Quispisisa obsidian was traveling distances of 800km to sites like San Jose de Moro, Marca Huamachucho and Ancash on the north coast (Lau 2002). While the full distribution and extent of Quispisisa obsidian is still being studied, it is clear that it was both widely utilized and widely distributed in prehistory. Prior to the Middle Horizon, populations were likely acquiring Quispisisa obsidian through seasonal transhumance and *ayllu* exchange systems of vertical ecology (Eerkens et al. 2010; Vaughn 2006).

Alca

The Alca obsidian source (2,850 masl), located in the Cotahuasi Valley in the department of Arequipa, was first identified in geochemical sourcing studies as "Cuzco-type" obsidian (Burger et al. 2000; Burger et al. 1998). Within the Cotahuasi Valley, only 5% of the volcanic deposits are actually obsidian, and of those, only Cerro Aycano produces high-quality obsidian (quality in a region can differ due to varying rates of hydration and crystallization). Cerro Aycano is, therefore, the source location for Alca-type obsidian (Jennings and Glascock 2002; Burger 1998). Alca obsidian can range in color from black to brown, with occasional blue hues (in comparison to the often red hue of Quispisisa obsidian), and nodules from the Alca source can measure up to 30cm in maximum dimension (Jennings and Glascock 2002).

Like Quispisisa, the Alca source has been used consistently over the past 13,000 years. Some of the earliest evidence of prehistoric populations using obsidian form the source is found at sites like Quebrada Jaguay (11,105–9,850 BP), located over 130km from the Alca source, on the southern coast of Peru at an elevation of 40 masl (Sandweiss et al. 1998; Jennings and Glascock 2002). Similar to the average distance traveled by Quispisisa obsidian in early prehistory (260.3km), Alca obsidian was traveling distances of, on average, 249.6km (Tripcevich 2007). Despite the prevalence of Alca obsidian outside of the Cotahuasi Valley as early as 11,000 BP, the valley was only occupied beginning in the Middle and Late Archaic periods, meaning that prior to the Middle and Late Archaic periods people were specifically traveling to the Alca source to acquire obsidian (Jennings and Glascock 2002).

Extraction patterns at the Alca source suggest long-term, low-intensity extraction. The exception to this is found during the Middle Horizon, when extraction at the source increases, concurrent with an increase in the distance at which obsidian travels (Burger and Asaro 1979; Burger et al. 2000). Prior to the Middle Horizon, Alca obsidian was used predominantly in the Cuzco and Arequipa regions, but during the Middle Horizon, Alca obsidian is found at Wari sites like Jincamocco and Huari in the Ayacucho heartland, Marca Huamachucho on the north coast and Cerro Baul in the southern Moquegua region (Jennings and Glascock 2002). The increase in distance and use of the Alca source during the Middle Horizon led to assumptions that Alca obsidian was part of a Wari-controlled economy. Jennings and Glascock (2002), however, suggest that the Alca source would have been difficult to control (as would all obsidian sources). Large obsidian deposits scattered over a wide geographical source location, coupled with the intersection of numerous well-utilized trails, terraces, irrigation canals and long-occupied villages, would have required significant investment on behalf of the Wari in order to regulate access to the source. Jennings and Glascock (2002) argue that there is no archaeological evidence to suggest that Wari interfered in the region with the level of infrastructure that would have been necessary to control the Alca source.

Chivay

The Chivay obsidian source is located 175km to the NW of Lake Titicaca, at an elevation of 4,000-5,000 masl. The Chivay source was first identified in sourcing studies as "Titicaca-type" obsidian (Burger et al. 2000). Nodules from Chivay can reach lengths up to 30cm, with the highest-quality area of the source found at the Hornillo sector of the quarry (Tripcevich and Mackay 2011). Obsidian from Chivay is high-quality, and often black to light grey with occasional banding (Tripcevich 2010; Tripcevich 2007). Burger et al. (2000) consider obsidian from both the Chivay and Alca sources to be visually indistinguishable.

Evidence of early use of Chivay obsidian can be found at sites like Asana, in the southern central highlands from the Early Archaic period (8,200 BP) (Tripcevich and Mackay 2011; Aldenderfer 1998). Within the Titicaca Basin, approximately 90% of the obsidian used in prehistory is estimated to be from Chivay (Tripcevich 2007). Intensified extraction and use of the Chivay source is linked to the intensification of pastoralism and the domestication of camelids in the high-puna pasturelands in the region surrounding the quarry. Llamas were domesticated around 6000 BP (Wheeler et al. 1995), and Tripcevich (2007) links camelid domestication to the increased extraction and production of Chivay obsidian. Camelids would have been heavily involved with obsidian trade, as camelids were the only beasts of burden in the Andes, and would have been used to transport larger quantities of obsidian. Tripcevich (2007) suggests that llama herders would have circulated obsidian from Chivay as part of their seasonal migrations. In addition, camelid pastoralists would have required a sharp tool like obsidian in order to work with hides, meat and wool. Tripcevich's (2007) hypothesis is further supported by the presence of obsidian found in burials in the region by 5,500BP, with obsidian found alongside other status objects like gold pendants and lapis lazuli (Craig 2005).

Potreropampa and Lisahuacho

The Potreropampa and Lisahuacho sources, previously known as Andahuaylas type-A and Andahuaylas type-B obsidian, are located in the Province of Aymaraes in the Department of Apurímac. Both Potreropampa and Lisahuacho are high-quality obsidian sources, with minimal hydration and low crystallization, and with nodules reaching sizes up to 10-15cm in maximum dimension at Potreropampa and 9-12cm at Lisahuacho (Burger et al. 2006). The regions surrounding the source have been occupied continuously since the Preceramic period through the Late Horizon (Fajardo 1998). Potreropampa obsidian (and secondarily Lisahuacho) is the dominant source type in the neighboring Andahuaylas and Chicha-Soras regions throughout prehistory, but is rarely utilized outside of the Department of Apurímac, with a few exceptions (Burger et al. 2006). Potreropampa has occasionally been found outside of the region at Early Horizon sites like Hacha in Acarí and Chavín de Huantar in the north (Burger et al. 2006). And during the Early Intermediate Period, Potreropampa is found in assemblages in Nasca (Eerkens et al. 2010; Vaughn and Glascock 2005). By the Middle Horizon, Potreropampa is found in Moquegua at sites like Cerro Baul (Burger et al. 2000). In contrast, Lisahuacho is never found outside of Apurímac. Even within the region, Lisahuacho is utilized secondarily to Potreropampa. This preference for Potreropampa in the region changes during the Late Intermediate Period following the collapse of the Wari Empire, when Lisahuacho becomes the dominant source in the region (Kellett et al. 2013).

Jampatilla and Puzolana

The Jampatilla and Puzolana sources are located in the Ayacucho region, with Jampatilla located approximately 125km south of the Wari capital and Huari, while Puzolana is located just north of the capital (Burger et al. 1998b). Despite being located near to the capital, obsidian from Puzolana rarely makes it outside of the Ayacucho heartland, both before and during the Middle Horizon (Burger et al. 2000). One possible explanation for this is the fact that Jampatilla and Puzolana are both regarded as lesser-quality sources (Burger et al. 2000). Both Jampatilla and Puzolana are characterized by relatively smaller nodules, averaging only 5cm in maximum dimension (although Puzolana can occasionally reach larger sizes) (Schreiber pers. comm.). This is minuscule compared to the 30cm lengths found at Quispisisa, Alca and Chivay and the 15cm lengths found at Potreropampa and Lisahuacho (Burger et al 2000).

Although not transported outside of the region, Puzolana was heavily utilized by populations living in the Ayacucho heartland as early as the Preceramic period, during the local Puente phase (10,950–9,050 BP) (Burger et al. 2000). In general, Puzolana comprises 18% of the obsidian assemblage from sites in the Ayacucho basin prior to the Middle Horizon (Burger et al. 2016). Jampatilla obsidian has been found outside the Ayacucho heartland in limited frequencies on the south coast, at sites like Hacha in Acarí during the Initial period (3750–2750BP). The absence of obsidian from Chivay and Alca sources at central south coast sites like Hacha, in favor of obsidian from Quispisisa, Jampatilla and

Puzolana, suggests that these source groupings likely operated within different interaction spheres (i.e., northern and southern interaction zones) (Burger et al. 2000). There are, however, shared ceramic forms and iconography between the proposed northern and southern interaction zones. This leads Burger et al. (2000) to suggest that pottery and obsidian were distinct mediums with different mechanisms operating in the production, distribution and consumption of each medium (Burger et al. 2000).

IV. Middle Horizon Obsidian in the Ayacucho Valley

> "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 a matter of weight or value, but rather a question of consistency and changes in the proportions of particular sources utilized over time" (Tripcevich 2007: 196).

As stated by Tripcevich (2007), an exploration of the use of obsidian by the Wari Empire during the Middle Horizon necessitates an understanding of diachronic changes in distribution and consumption patterns both in the Wari heartland and in the hinterland.

Conchopata

Conchopata, the closest site to the Wari capital at Huari (and presumably second-most important Wari site), has a very different pattern of obsidian consumption during the Middle Horizon than that found at Huari. Burger et al. (2016) analyzed 93 samples from Middle Horizon contexts at Conchopata and found that 99% of the obsidian could be sourced to Quispisisa and 1% to Puzolana. While Puzolana was used throughout the entire Ayacucho Basin prior to the Middle Horizon (comprising 18% of the obsidian consumed), it experienced a dramatic decrease from 18% to 1% during the Middle Horizon. The use of Puzolana obsidian at Conchopata (even minimally) is not surprising, as the source is very close to the site (less than 20km). In contrast, Quispisisa dominates the assemblage at Conchopata, but also would have required a journey of approximately five days using camelids (Burger et al. 2016). Despite the increased effort it would take to procure and transport obsidian from Quispisisa, Bencic and Glascock (2016) documented that obsidian was used relatively inefficiently at the site. Simply put, while some expedient obsidian tools were being reused by the population at Conchopata, most tools and artifacts were simply discarded after their initial period of use. Bencic and Glascock (2016) interpret this behavior as evidence that the population at Conchopata may have believed that obsidian was a reliable resource, readily available and in unlimited quantity. This is further supported by the fact that Bencic and Glascock (2016) found that lithic manufacture was not taking place at Conchopata (save for minor retouching), implying that bifaces and other tools were being produced elsewhere and imported to the site as already finished products.

Bencic and Glascock (2016) analyzed over 1,000 obsidian artifacts (primarily debitage) and found that the point types were typically lanceolate in body, with both straight and convex bases. These point types correspond to Vining's "Types D and F" (Vining 2005). Vining (2005) identified "Type D" bifaces (lanceolate bodies with straight bases) as the "Wari-type" (see Figure 5.2). Wari-type bifaces are generally larger (up to 10cm or longer at maximum dimension), and are usually produced from Quispisisa obsidian. The correlation between Quispisisa obsidian and Wari-type bifaces may be due to the naturally larger sizes of Quispisisa nodules (up to 30cm in length). At Conchopata, Bencic and Glascock (2016) identified 13 complete Wari-type points ranging in size from 2.4cm to 11.6cm. These points would have naturally required the use of Quispisisa over Puzolana in order to produce the larger dimensions. However, the smaller artifacts found at the site (triangular points, ovoid tools, biface preforms and retouched flakes and tools) could have been constructed from Puzolana, but were not. The preference for Quispisisa obsidian over Puzolana, therefore, was not simply a matter of "function".

In addition to bifaces, Bencic and Glascock (2016) identified seven possible biface preforms corresponding to Vining's "Type J" (Vining 2005). These preforms were similar in dimension to the finished bifaces, but more irregular in shape. The debitage found at Conchopata was sorted based on size-grade categories, with the expectation of waste from biface production, which results in debitage measuring between 6.35mm to 12.7mm (anything smaller falls through the standard 0.25in screen) (Bencic and Glascock 2016). Only 5% of the debitage at Conchopata is smaller than 12.7mm, suggesting that very minimal production was being conducted at the site. This is further confirmed by examining the cortex, terminations, and platforms of the debitage (Bencic and Glascock 2016). Cortical pieces (exterior of the rock) of debitage are linked to earlier production phases and the preparation of blanks (Kooyman 2000; Odell 1989). Only 21% of flakes larger than 25.44mm at Conchopata had a cortical surface, suggesting that only limited amounts of early-phase preparation of tools, as well limited amounts of blank preparation, were occurring at Conchopata. Flake terminations (the distal portion of a flake) can be a relative estimate for the experience-level of the producer, particularly for obsidian due to its easy and predictable fracture mechanics (Bencic and Glascock 2016). 56% of the flakes with terminations were feathered (reflecting experience), while 44% of the flakes with terminations were stepped or hinged. Stepped and hinged terminations are often the result of inexperience, causing fractures in the flake due to improper technique (incorrect striking angle and force applied). Flake striking platforms (where the striking implement hits the objective piece) can be a reflection of the type of tool being produced. Bifaces, because they are more heavily worked, often have complex or abraded platforms (Bencic and Glascock 2016). At Conchopata, complex and abraded platforms are only found on 44% of the obsidian flakes.

The lack of source diversity at Conchopata, coupled with the importation of completed obsidian tools, the limited production occurring in-situ, and the preference for discard over reuse of tools, suggests that Conchopata was part of an obsidian distribution network (Bencic and Glascock 2016). Conchopata relied almost entirely on obsidian from Quispisisa, leading Burger et al. (2016) to conclude that the site was likely not a cosmopolitan city, but was acquiring its obsidian through a controlled or a singular distribution channel. In comparison, the capital of Huari had a relatively greater obsidian source diversity, indicating that perhaps Huari was more cosmopolitan in nature, or that the distribution mechanism for obsidian operated differently for each of the Wari heartland sites. In addition, the distribution channel may may originate outside of the Huari heartland (whether by Wari control or not), and a different "order" is delivered to Huari than is delivered to Conchopata.

Huari

In 1977, Burger and Asaro conducted a geochemical sample of 52 obsidian artifacts from Huari. 50 artifacts (96%) were sourced to Quispisisa, 1 artifact (2%) was sourced to Potreropampa and 1 artifact (2%) was sourced to Alca (Burger and Asaro 1977). This distribution is relatively more diverse than the assemblage examined by Glascock et al. (2016) from Conchopata. Similar to the consumption pattern at Conchopata, Quispisisa is the overwhelmingly dominant source-type within Huari samples. This is in contrast to the distribution of obsidian in the region prior to the Middle Horizon (Burger et al. 2016). Prior to the Middle Horizon, Puzolana obsidian was used in relatively greater frequency. From a sample of 80 artifacts from pre-Middle Horizon sites in the Ayacucho Valley, 15 artifacts (18.75%) were sourced to Puzolana (Burger et al. 2016). This is in stark contrast to the Middle Horizon, where the local Puzolana source is conspicuously absent from Huari, despite its close proximity and occurrence (even in limited quantities) at Conchopata. The presence of Alca and Potreropampa obsidian at Huari indicates a widened interaction sphere during the Middle Horizon, and their absence at Conchopata might suggest that Huari was much more of an operational hub or cosmopolitan capital than was Conchopata. Despite the increased obsidian source diversity, Huari had a production pattern similar to that at Conchopata—it was not a location for intensive obsidian production (Stone 1983).

Stone's (1983) dissertation examined 921 obsidian artifacts from surface collections at Huari to explore activity specialization and production patterns. Stone (1983) found that while there was specialized activity at the site based on material type (e.g., obsidian vs. andesite), there was no evidence for obsidian production workshops. Furthermore, she found a strong co-presence of ceramics and obsidian within shared contexts (Stone 1983). The mean length for bifaces at Huari was 2.3cm (similar to the dimensions of bifaces found at Conchopata). Flakes at Huari had a mean length of 18mm and width of 12mm (Stone 1983). These dimensions pertain to Bencic and Glascock's (2016) second size-grade category, implying that there was minimal production of bifaces occurring at the site of Huari.

Stone (1983) also addressed changes in obsidian production through different temporal phases at Huari and found that during the Early Intermediate Period or Huarpa phase of the site, imported materials (Puzolana and Quispisisa are considered local) were used sparingly. During the Middle Horizon, obsidian use increases to comprise 48% of the entire lithic assemblage, with a concurrent decrease in the production of tools at the site itself. This implies that obsidian became an important and heavily utilized resource during the Middle Horizon, but was not in large part produced by the population living at Huari. Apart from Stone (1983), Burger and Asaro (1977) and Burger et al. (2000), very little analysis of both obsidian and lithics in general have been conducted at Huari.

V. Regional Distribution of Obsidian in the Middle Horizon

The Quispisisa source is routinely recognized for having the greatest distribution of all obsidian sources during the Middle Horizon (Burger et al. 2000). This widespread use may account for the "doughnut quarries" identified by Tripcevich and Contreras (2011) at the Quispisisa source; a result of short-term, intensive exploitation on behalf of the Wari Empire. The Qhapaq Ñan (Inca road) was, in large part, constructed over top of previous Wari roads, and its route takes a traveler just across the Caracha river from the Jichja Parco quarries at Quispisisa. From Quispisisa, a traveler could continue on their journey from Ayacucho to Nasca and the south coast. The large nodules found at Quispisisa have been suggested as a possible rationale for investment at the Quispisisa source and the correlation between Quispisisa and large Wari bifaces seems to confirm this. Wari-type bifaces are among the largest found in the Andes, measuring 10cm in length on average, and are always associated with Wari contexts. Wari-type bifaces have been found at sites like Huari, Conchopata, Cerro Baul, Pikillata, Jincamocco and other Wari administrative centers, and are commonly produced from Quispisisa source-type obsidian (Tripcevich and Contreras 2011). One possible explanation is that as large Wari-type lanceolate bifaces with straight bases (Vining's "Type D") spread as a component of Wari ideology/iconography, their movement brought with them the increased movement of Quispisisa obsidian, in general. Part of understanding the increased movement and distribution of Quispisisa obsidian is understanding how this distribution correlates with earlier hinterland distribution and consumption patterns of both Quispisisa and other obsidians source-types.

Central Highlands

The Andahuaylas region, within the Department of Apurímac, was closely associated prior to the Middle Horizon with the Potreropampa and Lisahuacho obsidian sources and experienced a fairly dramatic shift in the distribution of obsidian concurrent with the expansion of the Wari Empire. While the region predominantly relied on obsidian from Potreropampa and Lisahuacho, Quispisisa obsidian comprised approximately 5% (n=1) of the assemblage as early as the Muyu Moqo phase, spanning the Initial Period through the Early Horizon. During the Muyu Moqo phase, Potreropampa comprised 75% (n=15) of the sample and Lisahuacho 5% (n=1) (Kellett et al. 2013). A similar pattern is found at multiple sites across the Andahuaylas region, including the sites of Waywaka and Qasawirka. In a representative sample from all temporal phases, Potreropampa obsidian represented 53% (n=50), Lisahuacho represented 21% (n=20), Quispisisa represented 12% (n=11) and Jampatilla represented 6% (n=6) of the sample (Kellett et al. 2013). In addition, a single Alca flake has been found at the site of Waywaka, suggesting that even marginally, southern Andean interaction spheres may have been part of the Andahuaylas region prior to the Middle Horizon (Burger et al. 2000).

By the Middle Horizon, Quispisisa obsidian makes up 23% (n=5) of the assemblage from the Andahuaylas region, while the reliance on the Potreropampa source drops from 75% to 63% of the sampled material (Kellett et al. 2013). This difference is notable, in that obsidian from Quispisisa would have required an additional several days of travel when compared to acquisition of obsidian from the Potreropampa source. Furthermore, the nodules at Potreropampa would have been sufficiently large enough to create the “Wari-type” larger bifaces, indicating that the shift to Quispisisa wasn’t solely about “functionality”. Following the Middle Horizon, the use of Quispisisa obsidian in the region decreases to comprise only 12% of the assemblage, and the local source of Lisahuacho jumps from 0% during the Middle Horizon to 37% (n=19) in the Late Intermediate Period (Kellett et al. 2013). Despite the fact that during the Middle Horizon, local sources were still the predominant source-types of obsidian used in the Andahuaylas region, there is a statistically significant increase in the consumption of Quispisisa obsidian during the Middle Horizon, and a subsequent decrease in its use after the Wari Empire collapses (Kellett et al. 2013).

The decreased reliance on Potreropampa obsidian in favor of Quispisisa obsidian in the Andahuaylas region during the Middle Horizon is not found, however, in the neighboring region of Chicha-Soras (Department of Apurímac), which, like its neighbor, also heavily relied on Potreropampa and Lisahuacho obsidian prior to the Middle Horizon (Kellett et al. 2013). At the site of Chiqna Jota in the Chicha-Soras region, excavated by Frank Meddens (1985), Burger et al. (2006) found that the use of obsidian during the Middle Horizon was exclusively sourced from Potreropampa or Lisahuacho obsidian, not from Quispisisa. Because Chicha-Soras and Andahuaylas are neighboring regions within the Department of Apurímac, with similar obsidian distribution patterns prior to the Middle Horizon, why would their obsidian distributions be different during the Middle Horizon? While this result may be due to the small sample size (n=2), it may also be due to differing relationships with the Wari Empire. Furthermore, the site of Chiqna Jota is built in a Wari architectural style, an attribute that is closely associated with proposed imperial control over the region and the valley's capacity for camelid herding (Meddens 1985). Why was obsidian from Quispisisa not brought to Chiqna Jota and the Chicha-Soras region, as it was to other territories under imperial control? And why would Andahuaylas, with no evidence of Wari imperial architecture or direct control, show a significant influx in Quispisisa obsidian? One answer may be the the use of Andahuaylas as a route from Ayacucho to Cusco.

Another region neighboring the Chicha-Soras and Andahuaylas regions is the Sondondo Valley, home to the Wari administrative center of Jincamocco. The Sondondo Valley is located only 48km from the Quispisisa source, only one to two days travel (Schreiber, in press). It is unsurprising, therefore, that Quispisisa makes up a relatively larger percentage of the obsidian collection throughout prehistory. In 1974, William Isbell, Katharina Schreiber, and Patricia Knobloch collected 70 obsidian artifacts from four sites in the valley spanning the Formative through Late Intermediate Period in the region. These samples were analyzed by Burger and Asaro (1979), who found that 47.14% (n=33) of the obsidian was sourced to Quispisisa, while 42.85% (n=30) was sourced to the local Jampatilla source (previously known as the Pampas source). Only two pieces of obsidian within the Sondondo Valley were sourced to Potreropampa, from the sites from Caniche and Corralpata.

And all five of the obsidian artifacts sourced to Alca were from the Wari administrative site of Jincamocco (Schreiber, in press).

The site of Jincamocco, although occupied in earlier temporal periods, was transformed into a Wari administrative center at the onset of the Middle Horizon. The importance of Jincamocco within the Wari network was evidenced by its location on a Wari road to the Southern Nasca Region, and by the fact that it was expanded by the Wari during the later Middle Horizon (Schreiber 1987; Schreiber and Edwards 2014). Of the 33 obsidian pieces sourced to Quispisisa, 24 (72.72%) were from the site of Jincamocco. In addition, the Wari established the site of Mamacha Coral nearby to the Jampatilla source, possibly for prohibiting local access, or to capitalize on the the source themselves. Despite the location of Mamacha Coral, there is still a heavy reliance on the Quispisisa source within the Sondondo Valley during the Middle Horizon.

Southern Nasca Region

The only region that doesn't experience a major shift in the pattern of obsidian distribution during the Middle Horizon is the Southern Nasca Region (SNR). Quispisisa was routinely used in the SNR as early as the Early Archaic and was, consistently throughout prehistory, the dominant source-type in the region (Eerkens et al. 2010). In fact, Quispisisa was used almost exclusively at sites in the region with few exceptions (Potreropampa, Jampatilla, Lisahuacho) during the Middle and Late Archaic, Early Nasca, and Late Intermediate periods. This is not entirely surprising as Quispisisa is the closest source to Nasca (100km). Obsidian from the Potreropampa source was imported as finished tools, while obsidian from Quispisisa was more likely to have been brought in as preforms and finished at regional Nasca sites (Vaughn and Glascock 2005). The Middle Horizon in Nasca shows a distribution pattern of exclusively Quispisisa obsidian (Eerkens et al. 2010).

Prior to the Middle Horizon, Potreropampa obsidian was found almost exclusively in Apurímac and the SNR, while Quispisisa obsidian had a greater distribution as early as the Formative period. The early use of Potreropampa obsidian in the SNR, coupled with Quispisisa obsidian, may suggest a connection between the Apurímac region and the SNR that pre-dates the Middle Horizon. Drawing on the prehistoric Andean economy centered on vertical ecology, it is possible that these two regions were engaged in *ayllu*-based, or even resource-motivated exchange systems. This is further supported by the fact that all of the Potreropampa points (across all time periods) recovered in the SNR are found in the Tierras Blancas valley, the same valley from which the Wari road network connects to the central highlands. In fact, of the Potreropampa material recovered in the SNR, 83% are points, and 66% are found above 1000 masl, further suggesting a link to vertical ecology and the acquisition of higher-elevation resources (Eerkens et al. 2010). The Wari administrative site of Pataraya lies within the upper limits of the Tierras Blancas valley suggesting that it was possible that populations were traversing the same set of pathways from the coast to the mountains prior to the Middle Horizon, and that pathways were only formalized by the Wari into what we now consider to be Wari roads. If so, this would place the SNR in the central highland interaction zone, within which the SNR, Ayacucho, Sondondo and Apurímac regions were utilizing (and possibly sharing/exchanging) obsidian from the Quispisisa source while southern interaction zones would have operated around the sources of Alca and Chivay (Burger et al. 2000).

If these four regions were part of the same interaction sphere prior to and during the Middle Horizon, and were connected through a system of long-term resource exchange relationships, this may explain why regions such as Chicha-Soras, that we would expect based on proximity to these regions to have the same obsidian distribution pattern, falls outside of expectation. The long-term existence of trade networks has been proposed to stem from demand for "relatively commonplace items that were unavailable locally" (Smith 1999: 61; Tripcevich 2010). Obsidian is, in fact, one of the most consistently transported materials throughout the entire prehistory of the Andes, and its limited occurrence would have necessitated the formation of exchange relationships built around this durable and incredibly useful material.

Cusco

At the site of Pikillacta, a Wari administrative outpost in the Cusco region, eight flakes (of a sample of nine) sampled by Burger and Asaro (1977) were sourced to Quispisisa. The distance from the Quispisisa source to the site of Pikillacta is over 280km, the equivalent of roughly eight days of travel (Kellett et al. 2013). Prior to the Middle horizon, Quispisisa was imported into the Cusco region in more limited quantities, but by the Middle Horizon, 41% of the obsidian from sites in the region was from Quispisisa (n=13), while 28% (n=9) was sourced to Alca, 3% (n=1) to Potreropampa and 3% (n=1) to Jampatilla (Burger et al. 2000). In sum, this means that roughly 50% of the obsidian from the Cusco region during the Middle Horizon was sourced from the Ayacucho region and central highland interaction sphere. This is in contrast to the Early Horizon and Early Intermediate Periods in Cusco where over 87% of the obsidian is sourced to Alca (and the southern interaction sphere), and no Quispisisa obsidian was present in the sample (Burger et al. 2000).

At the site of Huaro in the Cusco region, a proposed colonial outpost for Wari migrants to the region, Quispisisa represents the primary obsidian source at 60.38% of the assemblage (n=32), Alca represents 24.53% (n=13), and Chivay represents 9.43% (n=5) (Skidmore 2014). The presence of Quispisisa obsidian Huaro is in relatively greater proportion to the representation of Quispisisa obsidian across all Middle Horizon sites in the Cusco region (41%) (Burger et al. 2000). This may be due to the fact that Skidmore (2014) found that much of the material culture and architectural construction at Huaro was reminiscent of local Ayacucho lifeways, and suggested that residents of Huaro likely moved into the Cusco region from the Ayacucho Valley, possibly bringing with them knowledge of and access to Quispisisa distribution networks.

Moquegua

The Moquegua region, located on the very southern coast of Peru, is an important region for studies of the Middle Horizon, as the region was active within both the Wari Empire and the Tiwanaku interaction spheres. The site of Cerro Baul, with its prominent plateau, is one of the most intensively studied Middle Horizon sites from the region. Obsidian found at the Middle Horizon component of Cerro Baul has been sourced by Burger and Glascock (2000) and by Williams et al. (2012). The sample analyzed by Burger and Glascock (2000) was sourced to Chivay (79%), Alca (8%), Quispisisa (8%), and Potreropampa (8%). In other words, 16% of the obsidian found at Cerro Baul was moving into Moquegua from the Ayacucho region and central highland interaction sphere. Williams et al. (2012) analyzed obsidian from several contexts: 1) palatial residences on the summit; 2) specialist residences adjacent to the palatial residences; 3) two D-shaped temples; and 4) Wari residences located on the underlying terraces. The authors found that the obsidian was sourced to Alca (86%), Quispisisa (8%) and Chivay (4%) (Williams et al. 2012). Most interesting to their analysis was the identification of five points on the north-slope residences that were exclusively sourced to Chivay. This statistically significant pattern suggests that certain point-types or source-types, may have been connected to status, whether that be class, imperial identity, or other (Williams et al. 2012). This also may explain why Alca dominated the assemblage sourced by Williams et al. (2012), and Chivay the assemblage sourced by Burger and Glascock (2000).

Also in the Moquegua region, the site of Cerro Mejia has a similar obsidian distribution pattern to that found by Williams et al. (2012) at Cerro Baul, with 80% of the obsidian coming from Alca and 20% from Quispisisa. The representation of obsidian from Quispisisa is greater at the site of Cerro Mejia than it is at Cerro Baul. Another site in the region, Mejia Ladera has an even greater relative representation of obsidian from Quispisisa. At Mejia Ladera, 55% of the obsidian was sourced to Alca, 38% to Quispisisa and 1% to Chivay (Williams et al. 2012). Mejia Ladera was occupied during the early Middle Horizon during the initial phase of Wari expansion and it was abandoned relatively early, prior to the collapse of the Empire in AD 800. If Mejia Ladera represents an initial program of imperial expansion (through Wari-style bifaces), this may account for the larger quantity of Quispisisa obsidian present at the site, when compared to neighboring sites in the region like Cerro Mejia and Cerro Baul.

VI. Concluding Remarks

This chapter explored previous studies examining the regional distribution and consumption of obsidian throughout the prehistory of the Andes and in the Middle Horizon, more specifically. Several patterns emerge from a close examination of the data. First, highlighted in the analyses is a likely regional separation between the central highland and southern interaction spheres, linking Ayacucho, the Southern Nasca Region, Apurímac and Sondondo in a central highlands network, and the Titicaca Basin, Cusco, Moquegua and Arequipa into a southern network. Throughout most of prehistory these regions generally utilized obsidian from within their own networks, relying on the major high-quality obsidian sources of Quispisisa in the central highlands, and Chivay and Alca in the south. Second, prior to the Middle Horizon, there may have been long-established relationships, likely based on obsidian trade routes (among other elevation-specific resources) and the vertical ecology of Andean economic systems, that linked these regions within their respective interaction spheres. As one of the most ubiquitously transported materials that is only available in nine locations throughout the entire southern Andes, obsidian has a 13,000-year history of transportation and presence within exchange systems (Tripcevich 2007).

Third, during the Middle Horizon, the distribution of Quispisisa obsidian dramatically increases. Quispisisa is the closest high-quality source to the Wari capital, and its transportation to distant locations, and often its replacement of local sources, has been linked to projects of imperial expansion (Burger et al. 2000). But in addition to Quispisisa obsidian, the Potreropampa obsidian source (and to a lesser extent the Jampatilla source) also shows an increased distribution pattern, reaching sites like Cerro Baul in Moquegua and Pikillacta in

Cusco. Both regions did not use obsidian from Potreropampa or Jampatilla prior to the Middle Horizon. And fourth, Quispisisa (consumed both in the hinterland and in the Wari heartland) appears to have been produced in a location other than where it was consumed. Stone (1983) and Bencic and Glascock (2016) find that Quispisisa obsidian was generally not produced nor retouched at the Wari heartland sites of Conchopata and Huari, suggesting an alternate location for the production of obsidian tools. This pattern is similar in hinterland regions farther from the source as well. Tripcevich and Contreras (2011) suggest a possible production location near the Quispisisa source itself, in the region of Huanca Sancos. Further research is necessary to verify the extent of this production. This chapter attempts to explore the distribution and consumption of obsidian at the Huari capital itself to explore patterns connecting the heartland and more distant regions in obsidian transport, trade and consumption. The next several chapters will address original data collected and analyzed from the site of Huari, and a provide a discussion of how this data fits in with the pre-existing patterns.

CHAPTER 6

METHODS

The analyses for this dissertation derive from a sample of 628 obsidian artifacts from the 2012 excavations of the Vegachayuq Moqo sector of Huari, conducted by Dr. Jose Ochatoma Paravicino, Licenciada Martha Cabrera, and Licenciado Carlos Mancilla Rojas. All artifacts were analyzed in collaboration with the archaeology lab at the Universidad Nacional de San Cristóbal de Huamanga (UNSCH), Ayacucho, and all x-ray fluorescence analyses were conducted in Lima. This chapter presents a background and history of x-ray fluorescence analysis and its use in archaeology, as well as elaborates on sampling strategies, laboratory methods, and sourcing analyses conducted for this dissertation.

I. X-Ray Fluorescence

X-ray fluorescence (XRF), although currently a popular method for archaeological research, has only recently been made more readily available to researchers after little more than a century since the discovery of the x-ray in 1901 by German physicist Wilhelm K. Röntgen. While the x-ray was quickly utilized within physics, it wasn't until the early 1960s that scholars from the University of California Berkeley began to use XRF for geological and anthropological analyses. The first published XRF analysis of obsidian within an archaeological context was published in 1968 by Robert Jack and Robert F. Heizer from UC Berkeley (Shackley 2011). XRF soon became comparable to other methods of compositional analysis, such as Neutron Activation Analysis (NAA), and many scholars began to see the benefits of developing research using XRF (Jack 1971; Jack and Carmichael; Shackley 1991). XRF was beneficial in that the method was non-destructive, meaning that the sample could remain whole instead of being ground into a homogenous powder. XRF also involved minimal preparation of the sample, so it was fast, easy to use, and cost-effective for researchers (Shackley 2011).

As with all scientific developments, scholars began to search for a way to make XRF more efficient and, particularly for archaeologists, more research and fieldwork-friendly. In the early 2000s, portable x-ray fluorescence (PXRF) became the answer. Overall, PXRF allowed researchers to take the instrument into the field for in-situ spectrometric analyses. Its lightweight design encouraged transportation, was more accessible to a greater number of scholars, and was noticeably more cost-effective than heavier, more cumbersome equipment. Earlier PXRF instrument models, however, were not as accurate as other XRF devices (Craig et al., 2007), but this error has largely been eradicated due to newer and more precise PXRF instruments and calibration methods. The new and increasing accessibility of PXRF suggests that archaeology will continue to improve upon existing analysis methods and calibration techniques as more scholars become familiar with PXRF as a tool for research.

There are several different companies (i.e., Bruker, Niton) who manufacture PXRF instruments and each company, model, and individual instrument should be considered unique, and more accurate and comparable analyses involve trace element measurements taken from the same device, or across the same model, and subsequently company. This dissertation was conducted using a Bruker Tracer III, which was used for both in-field analyses of artifacts from Vegachayuq Moqo, as well as for comparative data collection from the Archaeological Research Facility at UC Berkeley. One downside to several models of

PXRF instruments, is their inability to function at high elevations (greater than 2,000 meters). (Several newer models for high-elevation applicability have only recently emerged). Because the Tracer III uses oil as an insulator/coolant for the high-voltage mechanisms of the device, changing the pressure (high altitude) can cause the oil to release gas and damage the x-ray tube (Bruker). Due to the constraints of the machine, material analyzed for this dissertation was brought from Ayacucho to Lima (coastal elevation) to avoid device malfunction during XRF analysis.

Physics of XRF

XRF works by sending a photon emitted from a short wavelength form (x-ray) of electromagnetic radiation (Kaiser 2015; Shackley 2011). The energy of the photon excites the atoms in the sample, causing the negatively charged electrons in the sample to dislodge from the inner electron shell. This movement causes a chain reaction whereby electrons from outer shells drop to the inner shells to create stability in the atom. When an electron drops from an outer electron shell to an inner electron shell, the energy of that movement is released in the form of another photon (fluorescent radiation), and the energy of this photon can be measured by an XRF instrument and identified not only to a specific element but also to a specific electron shell transition (Kaiser 2015; Shackley 2011) (Figure 6.1). For example, the K-shell (inner electron shell) of Iron (Fe) has an energy of 6.40 keV (electronvolts), so if the XRF instrument identifies a rebounding photon with an energy of 6.40 keV, the researcher knows that the element Iron is present in the sample. XRF works particularly well for spectrometric analysis because the researcher can choose the energy of the photon sent toward the sample, ranging from 1 keV to 250 keV. The energy of the photon will determine which elements in a sample become excited and drop electrons, this is especially useful for when a researcher is looking at relatively light or relatively heavy elements. The PXRF instrument is able to read the energy displaced from the atom, due to a siPIN Detector (silicon type photodiode).

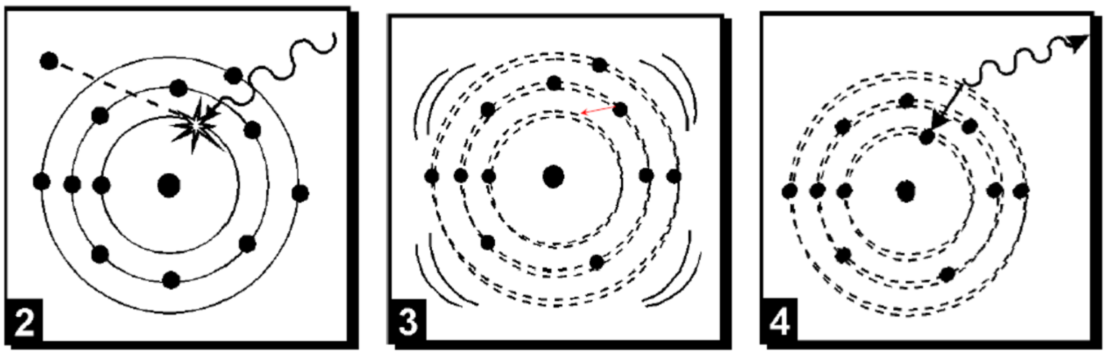


Figure 6.1. The Physics of X-Ray Fluorescence. 2) The photon from short wavelength radiation (an X-ray) hits the sample and excites an electron, which becomes displaced from the atom. 3) Electrons from the outer shells drop to the inner shells to take the place of the displaced electron. 4) The energy from the electron drop is released from the element as a photon, which is read by the XRF instrument as a unique elemental energy (e.g. Iron K-shell energy is 6.40 keV) (Kaiser 2015).

II. PXRF in Archaeology: Obsidian Source Analyses

The use of XRF and PXRF in archaeological applications has come a considerable distance since the first studies conducted at UC Berkeley in the 1960s. XRF is used to identify unknown elemental compositions of soil (Abrahams et al. 2010), pigments (Huntley 2012; Jones and Photos-Jones 2005) and metals (Rehren et al. 20120), and to source materials such as clay (Tedman 2012; Walker 2012), obsidian (Carter and Shackley 2007; Forster and Grave 2011; Golitko et al. 2010; Jia et al. 2010; Moholy-Nagy et al. 2013; Smith et al. 2007), basalt (Lundblad et al. 2011; Johnson et al. 2011; Winterhoff et al. 2007), chert (Wurtzburg 1991; Milne et al. 2011), and other silicate materials. However, despite the multiple applications for XRF in archaeology, the most widely developed and researched is its use in defining and differentiating obsidian sources.

Why Study Obsidian?

Obsidian is a naturally occurring volcanic glass (igneous rock with a glassy texture) formed during the rapid cooling process of volcanic lava (see Chapter 5). Obsidian has a conchoidal fracture pattern (meaning that it fractures in a predictable curved break) and brittle composition that make it one of the easiest and most reliable materials for knapping (Andrefsky 2005). In addition, the sharp fractured edges are one of the sharpest edges formed by a natural material, an attribute that has been highly sought after in prehistory. In addition, it's relatively limited occurrence have added to its value (Chia et al. 2010). Apart from the more functional aspects of obsidian, its phenotypic appearance, usually black and translucent with occasional red or brown inclusions, naturally sharp edge, and frequent association with hunting, warfare, ritual etc., has made it a commonly used prestige or high-value resource across the globe and throughout prehistory, based on aesthetic and symbolic values (Saunders 2001). (Chapter 5 presents a full discussion on the varying dimensions of obsidian in Andean prehistory.)

Because obsidian is homogenous and occurs in limited frequencies, it is an often studied material. A homogenous composition means that all obsidian from one source location will have relatively identical trace element compositions, making obsidian artifacts and obsidian sources an ideal research question for the application of XRF. XRF analyses of obsidian artifacts and sources is ongoing in North America (Doyel 1996; Joyce et al. 1995; Lesko 1989, Shackley and Tucker 2001), Mesoamerica (Brown et al. 2004; Healan 1993;

Moholy-Nagy et al. 1984), and South America (Burger and Glascock 2000; Burger et al. 2000; Tripcevich and Contreras 2011) as well as in Asia (Chia et al. 2010), the Near East (Frahm and Feinberg 2012; Healey 2007) and Oceania (Frederickson 1997; Fullagar et al. 1991). While there is overlap in the methods and application of XRF to source obsidian in these varying regions, it is important to understand that there are regional differences to the trace elemental composition of obsidian. And, in fact, it is these regional variations that make obsidian so easily sourced.

How to Source Obsidian

XRF analyses of obsidian work by isolating and reading the weight of the diffracted electrons to identify the concentration of trace elements within the sample. The most commonly identified elements, and most utilized for obsidian source comparisons, are potassium (K), calcium (Ca), titanium (Ti), manganese (Mn), iron (Fe), nickel (Ni), copper (Cu), zinc (Zn), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), niobium (Nb), palladium (Pd), and barium (Ba) (Shackley and Tucker 2001). Not all of these elements are important for determining source location, with the primary identifying elements varying from region to region. For example, in the Andes, scholars primarily look at concentrations of rubidium, strontium and manganese and secondarily at iron, zirconium and niobium (Craig et al. 2010; Kellett et al. 2013; Burger et al. 2015).

As previously mentioned, this dissertation was completed using a Bruker Tracer III PXRF and all sample measurements, calibrations and analyses were done in best practices and in an effort to be comparable to other obsidian studies in the Andes, for the following factors: 1) voltage; 2) current; 3) filter and 4) time (Burger et al. 2000; Eerkens et al. 2010;

Kellett et al. 2013; Burger et al. 2015). Each of these above factors is malleable, and reflect a choice made by the researcher during data collection. Each choice can produce a different concentration of trace elements, or target in on a different range of elements altogether. For these reasons, it is important that the choice for each element is carefully selected to produce accuracy, as well as to be relevant and comparable to other sourcing studies conducted in the region of interest. As addressed in the previous section, The PXRF instrument works by sending a photon of a specific energy toward the artifact sample to excite and measure the weight of the rebounding electrons. Based on the elements that a researcher is looking to analyze, the energy (voltage) of the emitted photon can be adjusted. For obsidian, the energy of the emitted photon is usually set to 40keV. The standard current setting for obsidian analyses is 35uA.

Obsidian analyses also benefit from the use of a filter, which serves as a mechanism for narrowing in on the specific target elements intended for study. For example, for obsidian, a Green filter essentially blocks elements that have energies lower than 17keV and greater than 40keV from reaching the SiPIN detector. This ensures that the elements that fall within the desired range are clearly visible during analysis. The last factor of the analysis that is dependent upon the researcher is the length of time that the photon is sent toward the sample. The general idea is that the longer the x-ray is hitting the sample the deeper into the material it will penetrate, providing greater strength to the analysis. Samples are generally run from 90 to 180 seconds, largely depending on the time available to the researcher. For this dissertation, all obsidian was analyzed using a voltage of 40keV, a current of 35uA, a Green filter, and all tests were run for 180 seconds.

III. Data Collection

The data for this dissertation are comprised of 628 obsidian artifacts from the site of Huari, located in the central highlands of Peru. The sample derives from the collections of material excavated from Sectors I, II and III of Vegachayuq Moqo at the site of Huari during the 2012 field season, under the direction of Dr. Jose Ochatoma, Licenciada Martha Cabrera and Licenciado Carlos Mancilla Rojas. The analyzed material represents a 100% sample of the obsidian assemblage from the corresponding collections. Permissions were given to conduct XRF analysis of the material for the months of July to September 2016. Inventory and preliminary analyses were conducted at the Archaeology Laboratory at the Universidad Nacional de San Cristóbal de Huamanga (UNSCH) in Ayacucho. Due to the potential malfunction of the PXRF instrument above 2,000 meters, all XRF analyses were conducted in Lima. Inventories of all material were submitted to Dr. Ochatoma and Lic. Cabrera prior to analysis in Lima and all materials were returned to their original locations at the Archaeology Laboratory at the UNSCH promptly after analysis.

Context

All material was examined and analyzed for basic lithic attributes at the UNSCH Archaeology Laboratory in Ayacucho, and a sample of the collection (505 artifacts) was selected for XRF analysis in Lima (see following section for discussion on sampling strategy). Some of the obsidian artifacts had already been separated by material type prior to my analysis, and the material that had not yet been sorted and catalogued was done so in collaboration with the UNSCH archaeology lab during this dissertation. All obsidian material was therefore inventoried along with corresponding contextual information, re-packaged and labeled in artifact material bags, and given to the archaeology lab along with the completed inventory.

All obsidian for Sectors I, II and III were inventoried and contextual information on each artifact pertaining to the site (within Huari), sector, sub-sector, *capa* (layer), level, feature and unit was recorded. Additional contextual information available was excavator name and the date of excavation, and each was noted when present. Because some of the obsidian artifacts had been inventoried and assigned an ID by the archaeology lab and some had not, I assigned each artifact a unique identification number for this analysis to keep information organized and identifiable. Table 6.1 provides a sample for context information collected for each artifact.

ID	***Site***	***Sector***	***Subsector***	***Capa***	***Nivel***	***E.A.***	***Unit***	***Excavator***	***Date***
0001	Vega	2	B4	M			XVI	OHL	1/12/12
0002	Vega	2	B4	M			XVI	OHL	1/12/12
0003	Vega	2	B4	M			XVI	OHL	1/12/12
0004	Vega	2	B4	N			XVI	OHL	1/12/12

Table 6.1 Example inventory for collected data, conducted at the Archaeology Laboratory at the University in Ayacucho and samples prepared for XRF analyses (*Capa*: layer; *Nivel:* level; E.A.: architectural feature).

Lithic Attributes

In addition to the inventory and contextual information, a basic lithic analysis of the materials was conducted in Ayacucho to identify the following attributes: artifact type (i.e., projectile point, biface, uniface, flake, nodule, core and fragment), length, width, thickness, and weight. Additional attributes were recorded for flake artifacts: flake termination (hinge, step, feathered, overshot), striking platform (flat, cortical, complex, abraded), cortex, and flake scars. A note was made of retouching present on all artifacts and all material was photographed. Table 6.2 shows the recording strategy for lithic attributes and Table 6.3 provides a definition of all recorded attributes. A further discussion of the application of flake termination, striking platform and other attributes to analysis and interpretation is discussed in Chapter 7.

ID	***Type***	***Length***	***Width***	***Thick***	***Weight***	***Term.***	***Platform***	***Cortex***	***Scars***
0001	Flake	30.94	25.26	11.95	8.6	H	F	2	1
0002	Flake	26.15	16.63	5.88	2.3	S	Cp	4	2
0003	Flake	17.73	20.23	6.46	1.7	F	Cp	4	3
0004	Flake	18.79	9.74	5.91	1.5	F	C	3	3

Table 6.2. Example inventory for lithic data. (Termination: H = hinged, S = step, F = feathered, O= overshot; Platform: F = flat, Cp = complex, C = cortical, A= abraded; Cortex: 1=100% cortex, 2 >50% cortex, 3 = <50% cortex, 4 = 0% cortex; Flake Scars: 1 = 0 flake scars, 2 = 1 flake scar, 3 = 2-5 flake scars, 4= >5 flake scars).

Attribute	*Description of Attribute*
Biface	Artifact that is heavily modified over both faces.
Uniface	Artifact that is moderately modified on one face of the artifact
Flake	The detached piece removed from the core. Flakes can be turned into bifaces or unifaces with modification, utilized as flake tools, or discarded in the form of debitage.
Nodule	A geological (not anthropogenic) specimen.
Core	Homogenous lithic material from which detached pieces (flakes) are removed.
Fragment	A broken artifact of any category.
Point	A biface that has been utilized as a spear point or arrow head (e.g., in contrast to a knife).
Edge Retouch	An artifact that has been worked on one or both sides (edges).
Flake Termination	Depending upon the force, angle and tool used, the distal end of a flake will have a different projection. Feathered terminations are smooth, and indicate the force traveled equally through the core and objective piece. Step terminations occur when the detached piece snaps or breaks. Hinge fractures occur when the force of impact moves toward the objective piece. And overshot terminations occur when the force of impact moves away from the objective piece.
Striking Platform	The striking platform, found at the proximal end of the flake, is the location where force of impact is applied. Different platform types pertain to different forces of impact and striking tools. A cortical platform occurs when the striking tool is applied to the cortex (or exterior) of the core. A flat platform is smooth, and typically results from removing the flake from a flat surface (i.e. non-bifacial tool, unidirectional core, flake blank). Complex and abraded platforms result from the impact tool striking a piece of the core that is multidirectional. Abraded platforms have been smoothed by abrasion or rubbing of the platform.
Cortex	Cortex is the natural exterior of the rock.
Flake Scar	Flake scar is the impression left on the objective piece from the detached flake. Multiple flake scars indicate increased modification.

Table 6.3. Definition of lithic attributes, adapted from Andrefsky (2005).

Sampling for PXRF

After the basic lithic attribute analyses were complete, a sample of the collection was prepared for PXRF analysis and transported to Lima. Sampling of the artifacts was done so with the intent of sampling as much material as possible, and only artifacts that could not be analyzed accurately were omitted. One such limitation derives from the thickness and size of the artifact. Artifacts that measure less than 3mm in thickness can not be accurately analyzed using PXRF due to the inability of the x-ray to penetrate the sample to a proper depth. In other words, too thin a sample means that less elemental information can be recovered from XRF analyses. This resulted in the removal of 82 artifacts from XRF analysis.

A second limitation stems from the need for the x-ray to hit the sample clearly and directly, without obstruction. Many of the obsidian samples that had been previously inventoried, had been given permanent laboratory identification numbers by the UNSCH Archaeological Laboratory, many of which were written onto the obsidian artifacts using a combination of white out and black permanent marker. The artifacts for which the white out or permanent marker obscured all flat surfaces were removed from the sample. If the x-ray were to pick up on the white-out or black marker, this would cloud the accuracy of the results. This resulted in another 41 samples being removed from the XRF analysis. In sum, 505 samples (80%) of the original collection were taken to Lima for XRF analysis. A comparison of artifact information by context and by attribute shown in Chapters 7 and 8 shows that despite the removal of artifacts for PXRF analysis, the sample is representative across context features and lithic attributes.

Conducting PXRF

The Bruker Tracer III, on loan from the University of California Santa Barbara, was temporarily housed at the Pontificia Universidad Católica del Peru (PUCP) in Lima from July to September 2016. During this time, XRF analyses were conducted over the course of six weeks after lithic analysis had been completed in Ayacucho. Sampled artifacts were lightly washed with water to remove loose dirt, allowed to dry, and then each artifact was analyzed using the PXRF instrument. To run the analysis, a flat piece of the artifact was placed on the instrument platform to cover the source location of the x-ray beam. It is important that a flat part of the sample covers the x-ray beam fully, and that it is flush with the sensor to ensure maximum accuracy. The instrument was placed upright on its stand, and each obsidian sample analyzed was small enough to allow for the safety shield cap to be used for each trial. The instrument settings were adjusted to send photons of 40keV at a current of 35uA, using a Green filter to magnify elements from 17 to 40keV. Each trial was conducted for 180 seconds and three trials were conducted for each obsidian artifact. Three trials were conducted to ensure there was no human or machine error and to account for surface variations on the sample. Each trial was run from a different location on each artifact. After all obsidian artifacts were analyzed using PXRF, the material was returned to the UNSCH Archaeology Laboratory in Ayacucho, along with the corresponding inventory.

IV. Data Analysis

XRF Data and Calibration

XRF analyses were conducted in the field using the Bruker program S1PXRF, which produced a visual display of the trace elemental composition and recorded data on the region of interest (ROI), or the area under the curve. In other words, the visual ROI data represented concentrations of different elements picked up during analysis by the SiPIN detector and is displayed by elemental weight (see Figure 6.2). Through this visual data, even without statistical analysis, it is possible to get as sense of what elements are present within the sample. Raw ROI data is in relation to only a single artifact and is not precise for comparison across a data set. However, ROI data can be used to determine a ratio between the concentration of two elements within an artifact. This ratio can then be compared to the ratio of the concentration of the same two elements in another artifact. For example, for artifact 0001 there is a ratio of 7097.31 strontium to 8334.49 rubidium (or 0.85) while for artifact 0002 there is a ratio of 6264.52 strontium to 7572.56 rubidium (or 0.82). The ROI provides a general description of elemental concentrations across a sample.

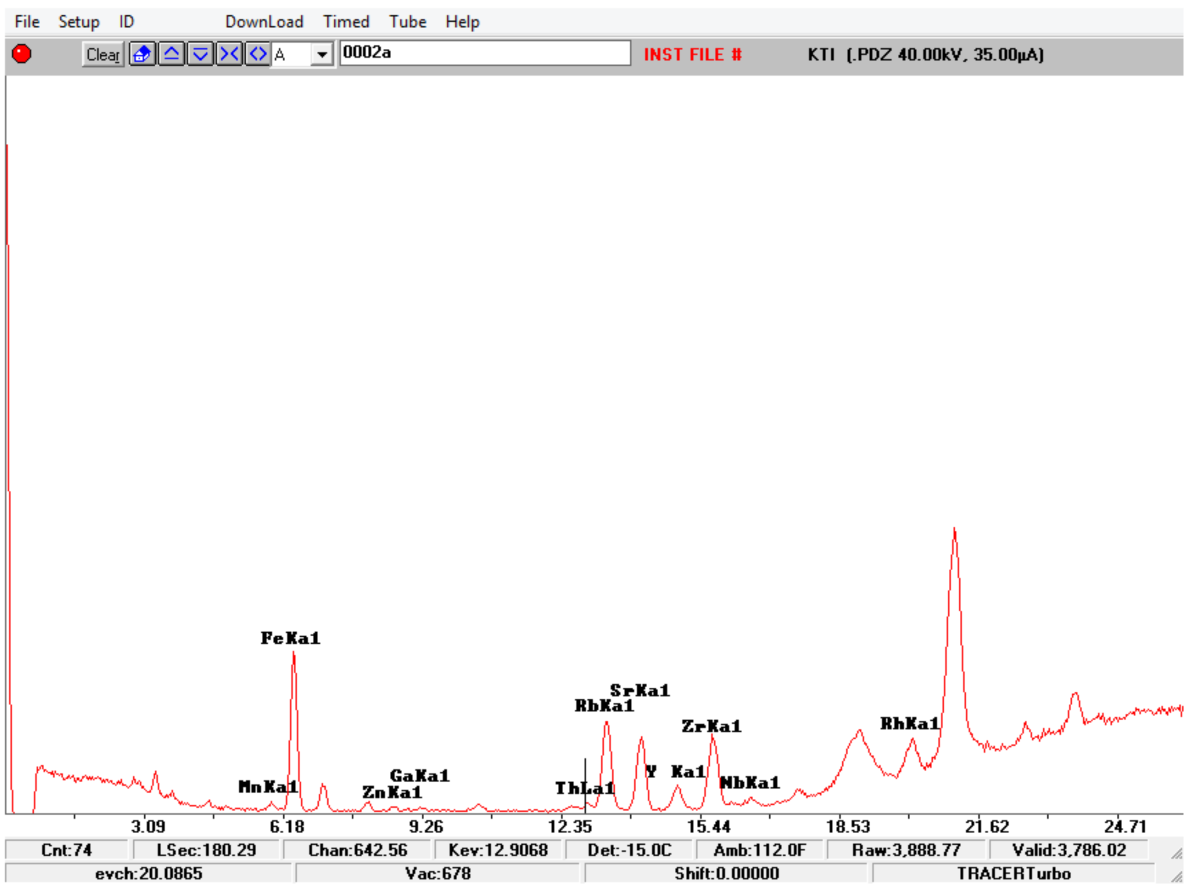


Figure 6.2. Graph of Elemental Regions of Interest (ROI), S1PXRF. Raw ROI data from PXRF analysis. (Peaks represent greater raw amounts).

For more detailed analyses of the collection, it is useful to acquire the concentration of elements in each sample in parts per million (PPM), not just the raw measurements registered by the SiPIN detector. In order to obtain the PPM for each element that can then be compared across a sample set, it is necessary to calibrate the data. Bruker provides a calibration specific to each instrument, which can be used to calibrate within a dataset (the company conducts prior tests and assessments of each individual device against known, standard materials and datasets which form the basis for the calibration). Each Bruker instrument analyzes a standard sample of obsidian from North and South America to create a calibration coefficient that can be applied to data acquired from that specific tracer to determine the PPM of each element within a sampled collection. The data calibration is run through a program developed by Bruker, called S1CalProcess. S1CalProcess operates as an add-in for the program Excel and the pre-calibrated obsidian standards are placed in the same file as the sample obsidian run for this dissertation. S1CalProcess then executes the program to calculate the calibrated PPMs for the sample obsidian. As a point of note, Shackley (2011) acknowledges that this calibration is often not appropriate for comparisons across multiple data sets and instruments, and may only be statistically useful for comparisons and analyses from the same instrument. Accordingly, the comparative data for obsidian sources used in this dissertation is derived from data collected by myself, following the same protocol on the same device, from comparative source collections at the Archaeological Research Facility at UC Berkeley, under the direction of Nicholas Tripcevich. (See Appendix 2 for a full list of calibrated PPMs for each artifact).

Sourcing the Data

The calibrated PPMs for each sampled artifact as well as the calibrated PPMs from the comparative source collection were compiled in SYSTAT for analysis. Figure 6.3 shows a graph of all known sources grouped by a concentration of the elements rubidium (Rb) and strontium (Sr). Figure 6.4 shows the raw data points prior to source identification of the sampled artifacts. Each artifact was compared for multiple element concentrations, although the most distinctive combinations were rubidium vs. strontium, rubidium vs. zirconium, and rubidium vs. niobium. All points were analyzed alongside 95% confidence ellipses for each known source location, and identified as belonging to a source if they fell inside the 95% confidence interval. Because each artifact was analyzed across three different trials, each trial was examined separately to conduct source identification and then source IDs were compared across the trials. If each trial produced a matching source ID, then the identification was considered accurate and noted. More specific results and analysis of XRF sourcing data can be seen in Chapter 8.

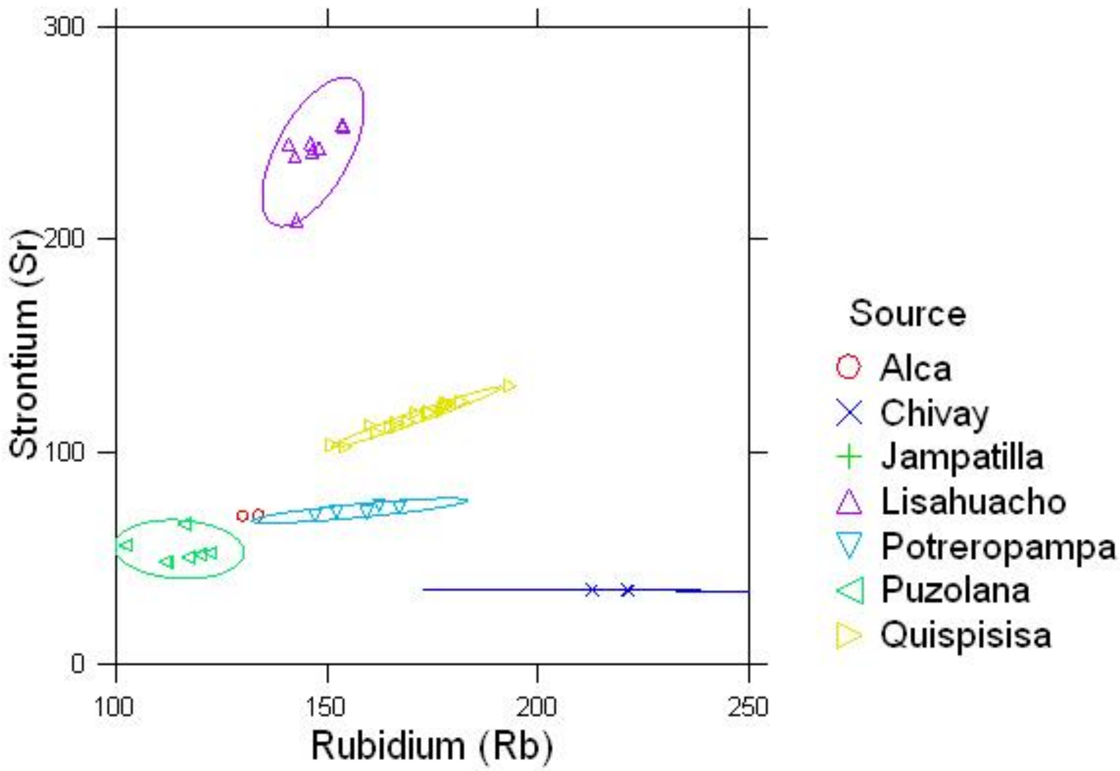


Figure 6.3. Graph of Obsidian Sources, known comparative collection. Collections courtesy of Nicholas Tripcevich and the Archaeological Research Facility at University of California Berkeley.

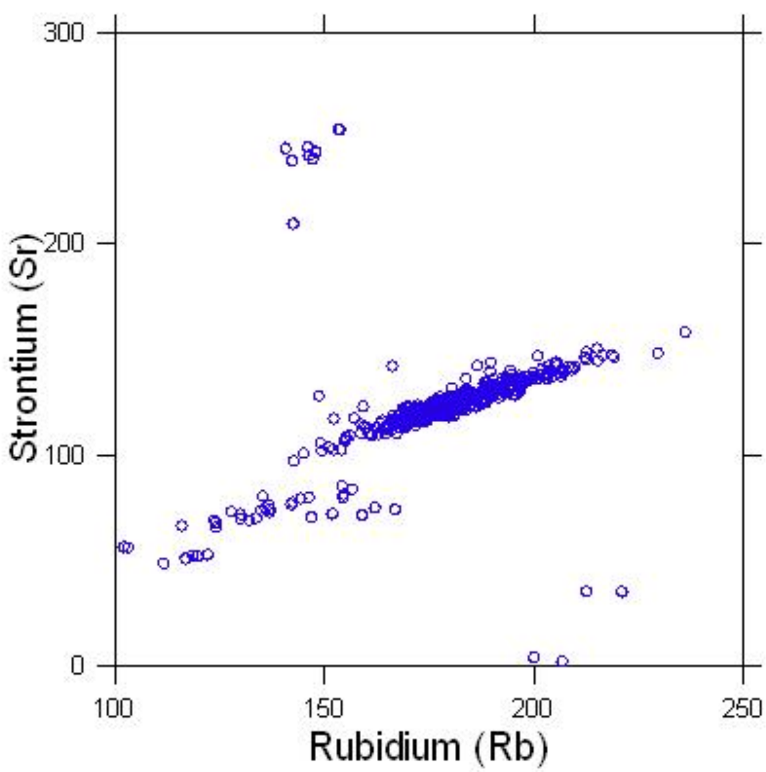


Figure 6.4. Graph of Total Sample. All obsidian points considered in this dissertation, includes sample collection and comparative collection.

Lithic Attributes

Basic lithic analyses were conducted for the previously mentioned attributes of artifact type, flake termination, flake striking platform, cortex and flake scar as well as excavation and temporal context. Because most features identified were categorical, tests of significance were largely conducted using chi-square tests to explore the relationship between two variables. Because chi-square tests can only reveal whether or not a relationship exists, and not what that relationship is, results from lithic attributes were compared with sourcing results, and background history of the Wari Empire and theories on imperial processes and resource/craft production provide the avenue for interpretation. More specific results and analyses from lithic attributes and excavation context can be seen in Chapter 7, and a discussion of the results follows in Chapter 9.

CHAPTER 7

ARTIFACT RESULTS

The obsidian samples analyzed for this dissertation derive from the 2012 excavations within the Vegachayuq Moqo sector of Huari, conducted by Professors Dr. Jose Ochatoma Paravicino, Licenciada Martha Cabrera and Licenciado Carlos Mancilla Rojas. The 2012 excavation project was titled "Investigación y Puesta en Valor del sector de Vegachayuq Moqo–Huari", and was conducted during the months of April to June, 2012, and December 2012. The obsidian artifacts analyzed for this dissertation represent a 100% sample of the obsidian recovered from their respective contexts. Some, but not all, of the lithic material from the excavations had been previously inventoried and assigned an identification number prior to my analysis. As a result, I assigned each obsidian artifact an independent ID, recorded contextual information about each artifact including sector, sub-sector, *capa* (layer), *nivel* (level), feature, bag number, excavators and date of excavation. In many instances, the obsidian artifacts were co-mingled with other lithic and ceramic material from the same excavation context (likely the result of material recovered through screening or sifting).

As part of this analysis I separated and inventoried the obsidian artifacts from the excavations, and the resulting inventory was given to the Archaeology Lab at the Universidad Nacional de San Cristóbal de Huamanga (UNSCH), alongside the data from the source analyses. The final sample consisted of 628 obsidian artifacts, ranging in type from debitage to projectile points (heretofore differentiated from non-projectile bifaces). All obsidian artifacts were analyzed according to their basic attributes (type, size, cortex, retouch, flake scars, flake platform and flake termination), context (sector, sub-sector, *capa* and time period) and source location (PXRF). By examining attributes, context and source location it is possible to get a wider understanding of the use of obsidian within the site of Huari in the Middle Horizon, Peru.

I. Excavation Context

Vegachayuq Moqo, Huari

Vegachayuq Moqo is one of the best-studied sectors within the site of Huari, due in large part to the D-shaped architectural feature located along the western edge of the sector (Figure 7.1). First excavated by Enrique Bragayrac and Enrique González Carré in 1982, and again by Bragayrac in 1991, the D-shaped structure, which measures 30m in diameter, has been interpreted by many as a temple of a ceremonial and/or ritual nature (Ochatoma et al. 2015; Carré and Bragayrac 1996; Bragayrac 1991). The sector of Vegachayuq Moqo was first occupied during the Early Intermediate Period by the Huarpa, and subsequently built over by the Wari Empire (Ochatoma et al. 2015). Within the sector it was common practice for Wari-period construction to rest on top of Huarpa walls that were filled with a layer of imported red sand (Ochatoma et al. 2015) (Figure 7.2). In addition to the sector's use prior to the Middle Horizon, there is also archaeological evidence of the purposeful destruction of the site, as well as pre-historic looting, following the collapse of the Empire during the Late Intermediate Period (Ochatoma et al. 2015). During the 2012 excavations, which were conducted with the intention of exploring architectural features and establishing a more refined chronology of the sector, the principal investigators found that temporal contexts were intact only for earlier phases of the site's occupation (Ochatoma et al. 2012). While

Huarpa and expansion-period Wari occupations were found with intact contexts, collapse and post-collapse period contexts were heavily co-mingled due to the above-mentioned destruction, looting, as well as more recent agricultural activity within the sector.

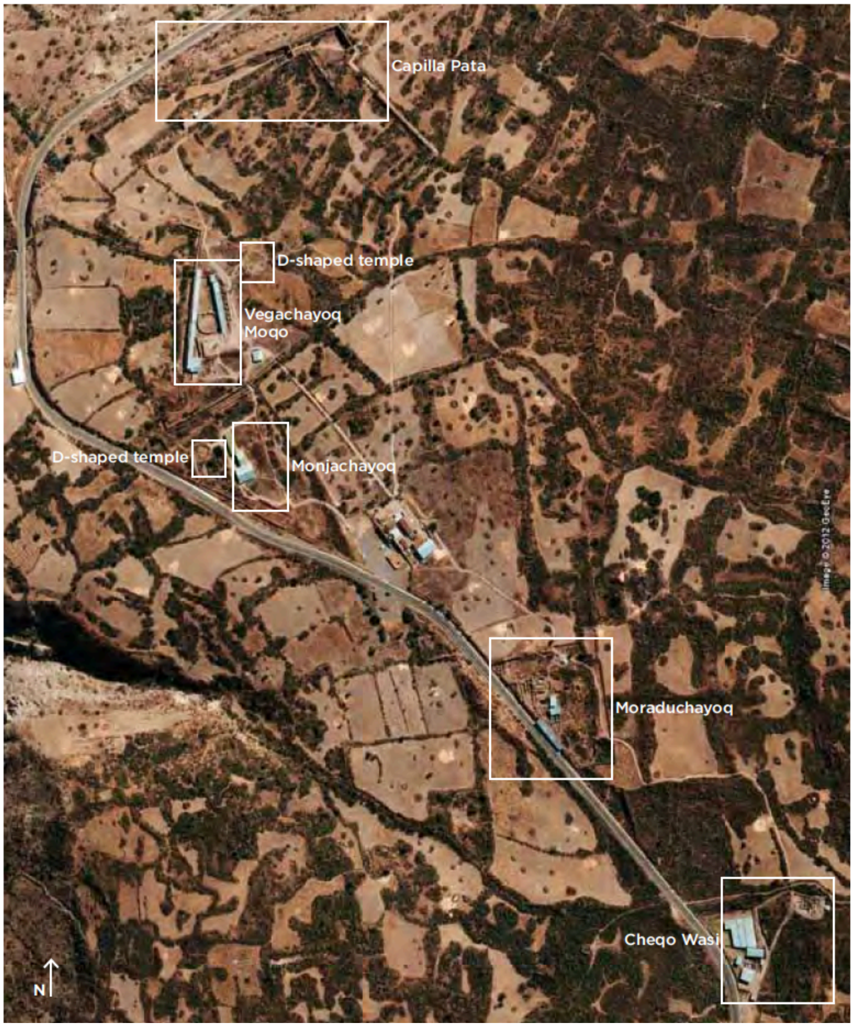


Figure 7.1. Map of Huari. Image courtesy of Schreiber (2013).

Figure 7.2. Photo of intentional red, sandy fill overlying Huarpa occupations. Photo courtesy of Ochatoma et al. 2012

The results of the 2012 excavations, presented in a final *informe* (report) to the Ministerio de Cultural in Lima, suggest that Vegachayuq Moqo was, in fact, a seat of power within the Ayacucho region as early as the Early Intermediate Period during the Huarpa occupation of the site. The sector continued to play an important role within the expanding Wari Empire until the end of the Late Middle Horizon (Ochatoma et al. 2012). The authors reaffirm that Vegachayuq Moqo was an important location within the site of Huari, as an architectural feature expressing imperial power, and also as a ceremonial space where rituals were conducted in honor of the gods: "*Vegachayuq Moqo fue un lugar donde se expresa claramente la arquitectura del poder en Huari desde el Intermedio Temprano hasta el colapso del estado imperial. Se trata de un espacio sagrado donde se realizaron rituales en honor a sus deidades"* (Ochatoma et al. 2012: 3).

Sectors, Sub-sectors, and Capas

The obsidian artifacts analyzed come from excavations conducted within three distinct sectors of Vegachayuq Moqo, within the site of Huari (Figure 7.3). Sub-sectors further define the location of excavation units, and *capa* (layer) refers to the vertical delineation of stratigraphic layers within an excavation unit. Excavation units across all three sectors were excavated to varying horizontal and vertical extents. Some units were trenches, while others were broad exposure, and not all were excavated to the same profundity (Ochatoma et al. 2012). In addition, *capas* were determined independently for each unit, and cannot be applied universally across the site. The analysis here approaches *capas* by sub-sector, which is how they are presented in the 2012 *informe* (Ochatoma et al. 2012). The *nivel* (level) designates subtle distinctions within each *capa*, however temporal information is presented as uniform for each *capa,* so the analysis presented in this dissertation uses *capa* as the smallest contextual designation.

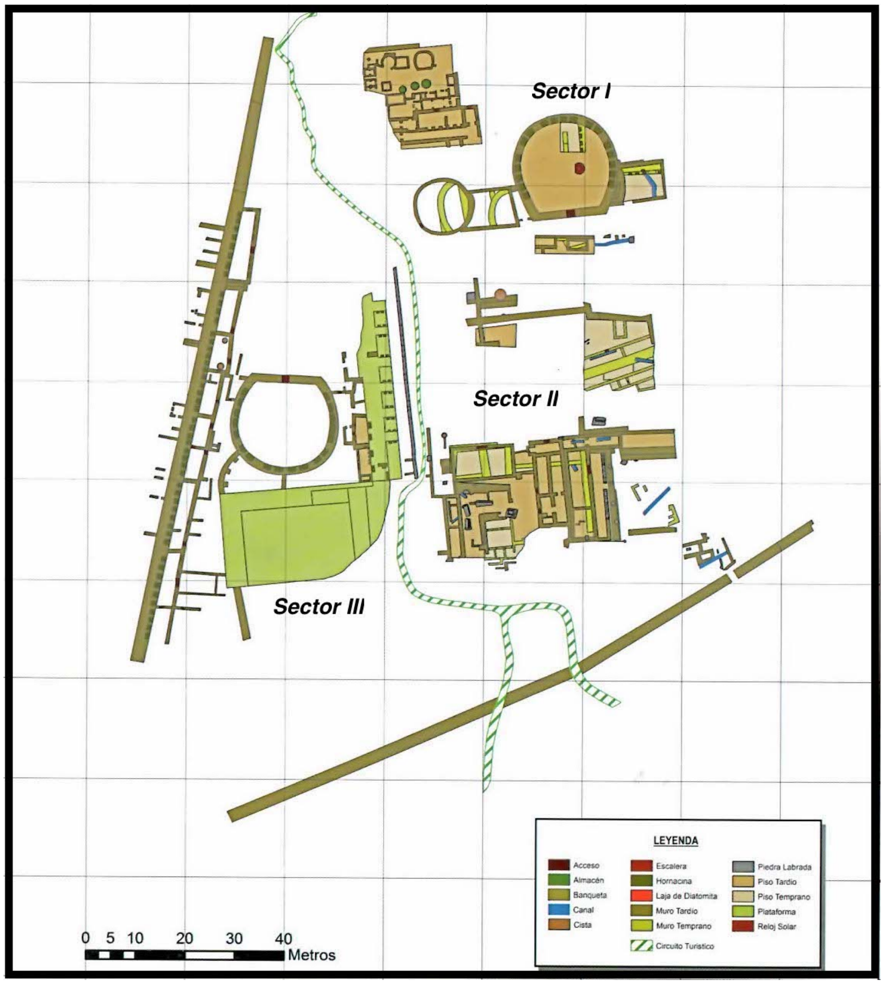


Figure 7.3. Map of Vegachayuq Moqo and 2012 Excavations, map adapted from Ochatoma et al. 2015.

Of the 628 obsidian artifacts analyzed, 20 (3.18%) were associated with Sector I, 419 (66.72%) with Sector II and 189 (30.10%) with Sector III (Table 7.1). This suggests that obsidian was most prevalent within Sector II, however, this assumption does not take into account the difference in the size of excavations within each sector. Sector I contained excavation units measuring a total of 639.149m^2, Sector II units measured a total of 786.147m^2, and Sector III measured a total of 350m^2. Because Sector III excavations were not as large as those conducted in Sector I and II, obsidian artifacts are underrepresented from Sector III.

	Sector I	*Sector II*	*Sector III*	*Total*
Count	20 (3.18%)	419 (66.72%)	189 (30.10%)	628 (100%)

Table 7.1. Obsidian count by sector.

The analysis of obsidian count by sub-sector faces similar complications, in that each sub-sector contained diverse excavation units with varying depths and horizontal extents. Furthermore, sub-sectors were not differentiated by temporal context, rather they were delineated by surface features, their location chosen through both judgmental and stratified sampling methods. For the investigators, sub-sectors were positioned primarily to investigate architectural features (Ochatoma et al. 2015). This makes it difficult to address variation in the frequency of obsidian by sub-sector to any degree of statistical significance. Nevertheless, exploring patterns of obsidian (type, size, source location) within each sub-sector is a potential avenue for analysis.

The basic obsidian count by sub-sector is presented in Table 7.2. Within Vegachayuq Moqo, 13 sub-sectors produced obsidian artifacts, and 21 artifacts were not attributable to one specific sub-sector (subsequently referred to as sub-sector N/A). As was expected, the sub-sectors with the highest counts of obsidian were found in Sectors II and III (most likely due to their larger excavations). For example, sub-sector C6, located within Sector II, produced 136 artifacts (21.66%) and sub-sector D9, located within Sector III produced 121 artifacts (19.27%). Some sub-sectors were co-mingled during collection and inventory, for example sub-sector A8-B8-A9, located within Sector III, which produced only three obsidian artifacts (0.48%).

	Count
A4-B4 (I)	20 (3.18%)
A5 (II)	80 (12.74%)
A6 (II)	62 (9.87%)
B4 (II)	80 (12.74%)
B5-B6 (II)	36 (5.73%)
C5 (II)	17 (2.71%)
C6 (II)	136 (21.66%)
A8-B8-A9 (III)	3 (0.48%)
C9 (III)	11 (1.75%)
D7-D8 (III)	19 (3.03%)
D9 (III)	121 (19.27%)
E10 (III)	22 (3.5%)
N/A	21 (3.34%)
Total	628 (100%)

Table 7.2. Obsidian count by sub-sector. (Sector noted in parentheses.)

Capas were designated in the field based on changes in soil type, artifact type, or architectural feature. For many *capas*, temporal context could be ascertained given the presence of diagnostic cultural material found within each layer, but in others there was little to no diagnostic material with which the the excavators could have made a definitive assessment (Ochatoma et al. 2012). Similar to analyses of sub-sector and sector, it is difficult to compare obsidian frequencies across *capas* due to differing layer thickness and soil disturbance patterns (looting, destruction, agricultural activity, bio-turbation, etc.). In addition, *capa* designations are not identical across sectors or even some sub-sectors, making comparison even more challenging. However, diagnostic material within a *capa* is the best approximation for temporal association apart from absolute dating techniques, which have yet to be conducted. To maintain contextual integrity, obsidian counts by *capa* are presented below in relation to their corresponding sectors and sub-sectors. All contextual information regarding the *capas* is derived from the *informe* presented by Ochatoma, Cabrera and

Mancilla (Ochatoma et al. 2012). A complete display of obsidian counts by *capa* can be found in the Appendix (Appendix 2.1).

Sector I

Sector I is located on the northwest side of Vegachayuq Moqo, near the D-shaped temple (see Figure 7.3). The excavations in Sector I covered an area of 639.149m^2 and were aligned with visible architectural walls, eroding floors and other architectural features of interest (Ochatoma et al. 2012). Of the total obsidian analyzed from Vegachayuq Moqo, 20 artifacts pertained to excavations from Sector I, 3.18% of the total sample (see Table 7.1). Obsidian from Sector I was only found in two sub-sectors: A4 and B4. Sub-sectors A4 and B4 correspond to unit 1 and units 20 and 21, respectively. Each sub-sector forms a square of 20m^2 and both were a southern extension of sub-sector A3 (a sub-sector from which no obsidian was found during the 2012 excavations). Within the obsidian collection, there was no contextual distinction made between these sub-sectors, and so for analysis they are considered one sub-sector.

Within sub-sectors A4 and B4, obsidian artifacts were found within *Capa* A and *Capa* B (see Table 7.3). *Capa* A consisted of a semi-compact, dry sediment of a dark brown color and a medium-fine matrix. The layer was 8-9cm thick and contained inclusions of roots and irregular-shaped rocks of basalt, rhyolite and puzolana (Ochatoma et al. 2012). Within sub-sector A4, *Capa A* had very little cultural material, mostly non-diagnostic ceramic fragments. Within sub-sector B4, *Capa* A produced relatively more cultural material, such as ceramics, obsidian, turquoise and human remains. However, all lithic material from both sub-sectors was co-mingled. *Capa* B was a semi-compact layer of a dark brown color and a fine matrix. Unlike *Capa* A, *Capa* B was humid, and contained roots, shell casings and irregular-shaped rocks of basalt and rhyolite. Little cultural material was present in *Capa* B, with the exception of ceramic fragments and isolated carbon deposits (Ochatoma et al. 2012). Similar to *Capa* A, more cultural material from *Capa* B was found in sub-sector B4 (including ceramics and obsidian artifacts), but all material was co-mingled during excavation and inventory. In sum, *Capa* A contained 70% of the obsidian found within sub-sectors A4 and B4 (n=14), while *Capa* B contained 30% (n=6) (Table 7.3).

	A	***B***	***Total***
Count	14 (70%)	6 (30%)	20 (100%)

Table 7.3. Obsidian count by *capa*, sub-sectors A4-B4, Sector I.

Sector II

Sector II is located on the east side of Vegachayuq Moqo, aligned with carved stone interpreted as possible platforms (Ochatoma et al. 2012; Carré and Bragayrac 1996) (see Figure 7.3). The excavations of Sector II covered an area of 786.147m^2, employing 3x1m and 2x2m trenches. Within Sector II, 419 obsidian artifacts (66.72%) were collected during excavations (Table 7.1). In addition, Sector II had the most defined cultural sequence of all three sectors and corresponded to the final phases of the Huarpa occupation at the end of the Early Intermediate Period and to the expansion and consolidation phases of the Wari Empire during the beginning and middle phases of the Middle Horizon. While later contexts are not as well-intact, Sector II overlays a colonial pathway connecting the archaeological site of Huari to the present-day towns of Quinua and Pacaycasa (Ochatoma et al. 2012). Within Sector II, obsidian was found from seven sub-sectors: A5, A6, B4, B5-B6, C5, and C6 (see

Table 7.2). Eight obsidian artifacts from Sector III could not be assigned to any sub-sector (N/A).

Sub-sector A5 pertains to excavation units 5, 6, 9, 13, 14, and 21. Obsidian was present in all stratigraphic layers within sub-sector A5 (see Table 7.4). The surface layer (S), 8-13cm thick, was a dark grey sediment with inclusions of roots and small stones. Few ceramic fragments were present and the layer appeared to have been used for agricultural activities in more recent decades. *Capa* A was a grey, semi-compact layer with a thickness of 8-14cm. The layer contained small stones and roots and limited cultural material, consisting mostly of non-diagnostic ceramic fragments. *Capa* B was a semi-compact, light grey layer of diatomaceous earth. The layer was 13-17cm thick and contained cultural material of plainware and polychrome ceramics, most of which were non-diagnostic. *Capa* C was a layer of beige sediment, with a medium matrix and thickness of 11-24cm. Within the layer were clay nodules, both diagnostic and non-diagnostic ceramics and dispersed animal bones. *Capa* D was a brown, compact clay floor with a medium matrix. The floor was 2-5cm thick and associated with a mixed deposit of ceramics of Huarpa, Viñaque, and Chakipampa styles, as well as domestic ceramics, camelid bones and obsidian. The contextual integrity of *Capa* D was compromised in some by its connection to a Wari patio associated with the D-shaped temple. *Capa* E was a semi-compact, red, sandy layer with a medium matrix. It was 5-10cm thick, and the intentional sandy fill was likely brought into the site from another location—the red sand is non-local to the Ayacucho region. This layer of red, sandy fill, appears multiple times throughout Vegachayuq Moqo, and is associated with the transition from Huarpa to Wari, often overlying Huarpa architecture (Ochatoma et al. 2015). This is supported by the fact that cultural material in *Capa* E was temporally associated with Huarpa and early Chakipampa ceramic styles (Ochatoma et al. 2012).

	Count
S	4 (5%)
A	1 (1.25%)
B	4 (5%)
C	29 (36.25%)
D	11 (13.75%)
E	10 (12.5%)
N/A	21 (26.25%)
Total	80 (100%)

Table 7.4. Obsidian count by *capa*, sub-sector A5, Sector II.

Sub-sector A6 was originally placed to align with a possible passageway that was proposed to link the higher elevation sectors of Huari to Vegachayuq Moqo. Upon excavation, it was found to correspond to a colonial pathway connecting the site of Huari to the present-day towns of Quinua and Pacaycasa. The investigators suggested that this colonial pathway may have originated as an earlier Wari canal (Ochatoma et al. 2012). Obsidian material found within sub-sector A6 comes from *capas* B, C and D (see Table 7.5). *Capa* B was a semi-compact, light grey layer with a thickness of 7-20cm. Cultural material included carbon, ceramics, lithics and animal bones and was associated with the Chakipampa ceramic style. In addition to pre-hispanic material culture, *Capa* B also contained contemporary material, likely due to agricultural use or tourism activities. *Capa* C was a compact, beige layer with a medium matrix. The layer was 15-24cm thick and contained cultural material that was predominantly Chakipampa and Huarpa in style, but some ceramic fragments recovered were also a mixed deposit of Kumunsenqa, Okros, Caja, Huamanaga and Huari styles (Ochatoma et al. 2012). In addition to ceramics, *Capa* C contained camelid remains and obsidian artifacts (the most within this sub-sector) as well as occasional lenses of red earth, interpreted as a possible intentional fill lying on top of an earlier wall structure. *Capa* D was a compact, dark beige layer with a medium matrix and a thickness of 4-15cm. The layer contained large rocks measuring 50cm by 40cm, under which a floor was found with ceramic fragments pertaining to Chakipampa, Huarpa, Okros and Kumunsenqa ceramic styles.

	B	***C***	***D***	***N/A***	***Total***
Count	3 (4.84%)	43 (69.35%)	11 (17.74%)	5 (8.06%)	62 (100%)

Table 7.5. Obsidian count by *capa*, sub-sector A6, Sector II.

Sub-sector B4 contained obsidian within 12 different *capas* (see Table 7.6). *Capa* A was a semi-compact, dark brown layer that contained roots as well as fragments of non-diagnostic ceramics, lithics and animal bones. *Capa* B was a brown, compact occupation floor with a thickness of 3-5cm. Within *Capa* B, cultural material consisted of ceramic fragments, lithics, animal bones and some isolated carbon deposits. *Capa* C was a semi-compact layer of red sand with an underlying, compact, dark brown to beige sediment. Cultural material found within *Capa* C consisted of animal bones and Huarpa-style ceramic fragments. This layer also contained an intrusion of loose rocks and ceramic fragments pertaining to Huarpa, Kumunsenqa, and Chakipampa ceramic styles. *Capa* D was a semi-compact, dark brown sediment mixed with red sand. The sand was located towards the top of the layer, with the sediment becoming more compact towards the bottom. *Capa* E was a semi-compact, beige layer lying above a possible occupation floor found in *Capa* F. This floor was dated to the EIP and contained fragments of animal bones, ceramics, metal, and lithics. Subsectors B5, B6 and C5 were an extension of sub-sector B4 and contained a similar stratigraphic profile (see Table 7.7 and Table 7.8). *Capas* G-P were presented without contextual information in the 2012 *informe*, and therefore, no contextual information about them is presented here (Ochatoma et al. 2012).

	Count
A	4 (5%)
B	5 (6.25%)
C	10 (12.5%)
D	8 (10%)
E	17 (21.25%)
G	5 (6.25%)
H	13 (16.25%)
J	2 (2.5%)
K	2 (2.5%)
M	3 (3.75%)
N	3 (3.75%)
P	8 (10%)
Total	80 (100%)

Table 7.6. Obsidian count by *capa*, sub-sector B4, Sector II

	C	***D***	***E***	***N/A***	***Total***
Count	1 (2.78%)	20 (55.56%)	9 (25%)	6 (16.66%)	36 (100%)

Table 7.7. Obsidian count by *capa*, sub-sector B5-B6, Sector II.

	D	***E***	***Total***
Count	11 (64.70%)	6 (35.30%)	17 (100%)

Table 7.8. Obsidian count by *capa*, sub-sector C5, Sector II.

Sub-sector C6 contained obsidian within six different *capas* (see Table 7.9). The surface layer showed evidence of recent plant cultivation as well as the remains of adobe walls, likely constructed during colonial times and associated with the path from Huari to Quinua and Pacaycasa. The surface was a semi-compact, dark brown layer with a thickness of 5-25cm. Agricultural activity had brought ceramic fragments and animal remains to the surface from lower lying layers. *Capa* B was a semi-compact, light grey layer with a medium matrix. The layer was 20-25cm thick and was interpreted as a layer of intentional fill covering an underlying floor of red earth. *Capa* C was a clay floor of a light brown color and a thickness of 3-5cm. On this floor, excavators found fragments of ceramics, camelid remains and stone walls with irregular mortar. *Capa* D was another layer of intentional fill, composed of a fine, red sand. This sand, similar to that found in other sub-sectors, was not endemic to the site and would have been brought in from further distances. The intentional fill was 5-25cm thick and contained the most obsidian artifacts within this sub-sector (Table 7.9). However, because this layer is an intentional fill, the obsidian may be temporally associated with the later material in *Capa* E. *Capa* E was a semi-compact, dark brown layer with a medium matrix. The layer was 15-30cm thick and contained roots and more intentional fill covering temporally earlier walls and floors. This layer also contained abundant cultural material dating to the Huarpa occupation. The presence of several Huari-style ceramics within *Capa* E suggests an association with a late Huarpa and early Wari expansion phase of the site. *Capa* G was a compact, white floor with a medium matrix and thickness of 5cm and dated to the Huarpa occupation of the site (Ochatoma et al. 2012).

	Count
Surface	40 (29.41%)
B	8 (5.88%)
C	2 (1.47%)
D	74 (54.42%)
E	7 (5.14%)
G	4 (2.94%)
N/A	1 (0.74%)
Total	136 (100%)

Table 7.9. Obsidian count by *capa*, sub-sector C6, Sector II.

Sector III

Sector III was located on the south side of the D-shaped structure within Vegachayuq Moqo, and was aligned with a possible access route to the platform, as well as with possible habitation zones (Ochatoma et al. 2012). Excavations within Sector III covered an area of 350m^2, and were conducted in 2x2m excavation units. The investigators opened Sector III with the intention of defining the walls of the architectural features located within the sector (Ochatoma et al. 2012). Sector III contained 189 obsidian artifacts, or 30.10% of the total obsidian sample. However, this sector was the smallest of all sectors excavated, suggesting that obsidian from Sector III is relatively underrepresented within the entire assemblage. Obsidian was found within sub-sectors A8-B8-A9, C9, D7-D8, D9, E10 and F (see Table 7.2).

Sub-sectors A8 and B8 produced only one obsidian artifact from within *capas* B-D, but all material for these layers was co-mingled during collection and inventory (see Table 7.10). *Capa* B pertained to a floor, 2-4cm thick, that extended through adjacent sub-sectors (A9 and A10) and was composed of diatomaceous earth. The floor was white and cream in color and cultural material found included a multipurpose stone tool and a concentration of Huari style ceramics. *Capa* C was divided into two distinct levels, relating to the delimitation of a wall running through the sector. *Capa* C1 contained a concentration of angular stones of varying sizes and inclusions of volcanic rock. This level was a semi-compact, dark brown sediment. *Capa* C2 similarly contained stones of varying sizes, but was a semi-compact, light brown sediment. *Capa* D was located within a different architectural space of the sub-sector, and produced ceramics associated with the Chakipampa A ceramic style. Sub-sector A9 was an extension of sub-sectors A8 and B8 and had a similar stratigraphic composition. While sub-sector A9 did not produce much cultural material, it lay adjacent to sub-sector A10, where excavators found a collection of 15 copper metal artifacts within *Capa* D, including five *tupus* of varying sizes.

	B	***D***	***Total***
Count	1 (33.33%)	2 (66.67%)	3 (100%)

Table 7.10. Obsidian count by *capa*, sub-sector A8-B8-A9, Sector III.

Sub-sector C9 contained obsidian material within *capas* A, B, C, and E (see Table 7.11). *Capa* A was a semi-compact, dark brown sediment and contained roots extending into the layer from the surface. Within *Capa* A were cultural materials associated with Chakipampa, Huamanga, Aqo Wayqo, Okros, Caja and Huarpa ceramic styles, as well as animal bones, carbon and plaster of both green and red colors that was associated with a wall running through the sub-sector. *Capa* B, a floor composed of white, diatomaceous earth, also had remains of plaster of both green and red colors, similar to those found in *Capa* A. Within *Capa* B were several intrusions, one of which contained ceramics of both Huarpa and Chakipampa styles as well as burned animal bone. *Capa* C was a compacted layer lying under the floor of *Capa* B. It was a dark brown sediment with a medium-fine matrix and was associated with a late Huarpa-phase wall. *Capa* C lay directly above *Capa* D which was a layer of intentional fill. Under the fill was *Capa* E, a floor of diatomaceous, white earth with dark brown and black mineral inclusions. Sub-sector D9 was an extension of sub-sector C9 and had a similar stratigraphic profile (see Table 7.12).

	A	***B***	***C***	***E***	***N/A***	***Total***
Count	3 (27.27%)	1 (9.09%)	4 (36.37%)	1 (9.09%)	2 (18.18%)	11 (100%)

Table 7.11. Obsidian count by *capa,* sub-sector C9, Sector III.

	A	B	D	E	Total
Count	2 (1.65%)	1 (0.83%)	16 (1.65%)	102 (14.05%)	121 (100%)

Table 7.12. Obsidian count by *capa,* sub-sector D9, Sector III.

Sub-sectors D7 and D8 contained obsidian artifacts from both *Capas* B and C, however, material from these two sub-sectors were co-mingled during collections and inventory (see Table 7.13). *Capa* B was a semi-compact layer of a light brown color and was likely intentional fill (Ochatoma et al. 2012). Cultural material recovered from *Capa* B consisted of ceramics of Huarpa, Chakipampa, Aqo Wayqo, and Huamanga ceramic styles, with limited numbers of Kumunsenqa, Caja, Okros, Huari, Viñaque, and Totora ceramic styles. In addition, *Capa* B also contained spondylus, animal bones, and lithic material. *Capa* C was a white, compact floor measuring 10-12cm in thickness. Most of the floor had been destroyed by intrusions; only 30% of the original surface remained. Within *Capa* C, cultural material found included large pieces of spondylus. *Capa* D lay just under the floor of *Capa* C, and also consisted of a white, diatomaceous earth.

	B	C	D	Total
Count	15 (78.95%)	3 (15.79%)	1 (5.26%)	19 (100%)

Table 7.13. Obsidian count by *capa*, sub-sector D7-D8, Sector III.

Sub-sector E10 contained material from three *capas*: C, F and J (see Table 7.14). *Capa* C was defined by a wall, 80cm thick, that extended through units 10 and 11. Cultural material within *Capa* C consisted of ceramic fragments and animal bones as well as three fragments of spondylus. *Capa* D was a dark brown floor and contained cultural material including ceramic fragments, lithics, animal bones as well an an intrusion of filled earth, containing nodules, flakes and worked stone. *Capa* F was a light brown sediment with a semi-compact texture and, similar to *Capa* D, contained ceramics, animal bone, obsidian, as well as some bronze metal fragments. *Capa* J was not presented with context in the *informe*, and so no context for the layer is presented here.

	C	***F***	***J***	***Total***
Count	2 (9.09%)	13 (59.10%)	7 (31.81%)	22 (100%)

Table 7.14. Obsidian count by *capa*, sub-sector E10, Sector III.

Chronology

Due to varying depths and extents of excavation units, as well as the geographical placement and delineation of sub-sectors and sectors, it is difficult to assess frequency variations in obsidian within and across these contexts. It is, however, possible to explore frequency of obsidian artifacts from Vegachayuq Moqo within and across time periods. One difficulty in assessing temporal phases in association with obsidian artifacts (in general and for this dissertation) is the fact that almost the entire obsidian assemblage (with the exception of one projectile point) is non-diagnostic. Therefore, in order to explore chronology, it is essential to have intact excavation contexts that are well-documented in order to make temporal associations based on relative dating techniques. Not all *capas* from the 2012 excavation season were associated with diagnostic material or assigned to a relative occupation phase, but those that were provide a starting point. All of the associations for chronology provided here are established from ceramic typology and chronology determined by excavators and investigators during the 2012 field and lab seasons (Ochatoma et al. 2012; Ochatoma et al. 2015).

Much of the ceramic chronology for Middle Horizon ceramics builds upon the work of Dorothy Menzel (1967). Menzel (1967) based her seriation on south-coast (Ica) ceramic sequences and divided the Middle Horizon into four distinct phases: 1) Phase 1, the emergence of the empire 2) Phase 2, the consolidation of the empire and 3) Phases 3 and 4, the collapse. The accuracy of her chronology has been brought into question, and scholars continue to discuss and debate the dates for specific ceramic styles, with many noticing that there are often regional differences in the ceramic sequence, making absolute dating difficult (Knobloch 2005; Isbell 2004; Griesz and Makowski 2010; Vaughn et al. 2014). For the purposes of this dissertation, and because temporal contexts within the excavation were often mixed and difficult to accurately associate, three general time periods will be examined: 1) Huarpa, dating to the Early Intermediate Period; 2) Wari A, dating to the transitional phase from Huarpa to Wari at the beginning of the Middle Horizon; and 3) Wari B, the height of Wari expansion dating to the Middle Horizon. In many instances *capas* contained material from more than one of the above time periods, and so both were considered within the analysis. For example, sub-sector C9, *capa* B, was both Huarpa and Wari A (see Table 7.15).

According to Ochatoma et al. (2015), the sector of Vegachayuq Moqo predates the Wari Empire, having been previously occupied by the Huarpa during the Early Intermediate Period. This was confirmed by the many architectural spaces that were associated with Huarpa occupations underlying Wari structures. Ochatoma et al. (2015) suggest that Huarpa occupations were associated with floors of diatomaceous earth and were usually covered intentionally by a layer of imported red sand (see Figure 7.2). Ceramic material associated with this early Huarpa phase are Huarpa, Cruz Pata and Kumunsenqa ceramic styles (Isbell 2004; Ochatoma et al. 2015). The transition between Huarpa and Wari (here called Wari A) is more difficult to assess, due in large part to frequent inter-associations between multiple ceramic styles within assemblages that are attributable to both Early Intermediate Period and

Middle Horizon time periods (for example, Huarpa ceramics). Ceramic styles that suggest this transitional Wari A phase are Chakipampa A, Okros, Caja and Huarpa ceramic styles (Isbell 2004; Ochatoma et al. 2015). The expansion and consolidation phases of the Wari Empire (here called Wari B) are characterized by Chakipampa, Viñaque, Huamanga, Atarco, Aqo Wayqo, Okros, Caja, and (limited) Huarpa ceramic styles. In addition, Ochatoma et al. (2015) note the presence of green and red plaster was associated with the expansion and consolidation phase of the Empire (Wari B).

Table 7.15 presents associated temporal contexts for the obsidian analyzed in this dissertation. These temporal phases have been categorized based on on 1) ceramic style, 2) the presence of intentional red fill, and 3) the presence of red or green plaster within a specific *capa*. The time periods presented (and the combinations thereof), Huarpa, Wari A and Wari B, are best approximations. To note, layers lying above *capas* of known temporal association were not assigned a time period, as agricultural activity and bioturbation has disturbed more recent contexts within the sector. Layers lying below *capas* of a known date, however, were approximated and made note of (see Table 7.15).

Table 7.16 presents the number of obsidian artifacts that pertain to each specific time period. (If an artifact was dated to possible two time periods it is included in the count for each). Of the dateable assemblage, 368 artifacts (56.09%) date to the Huarpa occupation, 210 date to the Wari A expansion phase (32.01%) and 78 date to the Wari B consolidation phase (11.89%). Because younger time periods (primarily Wari B) are found in the upper layers of the excavation, these contexts are often disturbed, leading to an inability to confidently assign artifacts to a time period. This leads to an underrepresentation of artifacts from later time periods. In other words, even through Huarpa accounts for 56% of the assemblage, and

Wari B only 11.89%, Wari B likely is underrepresented in the analysis and more of the obsidian pertains to Wari than accounted for here.

	Temporal Phase	***Count***	***Diagnostic Material***
A (C9)	WB	3 (0.69%)	C, HM, AW, O, CA, H, red/green plaster
A (D9)	WB	2 (0.46%)	C, HM, AW, O, CA, H, red/green plaster
B (A6)	WB	3 (0.69%)	C
B (A8-B8-A9)	WA, WB	1 (0.23%)	H
B (C9)	H, WA	1 (0.23%)	H, C, diatomaceous earth
B (D7-D8)	H, WA, WB	15 (3.46%)	H, C, AW, HM, K, CA, O, V, T, sandy fill
B (D9)	H, WA	1 (0.23%)	H, C, diatomaceous earth
C (A6)	WA, WB	43 (9.93%)	C, H, K, O, CA, HM, H, sandy fill
C (B4)	H, WA	10 (2.31%)	H, K, C, sandy fill
C (B5-B6)	H, WA	1 (0.23%)	H, K, C, sandy fill
C (C9)	H, WA	4 (0.92%)	H, H wall, sandy fill
C (D7-D8)	H, WA	3 (0.69%)	Sandy fill
D (A5)	WA, WB	11 (2.54%)	H, V, C, sandy fill
D (A6)	H, WA	11 (2.54%)	H, C, O, K, sandy fill
D (A8-B8-A9)	WA	2 (0.46%)	C
D (B4)	H	8 (1.85%)	Sandy fill
D (B5-B6)	H	20 (4.61%)	Sandy fill
D (C5)	H	11 (2.54%)	Sandy fill
D (C6)	H, WA	74 (17.1%)	H, Sandy fill
D (D7-D8)	H	1 (0.23%)	Diatomaceous earth
D (D9)	H, WA	16 (3.69%)	Sandy fill
E (A5)	H, WA	10 (2.31%)	H, C, sandy fill
E (B4)	H	17 (3.92%)	Sandy fill
E (B5-B6)	H	9 (2.08%)	Sandy fill
E (C5)	H	6 (1.38%)	Sandy fill
E (C6)	H, WA	7 (1.61%)	H, sandy fill
E (C9)	H	1 (0.23%)	Diatomaceous earth
E (D9)	H	102 (23.56%)	Diatomaceous earth
G (B4)	H	5 (1.15%)	Below *capa* of known association
G (C6)	H	4 (0.92%)	H
H (B4)	H	13 (3%)	Below *capa* of known association
J (B4)	H	2 (0.46%)	Below *capa* of known association
K (B4)	H	2 (0.46%)	Below *capa* of known association
M (B4)	H	4 (0.69%)	Below *capa* of known association
N (B4)	H	3 (0.69%)	Below *capa* of known association
P (B4)	H	8 (1.85%)	Below *capa* of known association
Total		433 (100%)	

Table 7.15. Obsidian count by temporal context and *capa*. (Sub-sector noted in parentheses.) (C=Chakipampa, HM=Huamanga, AQ=Aqo Wayqo, O=Okros, CA=Caja, H=Huarpa, V=Viñaque, T=Totora, K=Kumunsenqa; H=Huapa, WA=Wari A, WB=Wari B).

	Count
Huarpa	368 (56.09%)
Wari A	210 (32.01%)
Wari B	78 (11.89%)
Total	656 (100%)

Table 7.16. Obsidian count by temporal context.

	Count
Huarpa	215 (49.65%)
Huarpa, Wari A	138 (31.87%)
Wari A	2 (0.46%)
Wari A, Wari B	55 (12.70%)
Wari B	8 (1.84%)
Huarpa, Wari A, Wari B	15 (3.46%)
Total	433 (100%)

Table 7.17. Obsidian count by temporal context, grouped.

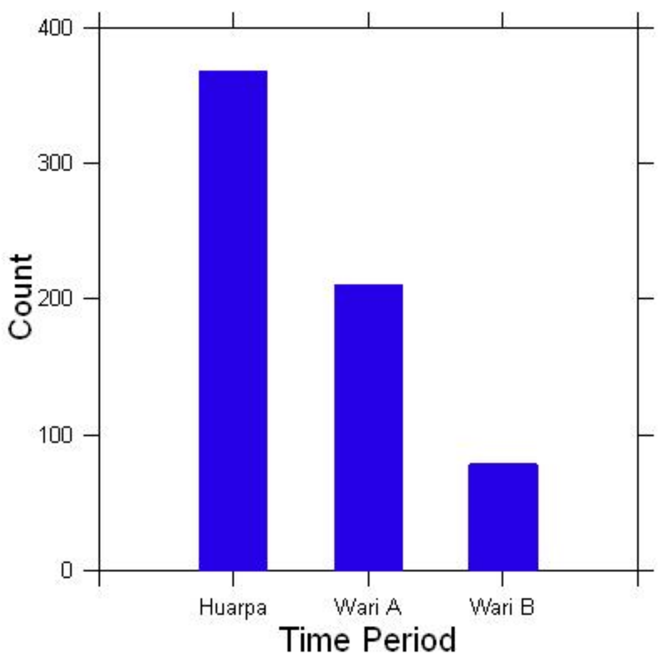


Figure 7.4. Graph of obsidian by time period.

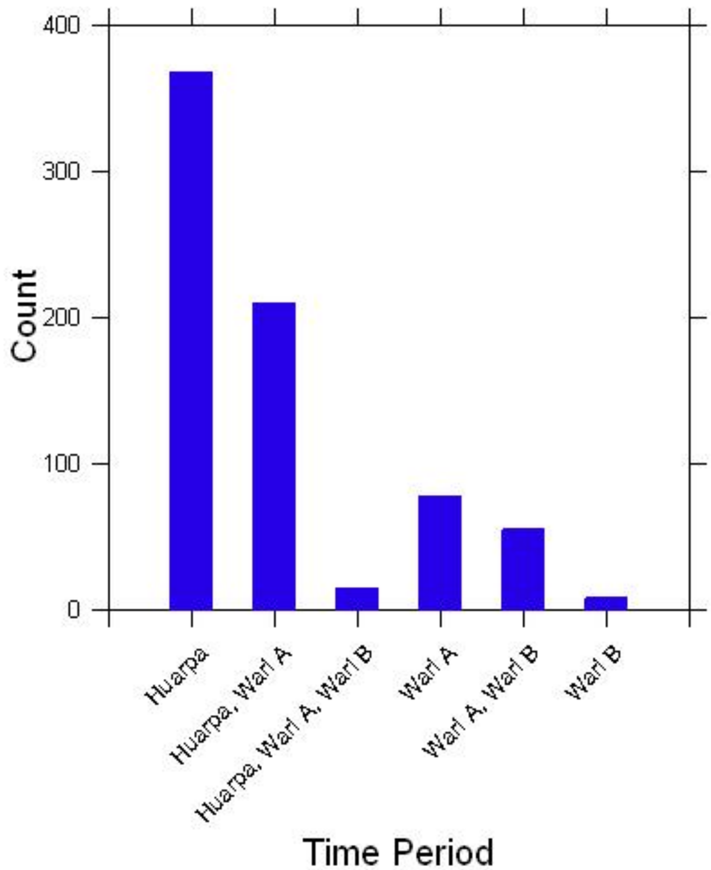


Figure 7.5. Graph of obsidian count by time period (grouped).

II. Results: Attributes

All obsidian artifacts analyzed for this dissertation were inventoried, and attributes (such as artifact type, dimension, weight, and artifact features) were recorded. Similar to the basic statistics presented above for contextual information of the obsidian, this section addresses basic statistics for artifact attributes, exploring each within the total assemblage as well as within specific temporal contexts. Analysis progresses from a more general description of artifact type, and is followed by a narrower focus on flakes and projectile points. Most emphasis is placed on the examination of flakes, as they comprise 57.48% of the assemblage (n=361) (see Table 7.18).

Artifact Type

Each obsidian artifact was categorized into the following artifact types: 1) biface (non-projectile); 2) core; 3) flake; 4) fragment; 5) point; and 6) uniface. Within the sampled artifacts, 22 (3.5%) were bifaces, 1 (0.16%) was a core, 361 were flakes (57.47%), 218 were fragments (34.71%), 1 (0.16%) was a nodule, 24 (3.82%) were points and 1 (0.16%) was a uniface (see Table 7.18). “Flakes”, as a general category, represents both flake tools (expedient) and debitage (production debris). Debitage and expedient tools are produced by the same processes and so are analyzed here as one category. “Fragments” represent broken tools (formal and expedient), broken debitage, as well as material affected by wear, discard processes and decay. Fragment pieces are difficult to identify, and so are considered one category. Formal tools were classified as “uniface" or “biface”.

	Biface	***Core***	***Flake***	***Fragment***	***Nodule***	***Point***	***Uniface***	***Total***
Count	*22 (3.5%)*	1 (0.16%)	361 (57.48%)	218 (34.71%)	1 (0.16%)	24 (3.82%)	1 (0.16%)	628 (100%)

Table 7.18. Artifact count by type.

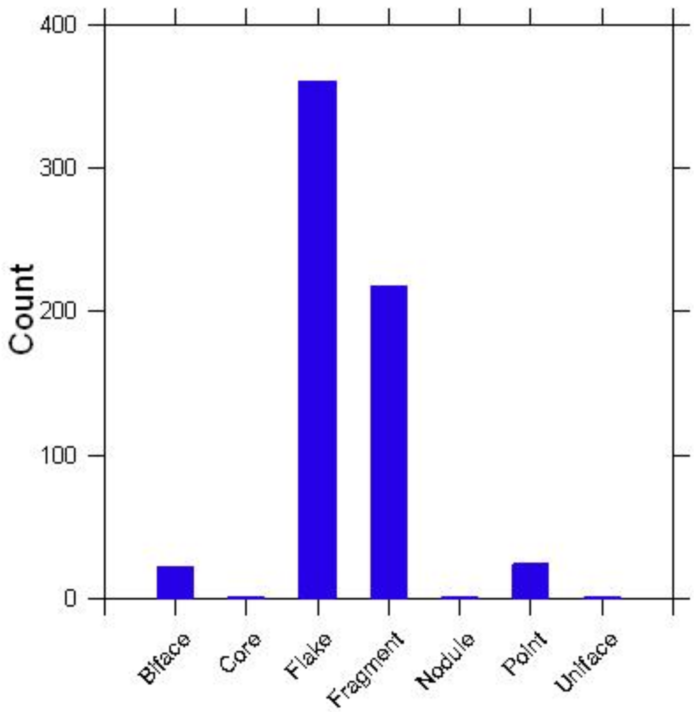


Figure 7.6. Graph of artifact type.

Artifact Type and Sector

A chi-square test was conducted to look at the relationship between the raw frequencies of artifact type and sector (H_o = no relationship). The results do not support the null hypothesis, and instead show a relationship between between artifact type and sector (value=38.78, df=3.78, p<0.0001). However, due to the absence of some artifacts resulting in zero values within the contingency table, and because the sample size is relatively large with variation in counts between sectors, there is a possibility that the chi-square test will provide a false positive correlation. Furthermore, the test only shows that a relationship between the two variables exists, and not what the nature of that relationship is. (For additional tables see Appendix 2.2 and 2.3). Nonetheless, a notable difference in assemblage composition between sectors does exist. For example, within each sector flakes are the dominant artifact type. And within Sector I, flakes make up 55% of the assemblage (n=11). Both Sectors II and III, also have a similar proportion of flakes within the assemblage at 56.56% (n=237) and 59.79% (n=113), respectively. One notable difference in assemblage composition between the sectors is the absence of bifaces and projectile points in Sector I, and their presence in Sectors II and III (see Table 7.19).

	Sector I	***Sector II***	***Sector III***
Biface	0 (0%)	13 (3.10%)	9 (4.76%)
Core	0 (0%)	1 (0.24%)	0 (0%)
Flake	11 (55%)	237 (56.56%)	113 (59.79%)
Fragment	8 (40%)	154 (36.75%)	56 (29.63%)
Nodule	0 (0%)	1 (0.24%)	0 (0%)
Point	0 (0%)	13 (3.10%)	11 (5.82%)
Uniface	1 (5%)	0 (0%)	0 (0%)
Total	20 (100%)	419 (100%)	189 (100%)

Table 7.19. Artifact types by sector assemblage.

Artifact Type and Sub-sector

In addition to looking at artifact type by sector, it is also possible to do so by sub-sector and *capa*. A Pearson chi-square test was conducted to test the relationship between artifact type and sub-sector (H_o = no relationship). The results do not support the null hypothesis and show a relationship between the two variables (value=109.989, df=72, p<0.003). Similar to the chi-square test conducted for sector, there are many cells within the contingency table with a value of zero, and therefore, the results of the chi-square test may be a false positive correlation. In general, flakes are the most common artifact type within each sub-sector. Only sub-sector A5 (n=46, 57.5%), and C9 (n=6; 54.55%) have more fragments than any other artifact type. Bifaces have the highest proportional representation in sub-sector C5 (n=2; 11.76%), despite the fact that sub-sector C6 has a greater biface frequency within the total assemblage (n=7) (Table 7.20). Points have the highest proportional representation in sub-sector D9 (n=8, 6.61%). (For additional tables see Appendix 2.4 and 2.5).

	Biface	Core	Flake	Frag	Nodule	Point	Uni	Total
A4-B4	0 (0%)	0 (0%)	11 (55%)	8 (40%)	0 (0%)	0 (0%)	1 (5%)	20 (100%)
A5	1 (1.25%)	0 (0%)	29 (36.25%)	46 (57.5%)	0 (0%)	4 (5%)	0 (0%)	80 (100%)
A6	2 (3.22%)	0 (0%)	34 (54.84%)	24 (38.71%)	0 (0%)	2 (3.22%)	0 (0%)	62 (100%)
B4	0 (0%)	0 (0%)	54 (67.5%)	21 (26.25%)	1 (1.25%)	4 (5%)	0 (0%)	80 (100%)
B5-B6	1 (2.78%)	0 (0%)	16 (44.44%)	18 (50%)	0 (0%)	1 (2.78%)	0 (0%)	36 (100%)
C5	2 (11.76%)	0 (0%)	8 (47.06%)	8 (41.18%)	0 (0%)	0 (0%)	0 (0%)	17 (100%)
C6	7 (5.15%)	1 (0.74%)	91 (66.91%)	35 (25.74%)	0 (0%)	2 (1.47%)	0 (0%)	136 (100%)
A8-B8-A9	0 (0%)	0 (0%)	2 (66.67%)	1 (33.33%)	0 (0%)	0 (0%)	0 (0%)	3 (100%)
C9	0 (0%)	0 (0%)	5 (45.45%)	6 (54.55%)	0 (0%)	0 (0%)	0 (0%)	11 (100%)
D7-D8	1 (5.26%)	0 (0%)	16 (84.21%)	2 (10.53%)	0 (0%)	0 (0%)	0 (0%)	19 (100%)
D9	8 (6.61%)	0 (0%)	68 (56.20%)	37 (30.58%)	0 (0%)	8 (6.61%)	0 (0%)	121 (100%)
E10	0 (0%)	0 (0%)	14 (63.64%)	8 (36.36%)	0 (0%)	0 (0%)	0 (0%)	22 (100%)
N/A	0 (0%)	0 (0%)	13 (61.90%)	5 (23.81%)	0 (0%)	3 (14.29%)	0 (0%)	21 (100%)

Table 7.20. Artifact type by sub-sector assemblage.

Artifact Type and Time Period

As has been discussed previously, each *capa* has been assigned to a temporal context based on association with diagnostic artifacts within the layer. Therefore, I provide here only the results of artifact-type by time period (Tables 7.21 and 7.22). (For tables relating to individual *capa* see Appendix 2.6). A chi-square test was conducted to test the relationship between artifact type and time period (H_o = no relationship). The results support the null hypothesis and suggest that artifact type and time period are not related (value=13.551, df=25, p<0.969). While not statistically significant, some notable patterns are still present within the results. For all time periods, flakes are the primary artifact type (>50%). The Huarpa-Wari A transitional phase contains the greatest proportion of bifaces across time periods (n=6; 4.35%). Despite low sample sizes, the Wari A/B and Wari B expansion and consolidation phases contain proportionally more projectile points when compared to earlier time periods. For example, projectile points (n=3) comprise 16.07% of the total assemblage for the Wari A/B and Wari B time periods. In comparison, projectile points (n=11) comprise 5.89% of the total assemblage for Huarpa and Huarpa/Wari A time periods. (For additional tables see Appendix 2.7 and 2.8).

	Biface	***Core***	***Flake***	***Frag***	***Nodule***	***Point***	***Total***
Huarpa	9 (4.19%)	0 (0%)	133 (61.86%)	64 (29.76%)	1 (0.46%)	8 (3.72%)	215 (100%)
Huarpa, Wari A	6 (4.35%)	1 (0.72%)	80 (57.97%)	48 (34.78%)	0 (0%)	3 (2.17%)	138 (100%)
Wari A	0 (0%)	0 (0%)	2 (100%)	0 (0%)	0 (0%)	0 (0%)	2 (100%)
Wari A, Wari B	1 (1.82%)	0 (0%)	31 (56.37%)	21 (38.18%)	0 (0%)	2 (3.57%)	55 (100%)
Wari B	0 (0%)	0 (0%)	4 (50%)	3 (37.5%)	0 (0%)	1 (12.5%)	8 (100%)
Huarpa, Wari A, Wari B	1 (6.67%)	0 (0%)	12 (80%)	2 (13.33%)	0 (0%)	0 (0%)	15 (100%)

Table 7.21. Artifact type by time period assemblage.

	Biface	*Core*	*Flake*	*Frag*	*Nodule*	*Point*
Huarpa	9 (52.94%)	0 (0%)	133 (50.76%)	64 (46.38%)	1 (100%)	8 (57%)
Huarpa, Wari A	6 (35.29%)	1 (100%)	80 (30.53%)	48 (34.78%)	0 (0%)	3 (21.42%)
Wari A	0 (0%)	0 (0%)	2 (0.76%)	0 (0%)	0 (0%)	0 (0%)
Wari A, Wari B	1 (5.88%)	0 (0%)	31 (11.83%)	21 (15.21%)	0 (0%)	2 (14.29%)
Wari B	0 (0%)	0 (0%)	4 (1.53%)	3 (2.17%)	0 (0%)	1 (7.14%)
Huarpa, Wari A, Wari B	1 (5.88%)	0 (0%)	12 (4.58%)	2 (1.45%)	0 (0%)	0 (0%)
Total	17 (100%)	1 (100%)	262 (100%)	138 (100%)	1 (100%)	14 (100%)

Table 7.22. Time period by artifact type assemblage.

Flake Size-Grade

Flakes recovered from Vegachayuq Moqo included both expedient flake tools and debitage. Following Catherine Bencic's (2016) study of the obsidian assemblage at Conchopata, flakes were measured by length, width and thickness (in mm) and assigned to one of four possible size-grades based on the maximum dimension of the artifact: 1) < 6.35mm; 2) 6.35–12.7mm; 3) 12.7–25.4mm; and 4) >25.4mm (Table 24). The majority of the flakes (n=197; 54.57%) fell into the third size-grade (12.7–25.4mm), while only two flakes (0.55%) measured less than 6.35mm. The low quantity of flakes measuring less than 6.35mm matches the pattern identified by Bencic (2016) at Conchopata and is likely the result of an underrepresentation of small flakes due to field methods of excavation and screening (Bencic 2016). First, during the excavation process some material does not pass through a screen, meaning that material has to be caught by the naked eye to be recorded, and small flakes less than 6.35mm are difficult to detect. And second, even when material is screened, the screens are rarely set with a grid small enough to catch material less than 6.35mm in size.

In general, flakes (both expedient flake tools and debitage) tend to decrease in size with increased levels of tool production (Bencic 2016). In other words, larger quantities of smaller-sized flakes indicate late-stage reduction activities. Bencic (2016) suggests that "on-site" tool production is indicated when the majority of flakes measure between 6.35mm–12.7mm. As Table 7.23 shows, only 3.6% (n=13) of the flakes from Vegachayuq Moqo fall within this size-grade category. Following Bencic (2016), this suggests that most obsidian production was occurring outside of Vegachayuq Moqo. This is a pattern that is also found at the neighboring site of Conchopata (Bencic 2016).

	< 6.35mm	***6.35–12.7mm***	***12.7–25.4mm***	***> 25.4mm***	***Total***
Count	2 (0.55%)	13 (3.60%)	197 (54.57%)	149 (41.27%)	361 (100%)

Table 7.23. Flakes by size-grade.

	Length (mm)	***Thickness (mm)***	***Width (mm)***	***Weight (g)***
Minimum	6.11	3.60	0.95	0.01
Maximum	59.39	51.30	22.67	9.50
Median	19.78	19.35	4.90	1.50
Mean	21.22	20.35	5.54	2.17
Std. Deviation	8.61	8.32	3.16	2.00

Table 7.24. Basic statistics for flakes.

Flake Size-Grade and Sector

A chi-square test was conducted to test the relationship between flake size-grade and sector (H_o = no relationship). The results do not support the null hypothesis, suggesting that there is a relationship between the two variables (value=67.140, df=6, $p<0.0001$). This may suggest that in-situ tool production was occurring in distinct spaces within Vegachayuq Moqo, although the results may reflect the low sample size for flakes measuring less than

6.35mm as well as the considerable variation in sample sizes across the sectors. In general, flakes measuring 12.7-25.4mm are the most common size-grade within each assemblage, suggesting a limited amount of in-situ tool production across sectors at the site (see Table 7.25). And although sample size is low, Sector I contains the only flakes measuring less than 6.35mm, although this may be due to excavation/screening procedures (For additional tables see Appendix 2.9 and 2.10).

	Sector I	***Sector II***	***Sector III***
< 6.35mm	2 (18.18%)	0 (0%)	0 (0%)
6.35–12.7mm	1 (9.09%)	10 (4.22%)	2 (1.77%)
12.7–25.4mm	5 (45.45%)	132 (55.70%)	60 (53.10%)
> 25.4mm	3 (27.27%)	95 (40.08%)	51 (45.13%)
Total	11 (100%)	237 (100%)	113 (100%)

Table 7.25. Flake size-grade by sector.

Flake Size-Grade and Sub-Sector

Results by sub-sector provide a point of comparison to those produced by sector. A chi-square test to explore the relationship between the variables (H_o = no relationship), does not support the null hypothesis and suggests a relationship between flake size-grade and sub-sector (value=118.276, df=36, p<0.0001). For flakes measuring less than 12.7mm, most are found within sub-sector B4 (Sector II) (Table 7.26). This contradicts the above results suggesting that Sector I was the location for tool production and calls into question the accuracy of exploring size-grade by excavation context due to varying sample sizes. In general, however, most sub-sectors are dominated by flakes measuring greater than 12.7mm, suggesting that limited in-situ tool production was occurring, and was likely not restricted to specialized areas within the site. This confirms the work conducted by Stone (1983) who found no evidence for specialized production locations at the site of Huari. (For additional tables see Appendix 2.11 and 2.12).

	< 6.35mm	6.35–12.7mm	12.7–25.4mm	> 25.4mm	Total
A4-B4	2 (18.18%)	1 (9.09%)	5 (45.45%)	3 (27.27%)	11 (100%)
A5	0 (0%)	0 (0%)	20 (68.97%)	9 (31.03%)	29 (100%)
A6	0 (0%)	0 (0%)	24 (70.59%)	10 (29.41%)	34 (100%)
B4	0 (0%)	8 (14.81%)	28 (51.85%)	18 (33.33%)	54 (100%)
B5-B6	0 (0%)	0 (0%)	7 (43.75%)	9 (56.25%)	16 (100%)
C5	0 (0%)	0 (0%)	2 (25%)	6 (75%)	8 (100%)
C6	0 (0%)	2 (2.20%)	48 (52.75%)	41 (45.05%)	91 (100%)
A8-B8-A9	0 (0%)	0 (0%)	2 (100%)	0 (0%)	2 (100%)
C9	0 (0%)	0 (0%)	2 (40%)	3 (60%)	5 (100%)
D7-D8	0 (0%)	0 (0%)	10 (62.5%)	6 (37.5%)	16 (100%)
D9	0 (0%)	0 (0%)	31 (45.59%)	37 (54.41%)	68 (100%)
E10	0 (0%)	2 (14.29%)	11 (78.57%)	1 (7.14%)	14 (100%)
N/A	0 (0%)	0 (0%)	7 (53.85%)	6 (46.15%)	13 (100%)

Table 7.26. Flake size-grade by sub-sector.

Flake Size-Grade and Time Period

Of the total flakes analyzed, only 262 were assigned to known temporal contexts. Those that were not able to be classified accurately due to a lack of contextual data are excluded from the analysis presented here. A chi-square test (H_o = no relationship) confirms the null hypothesis, suggesting that there is no relationship between size-grade and time period (value=9.71, df=10, p<0.446). This suggests that the production of expedient flake tools at the site (and limited production of more formal tools) was a pattern that pre-dated the Middle Horizon. Only a slight quantity (n=10) of flakes measuring less than 12.7mm were found in Huarpa and Huarpa/Wari A contexts and were not present in later Wari A and Wari A/B contexts (Table 7.27). (For more tables see Appendix 2.13 and 2.14).

	< 6.35mm	6.35–12.7mm	12.7–25.4mm	> 25.4mm	Total
Huarpa	0 (0%)	7 (5.26%)	63 (47.37%)	63 (47.37%)	133 (100%)
Huarpa, Wari A	0 (0%)	3 (3.75%)	42 (52.5%)	35 (43.75%)	80 (100%)
Wari A	0 (0%)	0 (0%)	2 (100%)	0 (0%)	2 (100%)
Wari A, Wari B	0 (0%)	0 (0%)	22 (70.97%)	9 (29.03%)	31 (100%)
Wari B	0 (0%)	0 (0%)	2 (50%)	2 (50%)	4 (100%)
Huarpa, Wari A, Wari B	0 (0%)	0 (0%)	8 (66.67%)	4 (33.33%)	12 (100%)

Table 7.27. Flake size-grade by time period.

Cortex

The cortex, or exterior weathered surface of the obsidian, is often examined to make inferences about the production phase and intended form of an artifact or assemblage (Bencic 2016). In general, earlier production phases for activities such as core preparation and/or blank production are indicated by an assemblage of flakes with greater amounts of cortex (Bencic 2016). However, cortex alone is not enough to determine either production phase or intended form, and it is often looked at in conjunction with flake size. Cortex measurements were examined for 358 flakes, and categorized into one of four groups: 1) 100% cortex; 2) 50-99% cortex; 3) 1-49% cortex; and 4) 0% cortex. Most of the flakes presented with zero amounts of cortex (n=277; 77.3%) (Table 7.28). Unsurprisingly, none of the flakes had 100% cortex, as this is an impossibility. Because cortex is more prevalent during earlier stages of core preparation and blank production activities, the fact that only 2.23% (n=8) of all analyzed flakes presented with more than 50% cortex, suggests that it is unlikely that early production phases were occurring within Vegachayuq Moqo.

Cortex and Size-Grade

Within the assemblage, the greatest presence of cortex (> 50%) was found on flakes measuring larger than 12.7mm (n=8; 2.23%). In total, 81 flakes (22.63%) displayed some amount of cortex (> 1%). Of all flakes that do contain cortex, 35 (9.78%) measured 12.7-25.4mm and 46 (12.85%) measured greater than 25.4mm (Table 7.29). A chi-square test (value=16.315, df=6, p<0.012) suggests that there may be a loose relationship between the amount of cortex present on flakes and the size of the flake. The relatively sizable amount of flakes larger than 12.7mm that present cortex (though not in a quantity nor the size-grade to suggest systematic on-site formal tool production), does suggest the use of expedient tools and the availability of raw material that requires little to no modification (Bencic 2016: 167). This pattern in cortex and cortex/size-grade is also seen at the site of Conchopata (Bencic 2016). (For additional tables see Appendix 2.15).

	0% Cortex	***1–49% Cortex***	***50–99% Cortex***	***100% Cortex***	***Total***
Count	277 (77.3%)	73 (20.39%)	8 (2.23%)	0 (0%)	358 (100%)

Table 7.28. Cortex present on flake artifacts.

	0% Cortex	***1–49% Cortex***	***50–99% Cortex***	***100% Cortex***	***Total***
< 6.35mm	2 (0.56%)	0 (0%)	0 (0%)	0 (0%)	2 (0.56%)
6.35–12.7mm	13 (3.63%)	0 (0%)	0 (0%)	0 (0%)	13 (3.63%)
12.7–25.4mm	159 (44.41%)	29 (8.10%)	6 (1.68%)	0 (0%)	194 (54.19%)
> 25.4mm	103 (28.77%)	44 (12.29%)	2 (0.56%)	0 (0%)	149 (41.62%)
Total	277 (77.37%)	73 (20.39%)	8 (2.23%)	0 (0%)	358 (100%)

Table 7.29. Cortex present on flake artifacts by size-grade.

Cortex and Sector, Sub-Sector and Time Period

A chi-square test (H_o = null relationship) was conducted for the variables of cortex and sector, and the test does not support the null hypothesis (value=12.810, df=4, $p<0.0008$). This suggests that cortex and sector may be loosely related. As seen in Table 7.30, the sample size within each sector may skew the results. Of note, however, is that most flakes with no cortex were found in Sector II (n=188; 80.34%) and Sector I was evenly split between flakes with no cortex and flakes with up to 49% cortex (n=5; 45.45%). A chi-square test (H_o = no relationship) confirms the null hypothesis and suggests there is no relationship between cortex and sub-sector (value=38.464, df=24, $p<0.031$).

	0% Cortex	***1–49% Cortex***	***50–99% Cortex***	***100% Cortex***	***Total***
Sector I	5 (45.45%)	5 (45.45%)	1 (9.09%)	0 (0%)	11 (100%)
Sector II	188 (80.34%)	39 (16.67%)	7 (2.99%)	0 (0%)	234 (100%)
Sector III	84 (74.34%)	29 (25.66%)	0 (0%)	0 (0%)	113 (100%)

Table 7.30. Cortex by sector.

	0% Cortex	***1-49% Cortex***	***50-99% Cortex***	***100% Cortex***	***Total***
A4-B4	5 (45.45%)	5 (45.45%)	1 (9.09%)	0 (0%)	11 (100%)
A5	18 (62.07%)	8 (27.59%)	3 (10.34%)	0 (0%)	29 (100%)
A6	26 (76.47%)	8 (23.53%)	0 (0%)	0 (0%)	34 (100%)
B4	1 (50%)	1 (50%)	0 (0%)	0 (0%)	2 (100%)
B5-B6	44 (84.62%)	6 (11.54%)	2 (3.85%)	0 (0%)	52 (100%)
C5	11 (68.75%)	5 (31.25%)	0 (0%)	0 (0%)	16 (100%)
C6	6 (75%)	2 (25%)	0 (0%)	0 (0%)	8 (100%)
A8-B8-A9	79 (86.81%)	10 (10.99%)	2 (2.20%)	0 (0%)	91 (100%)
C9	4 (80%)	1 (20%)	0 (0%)	0 (0%)	5 (100%)
D7-D8	15 (93.75%)	1 (6.25%)	0 (0%)	0 (0%)	16 (100%)
D9	47 (69.12%)	21 (30.88%)	0 (0%)	0 (0%)	68 (100%)
E10	12 (85.71%)	2 (14.29%)	0 (0%)	0 (0%)	14 (100%)
N/A	9 (75%)	3 (25%)	0 (0%)	0 (0%)	12 (100%)

Table 7.31. Cortex by sub-sector.

A chi-square test examining the relationship between cortex and time period (H_o = no relationship) confirms the null hypothesis and suggests that there is no relationship between the variables (value=10.131, df=10, p<0.429). 81.25% (n=65) of the flakes from Huarpa/Wari A contexts present with zero cortex, suggesting greater levels of reduction and/or later production activities; in comparison, only 67.74% (n = 21) of the flakes from Wari A/Wari B contexts present with zero cortex (Table 7.32). In conjunction, the greatest proportion of flakes with up to 49% cortex are found in Wari A/Wari B contexts, suggesting lower levels of reduction during this time period. (For additional tables see Appendix 2.16-2.20). In general, however, the results suggest overall minimal levels of later stage production processes (Bencic 2016).

	0% Cortex	***1-49% Cortex***	***50-99% Cortex***	***100% Cortex***	***Total***
Huarpa	103 (78.62%)	27 (20.61%)	1 (0.76%)	0 (0%)	131 (100%)
Huarpa, Wari A	65 (81.25%)	11 (13.75%)	4 (5%)	0 (0%)	80 (100%)
Wari A	1 (50%)	1 (50%)	0 (0%)	0 (0%)	2 (100%)
Wari A, Wari B	21 (67.74%)	9 (29.03%)	1 (3.23%)	0 (0%)	31 (100%)
Wari B	3 (75%)	1 (25%)	0 (0%)	0 (0%)	4 (100%)
Huarpa, Wari A, Wari B	11 (91.67%)	1 (8.33%)	0 (0%)	0 (0%)	12 (100%)

Table 7.32. Cortex by time period.

Terminations, Striking Platforms and Flake Scars

Flake termination refers to the shape of the distal end of the detached flake (struck off of the objective piece). In flintknapping, especially with a homogenous material like obsidian, a feathered termination is ideal and shows that the force of the strike traveled through the objective piece at optimum speed and distance. Most other types of terminations (hinged, step, and overshot) are considered errors and often result in unusable and/or broken cores, tools and objective pieces (Odell 2004; Bencic 2016). Because of this, termination is a useful indicator for the technical skill of the producer. More highly skilled tool-makers should create a much greater number of feathered terminations than less-skilled producers. 358 flakes were analyzed for termination (see Table 7.33), of those 193 (53.91%) flakes presented with feathered terminations while 165 (46.09%) presented with hinged, stepped, or overshot terminations. Because there is a relatively high proportion of flakes with terminations other than feathered, it suggests that the obsidian producers at Vegachayuq Moqo were not highly-skilled in biface or projectile point production techniques (Bencic 2016). Bencic (2016) found a similar pattern at the neighboring site of Conchopata. This pattern, coupled with striking platform and flake size, suggest a pattern of expedient tool production and use at the site. Parry and Kelly outline several key features of expedient tool production/core technology: 1) flaking techniques do not control for form of the flake, requiring little technical training or practice; 2) there is no distinction between "waste" and "tool"; and 3) tools are rarely modified, and are generally discarded after initial use (Parry and Kelly 1987: 287).

	Feathered	***Hinged, Stepped, Overshot***	***Total***
Count	193 (53.91%)	165 (46.09%)	358 (100%)

Table 7.33. Flake terminations.

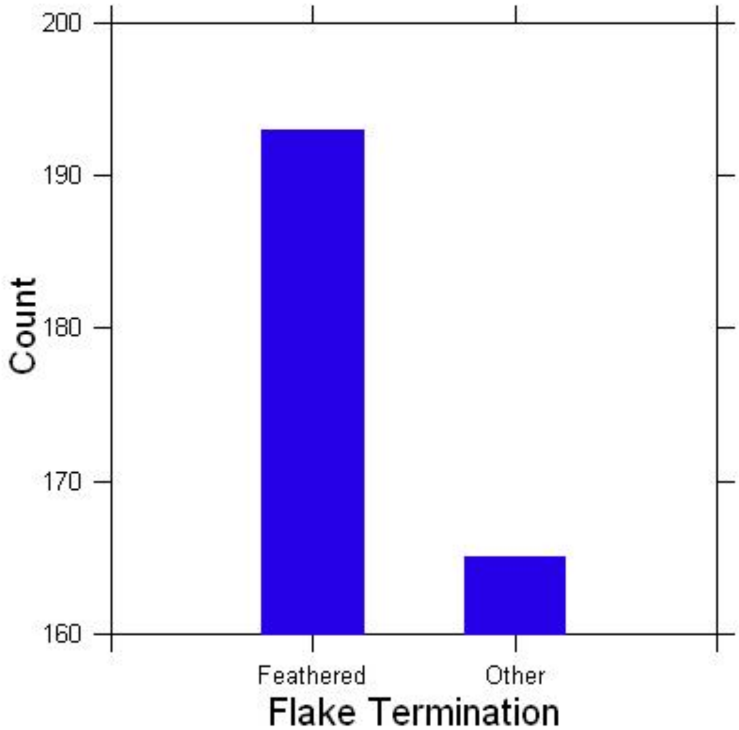


Figure 7.7. Graph of flake termination.

Flake Termination by Sector, Sub-Sector, and Time Period

Variations in the proportional frequency of terminations by context may also allow insight into varying production zones within the site. A chi-square test (H_o = no relationship) confirms the null hypothesis and suggests that there is no relationship between sector and flake termination (value=4.40, df=8, p<0.819). In general, feathered terminations make up just over half of the assemblage in Sectors II and III, while Sector I shows a greater proportion of hinged, stepped or overshot terminations (Table 7.34). As Sector I also contains material with relatively higher proportions of cortex, it may suggest that it was a location for expedient tool production, though not significantly different than Sectors II and III. Similarly, a chi-square test (H_o = no relationship) confirms the null hypothesis and suggests there is not a relationship between sub-sector and termination (value=59.157, df=48, p<0.130). The assemblage is relatively split between feathered and other termination types across sub-sectors with the exception of sub-sector C5, where 75% of the assemblage (n=6) is feathered terminations (Table 7.35).

Flake terminations are also relatively evenly distributed across time periods, and a chi-square test (H_o = no relationship) confirms the null hypothesis and suggests that time period and termination are also not related variables (value=21.539, df=20, $p<0.366$). One notable pattern is a small decrease in the frequency of feathered terminations through time, possibly suggesting that technical skill at lithic production decreased over time, although this result is not statistically significant. (For additional tables see Appendix 2.21-2.23).

	Feathered	***Hinged, Stepped, Overshot***	***Total***
Sector I	4 (36.36%)	7 (63.64%)	11 (100%)
Sector II	126 (53.85%)	108 (46.15%)	234 (100%)
Sector III	63 (55.75%)	50 (44.25%)	113 (100%)

Table 7.34. Flake termination by sector.

	Feathered	***Hinged, Stepped, Overshot***	***Total***
A4-B4	4 (36.36%)	7 (63.63%)	11 (100%)
A5	15 (57.69%)	11 (42.31%)	26 (100%)
A6	18 (52.94%)	16 (47.06%)	34 (100%)
B4	30 (55.56%)	24 (44.44%)	54 (100%)
B5-B6	7 (43.75%)	9 (56.25%)	16 (100%)
C5	6 (75%)	2 (25%)	8 (100%)
C6	45 (49.45%)	46 (50.55%)	91 (100%)
A8-B8-A9	1 (50%)	1 (50%)	2 (100%)
C9	2 (40%)	3 (60%)	5 (100%)
D7-D8	11 (68.75%)	5 (31.25%)	16 (100%)
D9	35 (51.47%)	33 (48.53%)	68 (100%)
E10	8 (57.14%)	6 (42.86%)	14 (100%)
N/A	11 (84.62%)	3 (23.08%)	13 (100%)

Table 7.35. Flake termination by sub-sector.

	Feathered	*Hinged, Stepped, Overshot*	*Total*
Huarpa	76 (57.14%)	57 (42.86%)	133 (100%)
Huarpa, Wari A	40 (50%)	40 (50%)	80 (100%)
Wari A	1 (50%)	1 (50%)	2 (100%)
Wari A, Wari B	13 (41.94%)	18 (58.06%)	31 (100%)
Wari B	2 (50%)	2 (50%)	4 (100%)
Huarpa, Wari A, Wari B	7 (58.33%)	5 (41.67%)	12 (100%)

Table 7.36. Flake termination by time period.

Flake Striking Platform

In addition to flake termination the striking platform can also reveal information about tool production techniques. The striking platform refers to the location on the objective piece where force is applied to remove detached pieces during production processes. Complex platforms are generally associated with tool production, while flat and cortical platforms are less likely to be the result of formal tool production. The striking platform was analyzed for 297 flakes; those for which the platform was difficult to accurately identify were not included in the analysis (see Table 7.37). Abraded platforms were also not included in the sample due to the difficulty in differentiating between intentional and natural abrasion (Bencic 2016). Of the flakes analyzed, only 154 (51.85%) presented with complex platforms. Because half of the flakes did not present with complex platforms (and instead with cortical or flat), it is unlikely that biface production was the primary objective of producers and consumers of obsidian at Vegachayuq Moqo, though it appears that it did occur to some extent. This is a similar to pattern to that found at Conchopata, where Bencic (2016) found that 44% of the flakes within the sample presented with a complex platform, suggesting that producers at Conchopata were not intending to make bifaces or projectile points.

	Flat	*Complex*	*Cortical*	*Total*
Count	110 (37.03%)	154 (51.85%)	33 (11.11%)	297 (100%)

Table 7.37. Flake striking platform.

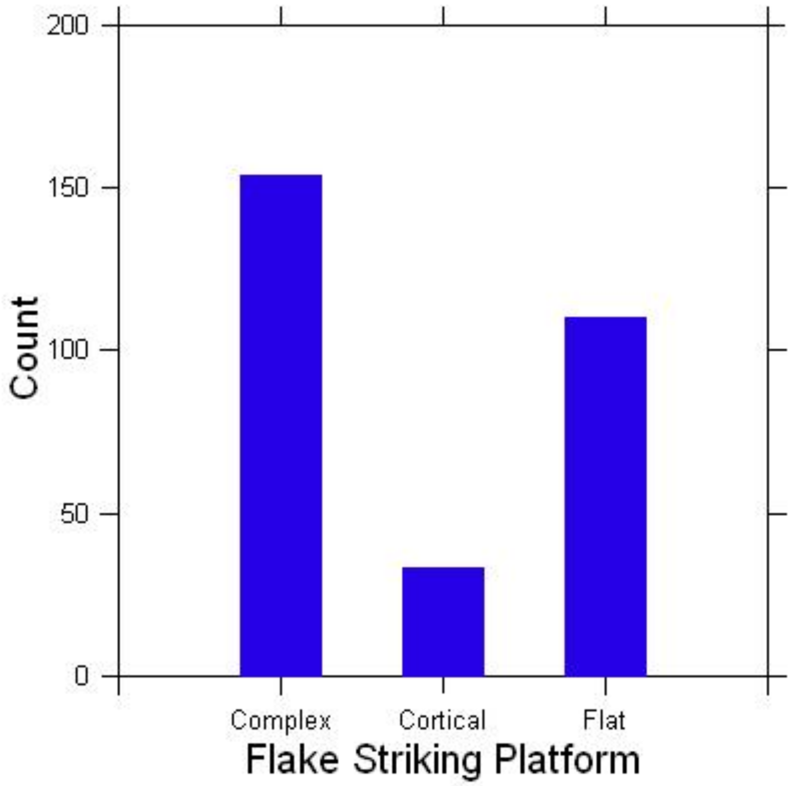


Figure 7.8. Graph of flake striking platform count.

Striking Platform by Sector, Sub-sector and Time Period

A chi-square test was conducted to test the relationship between the variables (H_o = no relationship). The results confirmed the null hypothesis and suggested that there is no relationship between striking platform and sector (value=20.550, df=10, p<0.024). Within Sector II, 57.65% (n=113) presented with complex platforms. In Sector III, 42.86% (n=39) had complex platforms and in Sector I only 20% had complex platforms (n=2) (Table 7.38). Because Sector I contains the fewest amount of complex platforms as well as the most stepped, hinged or overshot terminations, it suggests that more expedient tool production was occurring in this sector. However, results are not statistically significant, suggesting no variation in production type across the sectors.

A chi-square test was also conducted to look at striking platform and sub-sector (H_o = no relationship), and the results confirm the null hypothesis and suggest there is no relationship between the variables (value=83.739, df=60, p<0.023) (Table 7.39). Similar to other examinations of time period in relation to flake feature, it appears that there is also no relationship between the striking platform and time period (value=18.630, df=25, p<0.815). This suggests that production type followed a pattern that pre-dated the Middle Horizon occupation of the site. (For additional tables see Appendix 2.24-2.26). Parry and Kelly (1987) attribute emergent expedient core technologies as being linked to shifting settlement patterns. Through comparative analyses, they argue that expedient core technologies appear to be concurrent with the settlement of populations into large, nucleated, permanent villages (Parry and Kelley 1987: 297). This might attest to the pattern of expedient tool use and production at Huari predating the middle Horizon to the Huarpa period.

	Flat	***Complex***	***Cortical***	***Total***
Sector I	7 (70%)	2 (20%)	1 (10%)	10 (100%)
Sector II	63 (32.14%)	113 (57.65%)	20 (10.20%)	196 (100%)
Sector III	40 (43.96%)	39 (42.86%)	12 (13.19%)	91 (100%)

Table 7.38. Flake striking platform by sector.

	Flat	Complex	Cortical	Total
A4-B4	7 (70%)	2 (20%)	1 (10%)	10 (100%)
A5	6 (27.27%)	12 (54.55%)	4 (18.18%)	22 (100%)
A6	9 (34.62%)	13 (50%)	4 (15.38%)	26 (100%)
B4	5 (12.20%)	30 (73.17%)	6 (14.63%)	41 (100%)
B5-B6	5 (31.25%)	7 (43.75%)	4 (25%)	16 (100%)
C5	4 (50%)	2 (25%)	2(25%)	8 (100%)
C6	32 (40.51%)	47 (59.49%)	0 (0%)	79 (100%)
A8-B8-A9	1 (50%)	1 (50%)	0 (0%)	2 (100%)
C9	2 (33.33%)	2 (33.33%)	2 (33.33%)	6 (100%)
D7-D8	3 (15.79%)	8 (42.11%)	8 (42.11%)	19 (100%)
D9	27 (41.54%)	19 (29.23%)	19 (29.23%)	65 (100%)
E10	3 (15.79%)	8 (42.11%)	8 (42.11%)	19 (100%)
N/A	6 (50%)	3 (25%)	3 (25%)	12 (100%)

Table 7.39. Flake platform by sub-sector.

	Flat	Complex	Cortical	Total
Huarpa	37 (33.94%)	55 (50.46%)	17 (15.60%)	109 (100%)
Huarpa, Wari A	31 (44.93%)	35 (50.72%)	3 (4.35%)	69 (100%)
Wari A	1 (50%)	1 (50%)	0 (0%)	2 (100%)
Wari A, Wari B	6 (24%)	13 (52%)	6 (24%)	25 (100%)
Wari B	2 (50%)	1 (25%)	1 (25%)	4 (100%)
Huarpa, Wari A, Wari B	1 (11.11%)	6 (66.67%)	2 (22.22%)	9 (100%)

Table 7.40. Flake platform by time period.

Flake Scars

Flake scars represent those additional flakes taken off of the surface of the flake either prior to or after its detachment from the objective piece. More heavily produced tools (such as bifaces and projectile points), as well as flakes taken off from a heavily worked core, tend to have the most flake scars. Most flakes in the assemblage presented with zero flake scars (n = 103, 28.77%) and only 74 flakes (20.67%) had greater than five flake scars (Table 7.41). Flakes with zero flake scars suggest expedient tool production or early-phase production processes. Due to the results presented for cortex, platform and termination, it is likely that producers at Vegachayuq Moqo were producing expedient tools. Furthermore, the majority of flakes with more than five flakes scars were measured larger than 12.7mm, larger than would be expected for formal tool production. A chi-square test suggests a relationship between flake size-grade and flake scars (value=26.298, df=9, p<0.002), further confirming that flake scars at Vegachayuq Moqo are more representative of expedient tool production than early-phase production activities (Parry and Kelly 1987).

	0 Flake Scars	***1 Flake Scar***	***2-5 Flake Scars***	***> 5 Flake Scars***	***Total***
Count	103 (28.77%)	98 (27.37%)	83 (23.18%)	74 (20.67%)	358 (100%)

Table 7.41. Flake Scars

	0 Flake Scars	***1 Flake Scar***	***2-5 Flake Scars***	***> 5 Flake Scars***	***Total***
< 6.35mm	2 (0.56%)	0 (0%)	0 (0%)	0 (0%)	2 (0.56%)
6.35–12.7mm	2 (0.56%)	6 (1.68%)	5 (0.14%)	0 (0%)	13 (3.63%)
12.7–25.4mm	67 (18.72%)	52 (14.53%)	46 (12.85%)	29 (8.10%)	194 (54.19%)
> 25.4mm	32 (8.93%)	40 (11.17%)	32 (8.93%)	45 (12.57%)	149 (41.62%)
Total	103 (28.77%)	98 (27.37%)	83 (23.18%)	74 (20.67%)	358 (100%)

Table 7.42. Flake scars by size-grade.

Flake Scars Sector, Sub-sector and Time Period

A chi-square test (H_o = no relationship) was conducted to examine the relationship between flake scars and sector. The results confirm the null hypothesis and suggest that there is no relationship between the two variables (value=10.861, df=6, p<0.093). However, it may be notable that within Sector I, 63.64% of the assemblage is comprised of flakes with zero flake scars (Table 7.43). This is in comparison to Sectors II and III where approximately 27% of the assemblage is flakes with zero flake scars. Although Sector I has a small sample size (likely leading to the statistical insignificance), this does match the expedient tool production suggested in Sector I (greater cortex, hinged/stepped/overshot terminations and flat/cortical platforms). Again, the results are too similar across sectors to be of statistical significance. A chi-square test (H_o = no relationship) examining the relationship between sub-sector and flake scars, does not however, support the null hypothesis (value=78.670, df=36, p<0.0001). This may be due to a more even sample size distribution among the sub-sectors (in comparison to by sector).

A chi-square test (H_o = no relationship) examining flake scars and time period confirms the null hypothesis and suggests there is no relationship between the variables (value=28.561, df=15, p<0.018). As seen in previous results, it appears that production techniques, intended tools as well as technical skill are relatively consistent from the Huarpa occupation through the Wari occupation in the Middle Horizon. The only pattern of note may be the slightly greater proportion of flakes with zero flake scars during the Middle Horizon (Table 7.45), suggesting that Middle Horizon occupation of the site was producing relatively more expedient tools over formal tools than during the earlier Huarpa period.

	0 Flake Scars	***1 Flake Scar***	***2-5 Flake Scars***	***> 5 Flake Scars***	***Total***
Sector I	7 (63.64%)	2 (18.18%)	2 (18.18%)	0 (0%)	11 (100%)
Sector II	65 (27.78%)	62 (26.50%)	57 (24.36%)	50 (21.37%)	234 (100%)
Sector III	31 (27.43%)	34 (30.09%)	24 (21.24%)	24 (21.24%)	113 (100%)

Table 7.43. Flake scars by sector.

	0 Flake Scars	*1 Flake Scar*	*2-5 Flake Scars*	*> 5 Flake Scars*	*Total*
A4-B4	7 (63.63%)	2 (18.18%)	2 (18.18%)	0 (0%)	11 (100%)
A5	8 (27.59%)	13 (44.83%)	5 (17.24%)	3 (10.34%)	29 (100%)
A6	14 (41.18%)	10 (29.41%)	6 (17.65%)	4 (11.76%)	34 (100%)
B4	8 (15.38%)	11 (21.15%)	19 (36.54%)	14 (26.92%)	52 (100%)
B5-B6	3 (18.75%)	2 (12.5%)	3 (18.75%)	8 (50%)	16 (100%)
C5	5 (62.5%)	3 (37.5%)	0 (0%)	0 (0%)	8 (100%)
C6	26 (28.57%)	21 (23.08%)	24 (26.37%)	20 (21.98%)	91 (100%)
A8-B8-A9	1 (50%)	1 (50%)	0 (0%)	0 (0%)	2 (100%)
C9	3 (60%)	2 (40%)	0 (0%)	0 (0%)	5 (100%)
D7-D8	5 (31.25%)	2 (12.5%)	6 (37.5%)	3 (18.75%)	16 (100%)
D9	16 (23.53%)	23 (33.82%)	9 (13.24%)	20 (29.41%)	68 (100%)
E10	1 (7.14%)	5 (35.71%)	8 (57.14%)	0 (0%)	14 (100%)
N/A	6 (50%)	3 (25%)	1 (8.33%)	2 (16.67%)	12 (100%)

Table 7.44. Flake scars by sub-sector.

	0 Flake Scars	*1 Flake Scar*	*2-5 Flake Scars*	*> 5 Flake Scars*	*Total*
Huarpa	29 (22.14%)	38 (29.01%)	28 (21.37%)	36 (27.48%)	131 (100%)
Huarpa, Wari A	27 (33.75%)	15 (18.75%)	21 (26.25%)	17 (21.25%)	80 (100%)
Wari A	1 (50%)	1 (50%)	0 (0%)	0 (0%)	2 (100%)
Wari A, Wari B	14 (45.16%)	9 (29.03%)	4 (12.90%)	4 (12.90%)	31 (100%)
Wari B	2 (50%)	2 (50%)	0 (0%)	0 (0%)	4 (100%)
Huarpa, Wari A, Wari B	5 (41.67%)	1 (8.33%)	5 (41.67%)	1 (8.33%)	12 (100%)

Table 7.45. Flake scars by time period.

Projectile Points

As seen in Table 7.18, projectile points (n=24) comprise 3.82% of the artifact assemblage. Eight of the projectile points were found associated with Huarpa contexts while six were found in Middle Horizon contexts, and three pertain to contexts dating to the consolidation phase of the Wari Empire. Because most of the projectile points found were broken (all but one), it is difficult to look at dimensional attributes or diagnostic features of the body or base; the base is the most diagnostic part of the projectile point, and without it it is difficult to define chronological associations. Only three points (0340, 0561 and 0562) have intact bases and none of these were hafted. Two were straight bases (0340, 0562) and both came from different sectors (II and III), sub-sectors (A5 and D9) and temporal contexts (N/A and Huarpa). One point had a convex base (0561) and was found in sector III, sub-sector D9. This is also the only complete point, and represents Vining (2005)'s "type D", or Wari style point (Table 7.46, Figure 5.3). Its association with Huarpa contexts further shows the difficulty in assigning temporal phases to non-diagnostic obsidian material based on excavation context.

	Sector	***Sub-sector***	***Time Period***	***Thickness (mm)***	***Body***	***Base***
0026	2	B4	Huarpa	5.84	N/A	N/A
0036	2	B4	Huarpa	N/A	N/A	N/A
0064	2	B4	Huarpa	5.11	N/A	N/A
0069	2	B4	N/A	5.45	N/A	N/A
0165	2	C6	N/A	2.7	N/A	N/A
0200	2	C6	Huarpa, Wari A	7.24	N/A	N/A
0281	2	A6	Wari A, Wari B	N/A	N/A	N/A
0282	2	A6	Wari A, Wari B	4.47	N/A	N/A
0287	2	B5-B6	N/A	2.09	N/A	N/A
0338	2	A5	N/A	N/A	N/A	N/A
0339	2	A5	N/A	N/A	N/A	N/A
0340	2	A5	N/A	N/A	N/A	Straight
0389	2	A5	N/A	N/A	N/A	N/A
0493	3	N/A	N/A	4.78	N/A	N/A
0505	3	D9	Huarpa, Wari A	5.26	N/A	N/A
0506	3	D9	Huarpa, Wari A	6.71	N/A	N/A
0508	3	D9	Wari B	3.69	N/A	N/A
0519	3	N/A	N/A	4.41	N/A	N/A
0520	3	N/A	N/A	4.35	N/A	N/A
0530	3	D9	Huarpa	4.94	N/A	N/A
0553	3	D9	Huarpa	N/A	N/A	N/A
0554	3	D9	Huarpa	4.56	N/A	N/A
0561	3	D9	Huarpa	4.56	Lanceolate	Convex
0562	3	D9	Huarpa	5.83	N/A	Straight

Table 7.46. Projectile Points

Point 0282

Point 0281

Point 0287

Point 0338

Point 0340

Point 0339

Point 0493

Point 0505

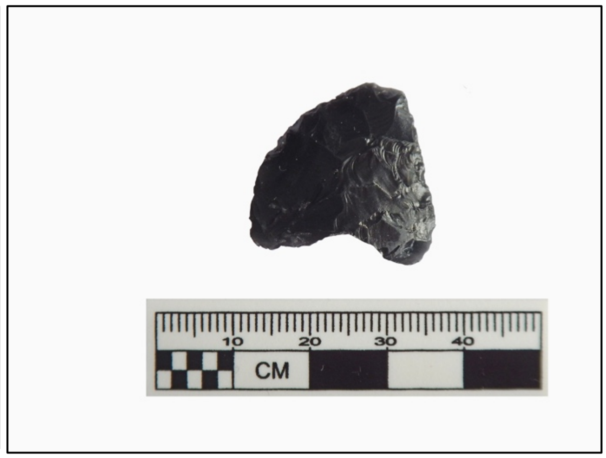
Point 0506

Point 0508

Point 0519

Point 0520

Point 0530



Point 0553

Point 0554

Point 0561

Point 0026

Point 0064

Point 0069

Point 0165

Point 0200

Figure 7.9. Projectile points, images taken by the author.

III. Summary

While a more detailed discussion the results (coupled with the results for the PXRF analysis) can be found in Chapter 9, a preliminary summary of the results in presented here. The three sectors of Vegachayuq Moqo produced different amounts of obsidian material, however this is likely due to varying excavation sizes and not differential production within the site. Sectors II and III produced a relatively similar amount of material (around 48% each) while Sector I produced around only 2.83% of the total obsidian from the 2012 excavation season. The limited sample size from Sector I makes drawing spatial conclusions on obsidian use and production at the site difficult. In her 1983 dissertation, Jane Stone (1983) found no evidence for specialized production locations at the site, and no evidence for specialized production locations was found at the neighboring site of Conchopata as well (Bencic 2016), suggesting that it may be more important to look at production and consumption by sub-sector and time period. This chapter explored artifact attribute variables of artifact type, flake size-grade, cortex, termination, striking platform, and flake scars.

The results show a general pattern for greater amounts of flakes (expedient tools and debitage) within the Vegachayuq Moqo than any other artifact type. This pattern is consistent across all sectors, sub-sectors and time periods (n=361; 57%). Bifaces and points comprise a relatively low portion of the total assemblage (n=46; 7%). The presence of bifaces and projectile points within the sample stays fairly consistent through time, with a slightly greater representation of projectile points within the Wari A and Wari A/B assemblages. In general, however, it appears that occupants at the site of Huari were not producing bifaces, projectile points or other formal tools in situ. Because flake size can serve as a general indicator for production activity, the relative paucity of flakes measuring less than 12.7mm, and the abundance of flakes measuring over 25.4mm suggests that limited bifacial production was occurring at Vegachayuq Moqo, and what production was occurring was either early phase production activities or largely expedient in nature. The relative absence of cortex on flakes within the assemblage suggests that production was expedient in nature. Only 2% of the flakes had more than 50% cortex, suggesting that limited early phase production activities were occurring in-situ, and therefore, the large size of the flakes found in the assemblage are likely the result of expedient production. This result matches those of Stone's (1983) dissertation work at the site of Huari, and those of Bencic (2016) at the Wari site of Conchopata. A comparison of flake-size across time period suggests that this pattern of expedient tool production (and limited or no bifacial production) pre-dates the Wari, Middle Horizon occupation of the site.

The expedient nature of the material produced and used at Vegachayuq Moqo is also related to the technical skill of the producers (Parry and Kelly 1987). The flake termination, or the shape of the distal end of a detached flake, can be an indicator for the technical skill of the producer, with feathered terminations created from more precise production techniques, particularly so for obsidian which has a homogenous, conchoidal fracture pattern making it one of the most easily produced and predictable materials to work with. At the site of Vegachayuq Moqo, just over half of the assemblage is characterized by feathered termination, much lower than would be expected for more highly-skilled producers (Bencic 2016). Although feathered terminations are slightly more prevalent during the Huarpa occupation of the site (57%), there are appears to be no statistical difference in termination type across time periods, suggesting that the technical skill of producers at the site (producing expedient tools) pre-dates the Wari occupation. The striking platform adds to the picture of Huari producers/consumers as ordinary producers, making expedient tools for likely personal consumption. Complex striking platforms indicate an intent to produce bifacial tools, and at Vegachayuq Moqo only 50% of the flakes have complex platforms, again, too low to suggest widespread biface/projectile point production. This further confirms that producers at Vegachayuq Moqo were not intending to produce bifacial tools and not succeeding, they were instead intending to produce expedient tools, for which high levels of technical skill is not necessary.

The patterns presented here very closely follow those seen at the Wari site of Conchopata (Bencic 2016), and may signify what Klarich et al. (2017) have termed "cavalier crafting". In other words, individuals at the site of Huari were producing expedient tools to be used on an individual/household basis, and were not taking great care in the type of tool, or the resuse of the tool. Bencic (2016) suggests this may be due to a relative ubiquity of obsidian at the site, and a perception by occupants at Huari that obsidian was a renewable, widely available resource. This is in direct contrast to what might be assumed, based on the relatively limited nature of obsidian sources in general. Chi-square tests examining attribute variables and time period, all confirmed the null hypothesis suggest that there was no relationship between the variables. In other words, the pattern of obsidian production, consumption at the site appears to pre-date the Middle Horizon, suggesting that the Wari occupants of the site were following an established pattern of obsidian use that pre-dated the empire, and the Wari political economy.

CHAPTER 8

OBSIDIAN SOURCING RESULTS

The obsidian data forming the basis of this dissertation were not only analyzed by lithic attributes (as seen in Chapter 7), but also by elemental analysis with the use of portable x-ray fluorescence (PXRF). PXRF analysis of the data explores the composition of trace elements within the obsidian sample, which can be used to determine obsidian source-type. As discussed in Chapter 5, obsidian is produced in a singular volcanic event, leaving a unique signature of trace elements within all obsidian from that specific location, or source-type. Looking at obsidian source-types present within the sample of artifacts from Vegachayuq Moqo, and subsequently exploring patterned variation in the use of source-types across the site, can illuminate aspects of a Wari political economy. This analysis uses PXRF to determine obsidian source-type from 505 sampled artifacts. Each artifact underwent PXRF analysis three times (180 seconds each), with the elemental reading taken from three different locations on the artifact to ensure accuracy of results (for a more detailed discussion on methods see Chapter 6). The trace element signature from each artifact was then compared to known source-types (acquired from the author's own data collected from UC Berkeley), to produce a confident source-type for each sample. The results were then compiled with the attribute results in Chapter 7 to provide a more nuanced picture of production, consumption and use of obsidian at Vegachayuq Moqo.

I. Portable X-Ray Fluorescence

The artifacts sampled for PXRF analysis derive from the same dataset addressed in the previous chapter (Chapter 7). Of the 628 total artifacts, only 505 were analyzed using PXRF. Those samples that were omitted include artifacts measuring less than 5mm in thickness (inconsistent reading of elements at varying depths), and those with permanent catalogue and inventory marks obscuring the surface of the artifact (compromised integrity of the elemental signature). (For more information on sampling procedure see Chapter 6).

Of the 505 artifacts analyzed for elemental composition using PXRF, 16 (3.16%) were from Sector I, 333 (65.81%) were from Sector II, and 157 (31.03%) were from Sector III (Table 8.1). This ratio across sectors is very similar to that seen in the attribute analysis in Chapter 7 (Table 7.1), confirming that the artifacts analyzed using PXRF form a representative sample of the entire collection. Further confirming the representative sample are the ratios of the artifacts analyzed using PXRF across sub-sector (Table 8.2), which are also very similar to those seen in the attribute analysis. The artifacts analyzed using PXRF also represent a similar sample across time periods, however Wari A (early expansion phase) and Wari B (later consolidation phase) are slightly more represented (19.51% in comparison to 12.7%) (see Table 8.3). This is likely due to differences in the size of the artifacts recovered from later these temporal contexts. In addition, bifaces and projectile points are represented in slightly higher numbers in the PXRF analysis, likely due to the larger size of bifaces and points when compared to flakes and fragments (Table 8.4).

	Sector I	***Sector II***	***Sector III***	***Total***
Count	16 (3.16%)	333 (65.81%)	157 (31.03%)	506 (100%)

Table 8.1. PXRF sample by sector.

	Count
Sub-sector A4-B4	16 (3.16%)
Sub-sector A5	58 (11.46%)
Sub-sector A6	45 (8.89%)
Sub-sector A8-B8-D9	3 (0.59%)
Sub-sector B4	67 (13.24%)
Sub-sector B5-B6	29 (5.73%)
Sub-sector C5	12 (2.37%)
Sub-sector C6	117 (23.12%)
Sub-sector C9	10 (1.98%)
Sub-sector D7-D8	16 (3.16%)
Sub-sector D9	102 (20.16%)
Sub-sector E10	15 (2.96%)
Sub-sector N/A	16 (3.16%)
Total	506 (100%)

Table 8.2. PXRF sample by sub-sector.

	Count
Huarpa	176 (34.85%)
Huarpa, Wari A	118 (23.37%)
Huarpa, Wari A, Wari B	13 (2.57%)
Wari A	2 (0.40%)
Wari B	5 (0.99%)
Wari A, Wari B	40 (19.51%)
Total	506 (100%)

Table 8.3. PXRF sample by time period.

	Count
Biface	22 (4.35%)
Core	1 (0.20%)
Flake	264 (52.17%)
Fragment	194 (38.34%)
Nodule	1 (0.20%)
Point	23 (4.55%)
Uniface	1 (0.20%)
Total	506 (100%)

Table 8.4. PXRF sample by artifact type.

Sourcing Results

The 505 sampled artifacts were all analyzed by their concentrations in parts per million (ppm) of trace elements (for a more detailed discussion on PXRF analysis see Chapter 6). In the Andes, scholars are primarily concerned with the trace elements rubidium (Rb), strontium (Sr), manganese (Mn), iron (Fe), zirconium (Zr) and niobium (Nb) (Craig et al. 2010; Kellett et al. 2013; Burger et al. 2015). The results from the PXRF analysis were then examined against a comparative data collection of known source-types from seven sources: Quispisisa, Alca, Chivay, Jampatilla, Puzolana, Potreropampa, and Lisahuacho. (All comparative data samples were collected by the author at the Archaeological Lab at UC Berkeley using the same Bruker III Tracer and following the same sampling procedure as conducted for all data from Vegachayuq Moqo). The source-types found to be present in the data sample from Vegachayuq Moqo were Quispisisa (n=485, 96.42%), Alca (n=17, 3.38%) and Puzolana (n=1, 0.20%). (Three data points were not assigned to a source-type as they could not be done so confidently). Figure 8.1 shows the distribution of sources by the trace elements of rubidium (Rb) and strontium (Sr). Figure 8.2 shows the distribution of the sample by rubidium (Rb) and zirconium (Zr) (note the change in slope, or ratio of the elements, for the Puzolana source-type). Figure 8.3 shows the distribution of rubidium (Rb) and niobium (Nb) (again note the change in slope of the Puzolana source). By comparing the distribution of the samples across multiple element ratios, the sample is confidently sourced within a 95% confidence interval.

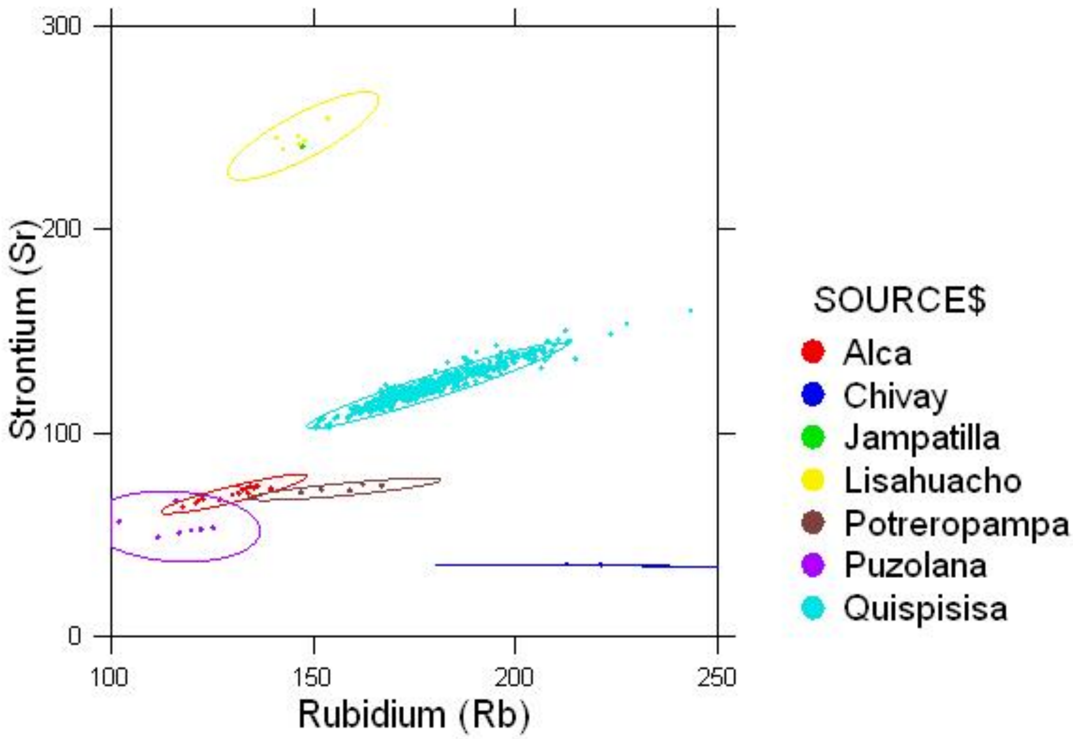


Figure 8.1. Sourcing Results, comparing elemental concentrations in parts per million (ppm) of rubidium (Rb) and strontium (Sr).

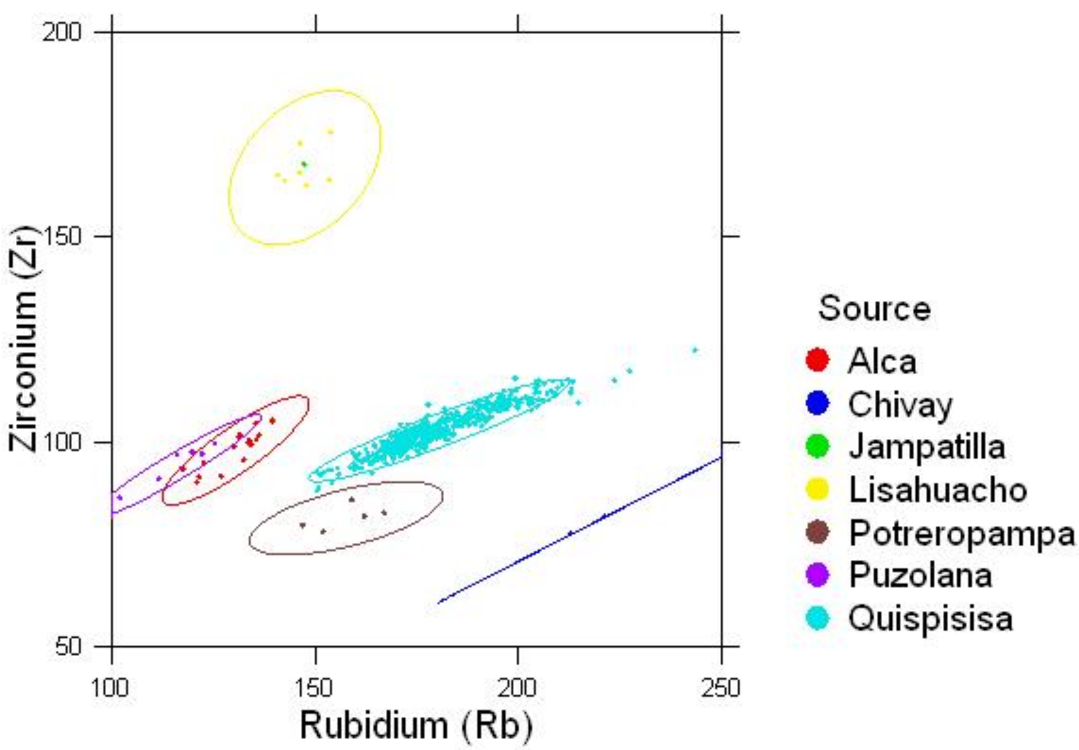


Figure 8.2. Sourcing Results comparing elemental concentrations in parts per million (ppm) of rubidium (Rb) and zirconium (Zr).

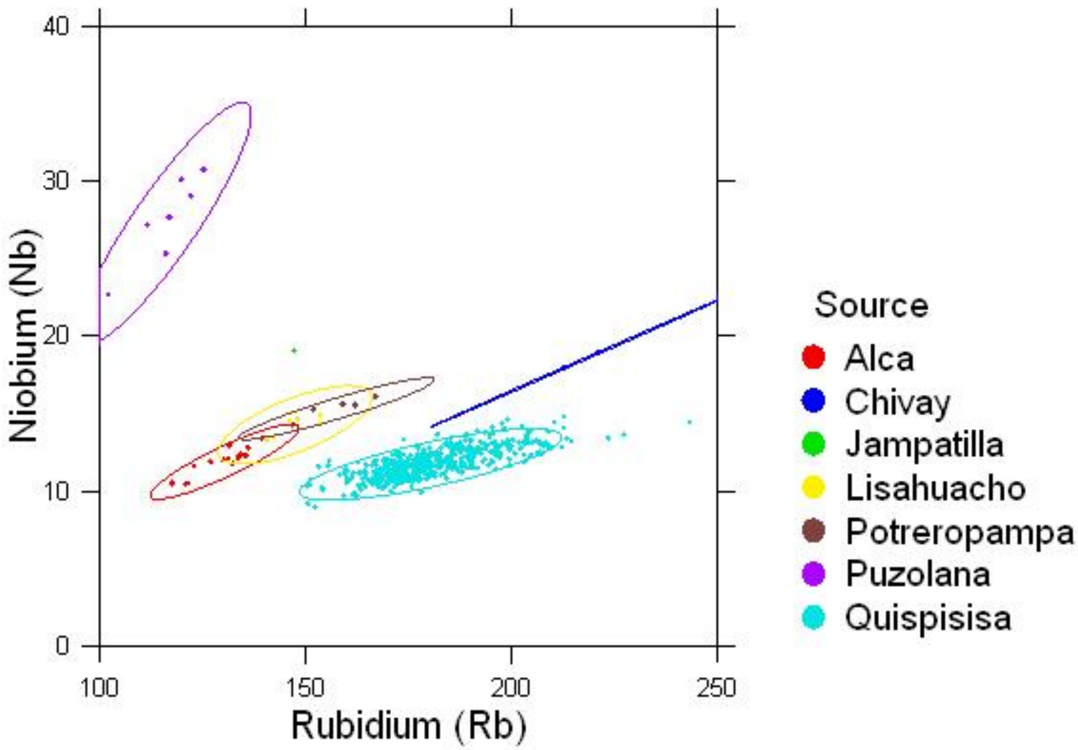


Figure 8.3. Sourcing Results, comparing elemental concentrations in parts per million (ppm) of rubidium (Rb) and niobium (Nb).

The presence of Quispisisa obsidian at Vegachayuq Moqo, comprising over 96% of the sample, is not altogether surprising, and matches the sourcing results from the neighboring site of Conchopata, where over 99% of the obsidian was sourced to Quispisisa (Burger et al. 2016). It also confirms the previous analyses undertaken by Burger et al. (2000), Burger and Glascock (2000), and Burger and Asaro (1977), which show Quispisisa obsidian uniformly dominating assemblages from sites in the central to northern highlands during the Middle Horizon. The presence of Alca obsidian within the sample at Vegachayuq Moqo (comprising just 3% of the sample), deviates from the sourcing results seen at Conchopata, where no obsidian from Alca is present within the sample (Burger et al. 2016). Because the site of Huari is the capital of the Wari Empire, this may account for the presence of Alca obsidian at Vegachayuq Moqo, and its absence at Conchopata. Alca was a dominant source-type in the Cuzco and Arequipa regions and during the Middle Horizon, Alca obsidian is noted to be found in the Wari heartland and farther north (Burger et al. 2000). Its presence within northern samples is likely due to increased movement of peoples and/or Wari investment and control in the Cuzco and Arequipa regions or even of the source itself (Jennings and Glascock 2002; Burger et al. 2000). The singular nodule from Puzolana is not unexpected, as Puzolana is the closest source in geographical proximity to Huari (and is found at 1% at Conchopata) and was used more heavily in the Ayacucho valley prior to the Middle Horizon (Burger et al. 2016). It is notable, however, that it is found in very limited numbers both at Vegachayuq Moqo (n=1) and at Conchopata (n=1) during the Middle Horizon, suggesting an unprecedented influx of Quispisisa obsidian in the region during this time that would have replaced use of the Puzolana source.

II. PXRF Results- Context

Sector

The results from the PXRF analysis indicate that obsidian from Vegachayuq Moqo derived from three distinct obsidian sources (Quispisisa, Alca and Puzolana). Therefore, it is possible to explore variation in source-types by site context and artifact attributes. This section approaches patterns in source-type by context. Most of the obsidian artifacts in the PXRF sample were found in Sector II (n=320, 63.24%), and were sourced to the Quispisisa source-type (Table 8.5). In fact, Quispisisa is the dominant source-type across all sectors (Table 8.6). In comparison, Alca source-type obsidian is found only in Sectors II and III and comprises 3% (n=10) and 4.46% (n=7) of each sector assemblage, respectively (Table 8.6).

Puzolana obsidian is only found in Sector II and comprises 0.30% of the sample (n=1). Despite the greater presence of Quispisisa obsidian in comparison to Alca and Puzolana, there is relatively little variation in the percentage of source-types across sectors (see Table 8.6), suggesting there is no relationship between source-type and sector. A chi-square test (H_o = no relationships) confirms the null hypothesis and suggests that there is no relationship between the variables of source-type and sector (value=1.893, df=6, p<0.929). (For additional tables see Appendix 3.1).

	Sector I	***Sector II***	***Sector II***	***Total***
Alca	0 (0%)	10 (1.97%)	7 (1.38%)	17 (3.36%)
Puzolana	0 (0%)	1 (0.20%)	0 (0%)	1 (0.20%)
Quispisisa	16 (3.16%)	320 (63.24%)	149 (29.45%)	485 (95.85%)
N/A	0 (0%)	2 (0.40%)	1 (0.20%)	3 (0.59%)
Total	16 (3.16%)	333 (65.81%)	157 (31.03%)	506 (100%)

Table 8.5. Source-type by sector.

	Sector I	***Sector II***	***Sector II***
Alca	0 (0%)	10 (3.00%)	7 (4.46%)
Puzolana	0 (0%)	1 (0.30%)	0 (0%)
Quispisisa	16 (100%)	320 (96.10%)	149 (94.90%)
N/A	0 (0%)	2 (0.60%)	1 (0.64%)
Total	16 (100%)	333 (100%)	157 (100%)

Table 8.6. Source-type by sector assemblage.

Subsector

Similar to the results exploring source-type and sector, there appears to be little to no relationship between source-type and sub-sector. A chi-square test (H_o = no relationship) confirms the null hypothesis and suggests that there is no relationship between the variables (value=19.515, df=36, p<0.989). Quispisisa obsidian is not only present in every sub-sector, but is the predominant source-type in each (see Table 8.7). In comparison, Alca source-type obsidian is only found in five of the 12 sub-sectors, and represents less than 9% of each of those corresponding assemblages (see Table 8.7). Quispisisa reaches its greatest representation in sub-sectors A4-B4, A8-B8-D9, B5-B6, C9 and E10, where it is the only source-type present, comprising 100% of the assemblage (Table 8.8). Alca has the greatest amount of material in sub-sector D9 (n=6), but is found in greater proportions in sub-sector C5 (8.33%). Puzolana's only artifact is found in sub-sector B4 and represents 1.49% of the sub-sector's assemblage (Table 8.8). Overall, however, there is no relationship between sub-sector and source-type. (For additional tables by sub-sector and *capa* see Appendix 3.2 and 3.3).

	Alca	***Puzolana***	***Quispisisa***	***N/A***	***Total***
A4-B4	0 (0%)	0 (0%)	16 (3.16%)	0 (0%)	16 (3.16%)
A5	3 (0.59%)	0 (0%)	55 (10.87%)	0 (0%)	58 (11.46%)
A6	0 (0%)	0 (0%)	44 (8.70%)	1 (0.20%)	45 (8.89%)
A-B8-D9	0 (0%)	0 (0%)	3 (0.59%)	0 (0%)	3 (0.59%)
B4	1 (0.20%)	1 (0.20%)	65 (12.85%)	0 (0%)	67 (13.24%)
B5-B6	0 (0%)	0 (0%)	29 (5.73%)	0 (0%)	29 (5.73%)
C5	1 (0.20%)	0 (0%)	11 (2.17%)	0 (0%)	12 (2.37%)
C6	4 (0.79%)	0 (0%)	112 (22.13%)	1 (0.20%)	117 (23.12%)
C9	0 (0%)	0 (0%)	10 (1.98%)	0 (0%)	10 (1.98%)
D7-D8	1 (0.20%)	0 (0%)	15 (2.97%)	0 (0%)	16 (3.16%)
D9	6 (1.19%)	0 (0%)	95 (18.77%)	1 (0.20%)	102 (20.16%)
E10	0 (0%)	0 (0%)	15 (2.97%)	0 (0%)	15 (2.97%)
N/A	(0.20%)	0 (0%)	15 (2.97%)	0 (0%)	16 (3.16%)
Total	17 (3.36%)	1 (0.20%)	485 (95.85%)	3 (0.59%)	506 (100%)

Table 8.7. Source-type by sub-sector.

Sub-sector	Alca	Puzolana	Quispisisa	N/A	Total
A4-B4	0 (0%)	0 (0%)	16 (100%)	0 (0%)	16 (100%)
A5	3 (5.17%)	0 (0%)	55 (94.83%)	0 (0%)	58 (100%)
A6	0 (0%)	0 (0%)	44 (97.78%)	1 (2.22%)	45 (100%)
A-B8-D9	0 (0%)	0 (0%)	3 (100%)	0 (0%)	3 (100%)
B4	1 (1.49%)	1 (1.49%)	65 (97.01%)	0 (0%)	67 (100%)
B5-B6	0 (0%)	0 (0%)	29 (100%)	0 (0%)	29 (100%)
C5	1 (8.33%)	0 (0%)	11 (91.67%)	0 (0%)	12 (100%)
C6	4 (3.42%)	0 (0%)	112 (95.73%)	1 (0.85%)	117 (100%)
C9	0 (0%)	0 (0%)	10 (100%)	0 (0%)	10 (100%)
D7-D8	1 (6.25%)	0 (0%)	15 (93.75%)	0 (0%)	16 (100%)
D9	6 (5.88%)	0 (0%)	95 (93.14%)	1 (9.80%)	102 (100%)
E10	0 (0%)	0 (0%)	15 (100%)	0 (0%)	15 (100%)
N/A	1 (6.25%)	0 (0%)	15 (93.75%)	0 (0%)	16 (100%)

Table 8.8. Source-type by sub-sector assemblage.

Time Period

Across temporal contexts, Quispisisa is the predominant obsidian source-type found at Vegachayuq Moqo. Quispisisa obsidian represents 96.42% of the PXRF sample in general, a percentage that is relatively consistent across each time period (Table 8.10). Alca is seen in smaller frequencies in general, but its presence in the later and smaller Wari B assemblages suggests its use during the Middle Horizon. In general, obsidian from earlier time periods is more represented in the entire sample due to excavation methods, but Alca appears to become increasingly popular at the transition to the Middle Horizon, during the transition from Huarpa in the EIP to the Wari Empire (Table 8.10). In fact, 63.64% (n=7) of all Alca material found at Vegachayuq Moqo, while limited, dates to this transition phase or later. The single Puzolana sample is found in contexts associated with the Huarpa occupation, consistent with the results found by Burger et al. (2016) at Conchopata and in the Ayacucho valley in general. Despite these patterns, a chi-square test (H_o = no relationship) confirms the null hypothesis and suggests that there is no significant relationship between obsidian source-type and time period at the Vegachayuq Moqo (value=9.974, df=15, p<0.821). This is notable because elsewhere in the Ayacucho valley and other Wari hinterland regions, Quispisisa obsidian has been thought to increase significantly at the onset the Middle Horizon (Burger et al. 2000, Burger et al. 2016). It appears that at Vegachayuq Moqo, Quispisisa obsidian is used relatively consistently through time, and that Wari use of Quispisisa obsidian follows a pattern established prior to the Middle Horizon (For additional tables see Appendix 3.4).

	Alca	*Puzolana*	*Quispisisa*	*N/A*	*Total*
Huarpa	4 (1.13%)	1 (0.28%)	170 (48.02%)	1 (0.28%)	176 (49.72%)
Huarpa, Wari A	6 (1.69%)	0 (0%)	111 (31.36%)	1 (0.28%)	118 (33.33%)
Huarpa, Wari A, Wari B	0 (0%)	0 (0%)	13 (3.67%)	0 (0%)	13 (3.67%)
Wari A	0 (0%)	0 (0%)	2 (0.56%)	0 (0%)	2 (0.55%)
Wari B	1 (0.28%)	0 (0%)	4 (1.13%)	0 (0%)	5 (1.41%)
Wari A, Wari B	0 (0%)	0 (0%)	40 (11.30%)	0 (0%)	40 (11.30%)
Total	11 (3.11%)	1 (0.28%)	340 (96.05%)	2 (0.56%)	354 (100%)

Table 8.9. Source-type by time period.

	Alca	*Puzolana*	*Quispisisa*	*N/A*	*Total*
Huarpa	4 (2.27%)	1 (0.57%)	170 (96.59%)	1 (0.57%)	176 (100%)
Huarpa, Wari A	6 (5.08%)	0 (0%)	111 (94.07%)	1 (0.85%)	118 (100%)
Huarpa, Wari A, Wari B	0 (0%)	0 (0%)	13 (100%)	0 (0%)	13 (100%)
Wari A	0 (0%)	0 (0%)	2 (100%)	0 (0%)	2 (100%)
Wari B	1 (20%)	0 (0%)	4 (80%)	0 (0%)	5 (100%)
Wari A, Wari B	0 (0%)	0 (0%)	40 (100%)	0 (0%)	40 (100%)

Table 8.10. Source-type by time period assemblage.

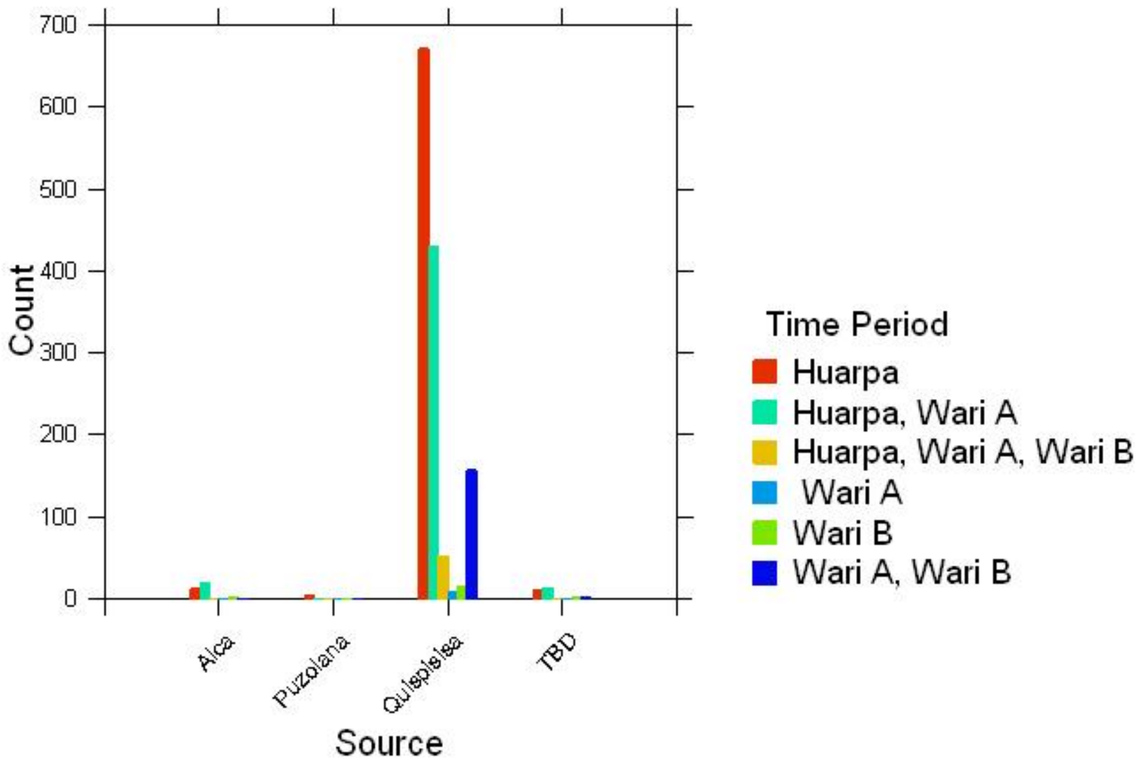


Figure 8.4. Graph of obsidian source results and time period.

<u>III. PXRF Results – Attributes</u>

Artifact Type

In Chapter 7, artifacts were grouped into six morphological categories: 1) biface; 2) core; 3) flake; 4) fragment; 5) point; and 6) uniface. As discussed previously the PXRF sample is representative of the total sample from Vegachayuq Moqo, with a slight over-representation of bifaces and projectile points, due to their larger size (material less than 5mm in thickness, which was removed from the sample, is overwhelmingly flakes and fragments). While there appears to be no relationship between context within Vegachayuq Moqo and source-type, there is a relatively strong relationship between artifact type and source-type as seen in a chi-square test (H_o = no relationship). The results do not support the null hypothesis and suggest a relationship between the variables (value=514.958, df=18, p<0.0001). This indicates that artifacts were intentionally (for a multitude of purposes or motives discussed in Chapter 9) produced from different obsidian source-types.

As has been the pattern, Quispisisa is the most predominant source-type for all artifacts and used exclusively for bifaces, unifaces and cores (Table 8.11). There are no nodules that derive from Quispisisa, but more notably, projectile points are the lowest represented artifact type produced from Quispisisa obsidian (n=20l; 86.86%); in comparison, Quispisisa obsidian comprises over 85% of the assemblage for non-projectile bifaces, cores, flakes and fragments. Projectile points, in comparison, are the greatest represented artifact type produced from Alca source-type obsidian, even with the limited sample size (n=2, 8.70%). In fact, projectile points represent only 5.06% of the Quispisisa obsidian assemblage while projectile points represent 11.76% of the Alca obsidian assemblage at Vegachayuq Moqo. And while sample sizes are very different between the two sources, these ratios may still indicate differential use of obsidian from both sources. Alca obsidian is traveling over 500km in distance to reach Huari, so the fact that it is even present at Huari (while not at Conchopata) indicates investment into the Alca source, and differential access to material from Alca within the Wari heartland (Burger et al. 2016). Puzolana obsidian is found exclusively as one unmodified nodule, a paucity that is very different from earlier sites within the Ayacucho valley (Burger et al. 2016; Burger et al. 2000). (For additional tables see Appendix 3.5).

	Alca	*Puzolana*	*Quispisisa*	*N/A*	*Total*
Biface	0 (0%)	0 (0%)	22 (4.35%)	0 (0%)	22 (4.35%)
Core	0 (0%)	0 (0%)	1 (0.20%)	0 (0%)	1 (0.20%)
Flake	8 (1.58%)	0 (0%)	255 (50.40%)	1 (0.20%)	264 (52.17%)
Fragment	7 (1.38%)	0 (0%)	186 (36.76%)	1 (0.20%)	194 (38.34%)
Nodule	0 (0%)	1 (0.20%)	0 (0%)	0 (0%)	1 (0.20%)
Point	2 (0.40%)	0 (0%)	20 (3.95%)	1 (0.20%)	23 (4.54%)
Uniface	0 (0%)	0 (0%)	1 (0.20%)	0 (0%)	1 (0.20%)
Total	17 (3.36%)	1 (0.20%)	485 (95.85%)	3 (0.59%)	506 (100%)

Table 8.11. Source-type by artifact type.

	Alca	*Puzolana*	*Quispisisa*	*N/A*	*Total*
Biface	0 (0%)	0 (0%)	22 (100%)	0 (0%)	22 (100%)
Core	0 (0%)	0 (0%)	1 (100%)	0 (0%)	1 (100%)
Flake	8 (3.03%)	0 (0%)	255 (96.59%)	1 (0.38%)	264 (100%)
Fragment	7 (3.61%)	0 (0%)	186 (95.88%)	1 (0.52%)	194 (100%)
Nodule	0 (0%)	1 (100%)	0 (0%)	0 (0%)	1 (100%)
Point	2 (8.70%)	0 (0%)	20 (86.96%)	1 (4.35%)	23 (100%)
Uniface	0 (0%)	0 (0%)	1 (100%)	0 (0%)	1 (100%)

Table 8.12. Source-type by artifact type assemblage.

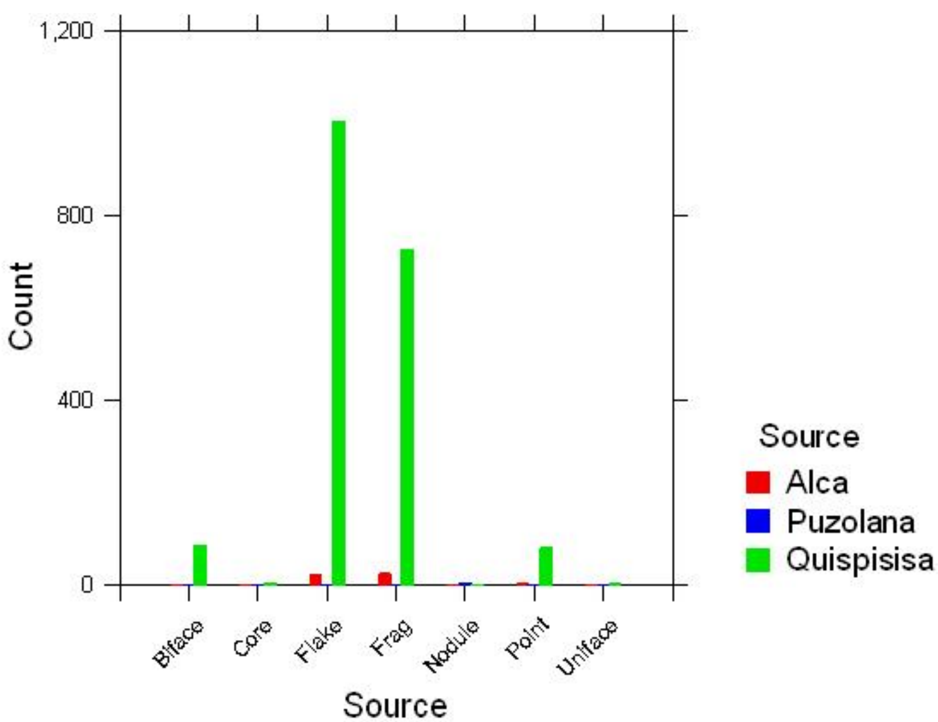


Figure 8.5 Graph of artifact type and obsidian source results.

Flake Size-Grade

As discussed in Chapter 7, the majority of flakes within the total sample from Vegachayuq Moqo measure greater than 12.7mm in maximum dimension, suggesting a relative lack of in-situ formal tool production (Bencic 2016). Because the PXRF sample does not include flakes measuring less than 5mm in thickness, only two flakes were analyzed using PXRF that measured less than 12.7mm. This may affect the accuracy of a chi-square test examining flake size-grade because there is an artificially greater amount of larger flakes. That said, there appears to be no statistical relationship between source-type and flake size-grade based on a chi-square test (value=2.67, df=4, $p<0.615$). Quispisisa obsidian represents the overwhelming majority of flakes of any size (96.59%). Within the Quispisisa assemblage, there is a relatively equal representation of flakes measuring smaller than 25.4mm and those measuring larger than 25.4mm (Table 8.13). In comparison, 75% of Alca flakes measure greater than 25.4mm. While not statistically significant, this pattern may still suggest that greater amounts of in-situ tool production were occurring with Quispisisa source-type obsidian, while Alca was was arriving to the site in completed form. This is further supported by the fact that in the attribute analysis (Chapter 7), only sub-sectors E10, C6, B4 and A4-B4 contained flakes measuring less than 12.7mm (suggesting in-situ tool production). Of these four sub-sectors, three of them were entirely composed of Quispisisa obsidian (see Table 8.7). (For additional tables see Appendix 3.6).

	Alca	*Puzolana*	*Quispisisa*	*N/A*	*Total*
6.35–12.7mm	**0 (0%)**	**0 (0%)**	**2 (0.76%)**	**0 (0%)**	**2 (0.76%)**
12.7–25.4mm	2 (0.76%)	0 (0%)	122 (46.21%)	0 (0%)	124 (46.97%)
>25.4mm	6 (2.27%)	0 (0%)	131 (49.62%)	1 (0.38%)	138 (52.27%)
Total	8 (3.03%)	0 (0%)	255 (96.59%)	1 (0.38%)	264 (100%)

Table 8.13. Source-type by flake size-grade.

	Alca	*Puzolana*	*Quispisisa*	*N/A*
6.35–12.7mm	0 (0%)	0 (0%)	2 (0.78%)	0 (0%)
12.7–25.4mm	2 (25%)	0 (0%)	122 (47.84%)	0 (0%)
>25.4mm	6 (75%)	0 (0%)	131 (51.37%)	1 (100%)
Total	8 (100%)	0 (0%)	255 (100%)	1 (100%)

Table 8.14. Source-type by flake size-grade assemblage.

Cortex

In Chapter 7, cortex was explored for all flakes as an indicator for production phase activities and/or intended form of tools produced at the site. The results (when combined with flake size-grade) led to the conclusion that obsidian at Vegachayuq Moqo was being produced expediently, from material requiring little to no modification (a pattern also seen at Conchopata) (Bencic 2016). The PXRF sample explored the presence of cortex on both flakes and fragments, with the intent of exploring the nature of tool production and/or use at Vegachayuq Moqo (n=461). A chi-square test (H_o = no relationship) does not support the null hypothesis and suggests that there is a relationship between cortex and obsidian source-type (value=465.010, df=9, $p<0.0001$). In general, the majority of flakes presented with zero to 49% cortex. Quispisisa material was comprised of 358 (80.81%) artifacts with zero cortex, with 19.19% of the assemblage characterized by some amount of cortex (Tables 8.14 and 8.15). This suggests some degree of raw material being worked at the site. In comparison, 100% of the Alca material presents with zero cortex, suggesting that Alca source-type obsidian was brought into Vegachayuq Moqo in a reduced form, perhaps as a movable core or blank. This makes sense based on the physical distance (500km) that Alca had to travel to reach the site of Huari. The only artifact from Puzolana, a nodule, presents with 100% cortex and it is the only object of its kind in the sample. Puzolana is the closest source to the site of Huari. (For additional tables see Appendix 3.7).

	Alca	*Puzolana*	*Quispisisa*	*N/A*	*Total*
0% Cortex	15 (3.25%)	0 (0%)	358 (77.66%)	2 (0.43%)	375 (81.34%)
1–49% Cortex	0 (0%)	0 (0%)	78 (16.92%)	0 (0%)	78 (16.92%)
50–99% Cortex	0 (0%)	0 (0%)	7 (1.52%)	0 (0%)	7 (1.52%)
100% Cortex	0 (0%)	1 (0.22%)	0 (0%)	0 (0%)	1 (0.22%)
Total	15 (3.25%)	1 (0.22%)	443 (96.10%)	2 (0.43%)	461 (100%)

Table 8.15. Source-type by cortex.

	Alca	*Puzolana*	*Quispisisa*	*N/A*
0% Cortex	15 (100%)	0 (0%)	358 (80.81%)	2 (100%)
1–49% Cortex	0 (0%)	0 (0%)	78 (17.61%)	0 (0%)
50–99% Cortex	0 (0%)	0 (0%)	7 (1.58%)	0 (0%)
100% Cortex	0 (0%)	1 (100%)	0 (0%)	0 (0%)
Total	15 (100%)	1 (100%)	443 (100%)	2 (100%)

Table 8.16. Source-type by cortex assemblage.

Flake Termination

Flake terminations, as discussed in Chapter 7, can be used to approximate the skill of the flintknapper. Feathered terminations show the greatest degree of technical control, accuracy, and skill, while hinged, stepped, or overshot terminations are generally considered errors in production due to misapplied force or incorrect striking angle. A chi-square test (H_o = no relationship) confirms the null hypothesis and suggests no significant relationship between flake termination and obsidian source-type (value=5.546, df=8, p<0.986). However, there are still several notable observations. First, there is a greater presence of feathered flakes within the Alca source-type assemblage than hinged, stepped, or overshot (see Table 8.17). And second, within the Alca assemblage, 87.5% (n=7) of the flakes have a feathered termination, while only 50.20% (n=126) of the Quispisisa source-type flakes have a feathered termination (Table 8.18). This suggests that obsidian from Alca may have been produced by more highly-skilled workers (Bencic 2016). Coupled with the information on flake size-grade and cortex, it is also possible that most Alca obsidian was produced elsewhere by highly skilled workers, and then brought into Vegachayuq Moqo in a more complete form. (For additional tables see Appendix 3.8).

	Alca	*Puzolana*	*Quispisisa*	*N/A*	*Total*
Feathered	7 (2.69%)	0 (0%)	126 (52.31%)	1 (0.38%)	134 (51.54%)
Hinged, Stepped, Overshot	1 (0.38%)	0 (0%)	125 (48.08%)	0 (0%)	126 (48.46%)
Total	8 (3.08%)	0 (0%)	251 (96.54%)	1 (0.38%)	260 (100%)

Table 8.17. Source-type by flake termination.

	Alca	*Puzolana*	*Quispisisa*	*N/A*
Feathered	7 (87.5%)	0 (0%)	126 (50.20%)	1 (100%)
Hinged, Stepped, Overshot	1 (12.5%)	0 (0%)	125 (49.80%)	0 (0%)
Total	8 (100%)	0 (0%)	251 (100%)	1 (100%)

Table 8.18. Source-type by flake termination assemblage.

Flake Striking Platform

The striking platform, as discussed in Chapter 7, can be examined as an indicator for the intended form of produced objects. Complex platforms are typically associated with bifacial or other forms of formal tool production, while flat and cortical platforms are more strongly associated with expedient tools. A chi-square test (H_o = no relationship) does not support the null hypothesis and suggests that there is a relationship between striking platform and obsidian source-type (value=40.122, df=10, p<0.0001). Similar to other attributes examined in this chapter, the variation in striking platforms lies in the differing treatments given to Alca and Quispisisa obsidian within Vegachayuq Moqo. For example, 100% (n=6) of the artifacts from Alca presented with complex striking platforms, while only 48.60% of the artifacts (n=104) from Quispisisa had complex striking platforms (see Table 8.20). This suggests that obsidian from Alca was produced with the intention of forming points, bifaces or other formal tools. Furthermore, when coupled with the data from artifact type and flake termination, addressed in this chapter and Chapter 7, it appears that material from Alca was produced by more highly skilled workers with the sole intention of projectile point or biface production, while Quispisisa was used more informally and expediently and produced by the general population at Vegachayuq Moqo. This is echoed in the data from Conchopata, where Bencic (2016) found that material produced at Conchopata suggested a ubiquitous presence of Quispisisa obsidian that could be expediently worked and then discarded by non-skilled workers. (For additional tables see Appendix 3.9).

	Alca	*Puzolana*	*Quispisisa*	*N/A*	*Total*
Flat	0 (0%)	0 (0%)	80 (36.20%)	0 (0%)	80 (36.20%)
Complex	6 (2.71%)	0 (0%)	104 (47.06%)	1 (0.45%)	111 (50.23%)
Cortical	0 (0%)	0 (0%)	30 (13.57%)	0 (0%)	30 (13.57%)
Total	6 (2.71%)	0 (0%)	214 (96.83%)	1 (0.45%)	221 (100%)

Table 8.19. Source-type by striking platform.

	Alca	*Puzolana*	*Quispisisa*	*N/A*
Flat	0 (0%)	0 (0%)	80 (37.38%)	0 (0%)
Complex	6 (100%)	0 (0%)	104 (48.60%)	1 (100%)
Cortical	0 (0%)	0 (0%)	30 (14.02%)	0 (0%)
Total	6 (100%)	0 (0%)	214 (100%)	1 (100%)

Table 8.20. Striking platform by source-type assemblage.

Flake Scars

Flake scars, as discussed in Chapter 7, represent the location where a flake was struck off of the objective piece. In Chapter 7, the attribute analysis explored flake scars present on flakes in order to explore production phase activities, as generally more heavily worked flakes represents later-stage production and/or more heavily produced artifacts and tools. The PXRF analysis presented here explores the presence of flake scars on both flakes and fragments, as both are the result of production techniques. A chi-square test (H_o = no relationship) confirms the null hypothesis and suggests that there is no relationship between the variables. However, the Alca source-type assemblage is dominated by flakes and fragments with more than five flake scars (n=10, 66.67%), while the Quispisisa assemblage consists of only 36.34% (n=161) flakes and fragments with more than five flake scars (Tables 21 and 22). This appears to indicate that Alca obsidian at Vegachayuq Moqo was more heavily worked (For additional tables see Appendix 3.10).

	Alca	*Puzolana*	*Quispisisa*	*N/A*	*Total*
0 Flake Scars	1 (0.22%)	1 (0.22%)	107 (23.21%)	1 (0.22%)	110 (23.86%)
1 Flake Scar	2 (0.43%)	0 (0%)	83 (18.00%)	1 (0.22%)	86 (18.66%)
2-5 Flake Scars	2 (0.43%)	0 (0%)	92 (19.96%)	0 (0%)	94 (20.39%)
> 5 Flake Scars	10 (2.17%)	0 (0%)	161 (34.92%)	0 (0%)	171 (37.09%)
Total	15 (3.25%)	1 (0.22%)	443 (96.10%)	2 (0.43%)	461 (100%)

Table 8.21. Source-type by flake scar.

	Alca	*Puzolana*	*Quispisisa*	*N/A*
0 Flake Scars	1 (6.67%)	1 (100%)	107 (24.15%)	1 (50%)
1 Flake Scar	2 (13.33%)	0 (0%)	83 (18.74%)	1 (50%)
2-5 Flake Scars	2 (13.33%)	0 (0%)	92 (20.77%)	0 (0%)
> 5 Flake Scars	10 (66.67%)	0 (0%)	161 (36.34%)	0 (0%)
Total	15 (100%)	1 (100%)	443 (100%)	2 (100%)

Table 8.22. Flake scars by source-type assemblage.

Projectile Points

Projectile points comprise 3.82% of the total artifact assemblage at Vegachayuq Moqo, and all but one was able to be analyzed using PXRF. (The one omitted was done so due to inventory markers comprising the elemental integrity of the sample). All of the 23 analyzed projectile points were sourced to either Alca (n=2, 8.70%) or Quispisisa (n=20, 86.96%). Despite the very low sample size of Alca points (and Alca artifacts in general), the fact that 2 of only 23 projectile points were sourced to Alca is meaningful. Quispisisa, in general, represents over 96% of the total artifact assemblage, but only 86% of the projectile points. The two points from Alca (0506, 0508) did not have an intact body or base in order to make an accurate typological identification, but they were assigned to a time period based on their excavation context – 0506 to the transition phase between Huarpa and the early Middle Horizon, and 0508 to the expansion and consolidation phase of Wari (see Table 8.23). Both points were found in the same excavation context (different *capas*), in Sector 3, sub-sector D9, along with six other points sourced to Quispisisa. Alca points' association with Middle Horizon temporal contexts suggests that imperial processes may have been involved with the movement of Alca obsidian to the site of Huari.

	Source	*Sector*	*Sub-sector*	*Time Period*	*Body*	*Base*
0026	Quispisisa	2	B4	Huarpa	N/A	N/A
0036	Quispisisa	2	B4	Huarpa	N/A	N/A
0064	Quispisisa	2	B4	Huarpa	N/A	N/A
0069	Quispisisa	2	B4	N/A	N/A	N/A
0200	Quispisisa	2	C6	Huarpa, Wari A	N/A	N/A
0281	Quispisisa	2	A6	Wari A, Wari B	N/A	N/A
0282	Quispisisa	2	A6	Wari A, Wari B	N/A	N/A
0287	Quispisisa	2	B5-B6	N/A	N/A	N/A
0338	Quispisisa	2	A5	N/A	N/A	N/A
0339	Quispisisa	2	A5	N/A	N/A	N/A
0340	Quispisisa	2	A5	N/A	N/A	Straight
0389	Quispisisa	2	A5	N/A	N/A	N/A
0493	Quispisisa	3	N/A	N/A	N/A	N/A
0505	Quispisisa	3	D9	Huarpa, Wari A	N/A	N/A
0506	Alca	3	D9	Huarpa, Wari A	N/A	N/A
0508	Alca	3	D9	Wari II	N/A	N/A
0519	Quispisisa	3	N/A	N/A	N/A	N/A
0520	Quispisisa	3	N/A	N/A	N/A	N/A
0530	Quispisisa	3	D9	Huarpa	N/A	N/A
0553	Quispisisa	3	D9	Huarpa	N/A	N/A
0554	Quispisisa	3	D9	Huarpa	N/A	N/A
0561	Quispisisa	3	D9	Huarpa	Lanceolate	Convex
0562	Quispisisa	3	D9	Huarpa	N/A	Straight

Table 8.23. Projectile Points.

IV. Summary

This chapter addressed the results from the PXRF analysis conducted on a sample of 505 obsidian artifacts (sampled from the total 608 artifacts) from Vegachayuq Moqo. (A more detailed discussion of both attribute and PXRF analysis follows in Chapter 9). The most salient result to emerge from the PXRF analysis is the presence of three distinct obsidian source-types within the sample from Vegachayuq Moqo. Quispisisa comprises

96.42% of the assemblage, Alca comprises 3.38% of the assemblage and Puzolana comprises only 0.20% of the assemblage. When compared with the data from the neighboring site of Conchopata, several distinctions emerge. First, Quispisisa obsidian is the dominant source-type at both Huari and Conchopata, but represents over 99% of the sample at Conchopata (Burger et al. 2016). Second, the only non-Quispisisa obsidian at Conchopata is one artifact produced from Puzolana-type obsidian. And third, while Alca is present at Huari, there are no Alca obsidian artifacts at Conchopata. Considering that Conchopata is an imperial Wari site, not far from the Huari capital, the absence of Alca material is salient. The Alca source lies over 500km from the Huari capital, and it would have taken a considerable effort to move. In addition, Quispisisa obsidian is found in the Cuzco and Arequipa regions (near the Alca source) during the Middle Horizon, so it is unsurprising that Alca obsidian would have also been present in the obsidian political economy during the Middle Horizon (Burger et al. 2000).

While chi-square tests suggest there is not a significant relationship between source-type and time period, it is notable that during the Middle Horizon, Alca source-type obsidian increases in its representation in the sample from Vegachayuq Moqo (see Table 8.10). However, this pattern may be the due less to temporal context than to the type of artifacts being produced and consumed with the different source-types. It may be more important, therefore, what type of artifact consumed and less when it was consumed. Chi-square tests did suggest source-type was significantly related to the stage of artifact production and the intended artifact. First, there is a strong relationship between artifact type and obsidian source-type (see Table 8.11). Quispisisa source-type obsidian is used primarily for bifaces, unifaces and cores while Alca source-type obsidian (however small of a sample size) is composed of primarily projectile points. Only 5.06% of the Quispisisa assemblage is projectile points while 11.76% of the Alca assemblage is projectile points. The projectile points themselves were found in contexts spanning the Huarpa occupation of the site through the consolidation of the Wari Empire (Wari B). However, the Alca flakes were only found in contexts associated with Wari (transition phase and consolidation phase), and may suggest that Alca was moving into the Wari heartland through imperial processes.

Other artifact attributes that attest to the skill level of the producers at Vegachayuq Moqo, as well as the type of tool being manufactured (such as cortex and striking platform), were also seen to have significant relationships with obsidian source-types. Cortex is often explored as a marker for the production phase and/or desired tool type and the results from the PXRF and attribute analysis suggest that obsidian at Vegachayuq Moqo was often produced in an expedient manner. Most artifacts in the sample presented with zero cortex, however Quispisisa obsidian showed 80.81% of material with zero cortex, while 100% of the Alca material had zero cortex (Tables 8.14 and 8.15). This suggests that the material being expediently worked at the site was likely Quispisisa source-type obsidian, while Alca was brought into Vegachayuq Moqo as a blank or completed tool. At Conchopata, Bencic (2016) found that Quispisisa obsidian (composing 99% of the sample) was utilized for expedient tools (not formal or bifacial tools), and was produced by less than highly-skilled craftsman and utilized and discarded frequently due to its ubiquitous presence.

The idea of "cavalier crafting" (Klarich et al. 2017) is further supported by the relationship between striking platform and source-type, seen as indicators for the type of objects being produced. While complex platforms are more strongly associated with formal tools (primarily bifaces and projectile points), flat and cortical platforms are more strongly associated with expedient tools. 100% of the flakes from the Alca source-type presented with complex striking platforms while only 48.60% of the Quispisisa flakes had complex striking platforms (see Table 8.20). This suggests a very different intent for obsidian production, and therefore consumption, between the Quispisisa and Alca obsidian sources. Most likely, Quispisisa was intended for expedient production while Alca was brought into the site of Huari as a completed tool.

What appears at Vegachayuq Moqo is a pattern of local obsidian use consistent with other sites in the Ayacucho valley. Quispisisa obsidian appears to be ever-present, and is treated accordingly (Bencic 2016; Stone 1983). It dominates the obsidian assemblage at over 96%, and similar to Conchopata, the producers and users of Quispisisa obsidian at Huari appear to be using the material in an expedient and non-renewable fashion. Burger and Asaro (1977) also found that Quispisisa represented 96% of the sample at Huari, and Stone (1983) suggested that there was very little production of imported material in earlier periods. The Quispisisa source is relatively close to Huari (less than 100km), and may have been provided to residents of the capital for their own needs and produced, consumed, and discarded as such.

Alca obsidian, however, tells a different story. Flake terminations suggest that it was produced by highly-skilled workers, and the two projectile points coupled with the presence of entirely complex striking platforms on flakes, suggests that Alca material was carefully manufactured with the intention of producing a biface or projectile point. The differing treatments of the two source-types may reflect distance (Alca is over 500km away in comparison to Quispisisa at 100km) and the difficulty in transporting raw nodules over that distance. Or perhaps it represents a difference in associated value, with Alca having an increased value as an object brought back by those who traveled to the Cuzco or Arequipa hinterlands. A similar pattern is seen in the use of Quispisisa in more distance hinterlands (Burger et al. 2000), where it is found as more formalized and specialized projectile points or bifaces. Because there are projectile points at Huari made from Quispisisa (most, in fact), it appears that the pattern might simply represent a more utilitarian facet of the political economy, with obsidian from a local source (brought in for consumption) and produced by local residents. At increasing distances, the obsidian is treated more thoughtfully, likely due to the nature of the travel (who is traveling) as well as the knowledge that the material came from a nonlocal source.

CHAPTER 9

DISCUSSION: OBSIDIAN NETWORKS AND IMPERIAL PROCESSES

The results from the previous chapters are presented here in discussion with other obsidian sourcing studies, lithic studies, as well as Wari imperial studies within the central and southern Peruvian highlands. The data analyzed in this dissertation build upon previous sourcing work done in the region by Burger and Asaro (1977), Burger et al. (2000), and Burger et al. (2016), as well as on lithic analysis conducted at the site of Huari (Stone 1983) and Conchopata (Bencic 2016), while contributing original sourcing research for the largest sample of obsidian sourced from the site of Huari (n=505). Overall, several general patterns are present within the dataset in relation to both obsidian exchange networks and the differential use of Quispisisa and Alca obsidian within the Wari heartland. First, the results from the data support the idea presented by Burger et al. (2000) for a regional separation in obsidian exchange networks. The research presented in this dissertation suggests that these networks predate the Middle Horizon and that the widespread use of Quispisisa obsidian during the Middle Horizon is best understood as the intensification and/or formalization of previously-utilized exchange networks. The only regions which appear to experience radical changes in obsidian source consumption during the Middle Horizon are Cusco, and secondarily Apurímac. Second, the results of this dissertation confirm that Quispisisa is the preferred, and most ubiquitous, obsidian source within the Wari heartland. In addition, the results show that Quispisisa was produced and consumed in an expedient manner at the site of Huari, similar to results found by Bencic (2016) at the site of Conchopata. Formal tools were generally produced outside of Wari imperial sites. And finally, the results show the presence of Alca obsidian at the site of Huari, in contrast to its absence at the site of Conchopata. Alca appears at Huari more often as formal and finished tools, in contrast to the expedient use of Quispisisa. This suggests that, similar to how Quispisisa is consumed at sites within the southern obsidian exchange network, the central highland obsidian exchange network used material from distant locations more conservatively, and more formally, than the more closely available Quispisisa source.

I. Obsidian Exchange Networks Prior to, and During, the Middle Horizon

Within the sampled material from Vegachayuq Moqo, 96.42% (n=485) of the obsidian is from the Quispisisa source, while 3.38% (n=17) is from the Alca source and 0.20% (n=1) is from the Puzolana source. These results are very much consistent with the other obsidian sourcing study conducted on samples of obsidian from Huari (Burger and Asaro 1977). Burger and Asaro (1977) analyzed 53 obsidian samples from the site of Huari using both Neutron Activation Analysis (NAA) and x-ray fluorescence (XRF) and found that 96% (n=51) of the sample could be sourced sourced to Quispisisa, 2% (n=1) to Potreropampa and 2% (n=1) to Alca. The neighboring Wari site of Conchopata was also dominated by Quispisisa source-type obsidian, comprising 99% of the sample (n=92) (Burger et al. 2016). This dissertation suggests that the overwhelming presence of Quispisisa at the sites of Huari and Conchopata follows a pattern within the Ayacucho Valley that pre-dates the Middle Horizon and Wari influence in the region. In addition to the sample from Huari, Burger and Asaro (1977) analyzed 65 obsidian artifacts from seven pre-Middle Horizon sites within the Ayacucho Valley, and found that 94% of the samples could be sourced to Quispisisa. A second study conducted by Burger et al. (2016) analyzed 80 obsidian artifacts from nine pre-Middle Horizon sites within the Ayacucho Valley and found that 81% of the samples could be sourced to Quispisisa, while 19% was attributed to the Puzolana obsidian source.

In general, it appears that even though Quispisisa obsidian comprises over 96% of obsidian assemblage during the Middle Horizon, this reliance pre-dates the rise of the Wari Empire, suggesting that the presence of Quispisisa within the region is a continuation, or possibly a formalization, of obsidian distribution channels established prior to the Middle Horizon. The relative lack of Puzolana material during the Middle Horizon (19% to less than 2%), may suggest that distribution channels became more formalized under Wari control, with individuals and communities exercising less individual agency over obsidian extraction and acquisition. This may be confirmed by the relative decrease in the overall use of obsidian throughout the Andes in the following Late Intermediate Period. In the Jauja region in the north highlands, obsidian stops being imported into the region from any source, and instead populations begin to reuse the obsidian material they already have (Russell 1988). This is in direct contrast to use at Vegachayuq Moqo and Conchopata, where obsidian (at least from Quispisisa) is readily discarded after use. Also during the Late Intermediate Period in Andahuaylas, populations suddenly begin sourcing obsidian from the Lisahuacho source, a source that was relatively absent in assemblages throughout prehistory, suggesting a major shift in extractive and distribution channels (Kellett et al. 2013). While these studies indicate that obsidian was still used after the collapse of the Wari Empire, it appears that the transportation of obsidian was linked to a political and economic landscape formalized and/or facilitated/controlled by the Wari, which falls out of operation after the end of the Middle Horizon (Russel 1988; Ogburn 2011).

The consumption of Quispisisa obsidian within the Ayacucho Valley, as mentioned above, has a long history; MacNeish et al. (1980) found evidence of Quispisisa obsidian in the Ayacucho region dating to approximately 15,000 BP. The Quispisisa source is the largest source in the central highlands (and northernmost within Peru) and lies approximately 100km south of the present-day city of Ayacucho, roughly a three to four-day journey. Not only is Quispisisa the largest source in the region, but it is also the highest quality source, dating to a relatively recent volcanic event approximately 2.5 million years ago (Castillo et al. 1993). In addition to its recent formation, the size of the nodules at the Quispisisa source is much larger when compared to other sources within the region, reaching up to 35cm in maximum dimension (Tripcevich and Contreras 2011). (For comparison, nodules from Jampatilla and Puzolana rarely measure over 5-10cm in maximum dimension). The obsidian from Quispisisa, while predominantly black, does occasionally have a red hue, perhaps an aesthetic feature that may have distinguished it from other sources (Tripcevich 2007). The above attributes of the Quispisisa source are very likely the primary reasons for its extensive presence throughout the central and northern Andes both prior to, and during, the Middle Horizon. The mechanisms by which it made its way (and in what quantity), were more subjective.

Most research on trade and exchange networks in the Andes focus on the role of craft products and exchange systems in relation to the rise and institutionalization of power (Vaughn 2006; Goldstein 2000; Levine et al. 2013). One common approach is to explore the role of prestige goods within burgeoning power relationships, whether in the form of spondylus from Ecuador, feathers from the Amazon, or obsidian from one of three major obsidian sources (Quispisisa, Alca, and Chivay). Trade and exchange networks, and the long-term existence and transformation of them, is not unique to the Andes and has been proposed to stem, in part, from a demand for “relatively common place items that were unavailable locally” (Smith 1999: 61; Tripcevich 2010). Despite obsidian’s relatively limited natural occurrence, it is one of the most widely utilized resources within the prehistory of the Andes, with obsidian found at locations far from obsidian sources by 13,000 BC. This widespread and early use of such a (geographically) limited material, would have necessitated the formation of exchange relationships, perhaps along geographic zones corresponding to obsidian sources as well as along vertical systems of exchange and Andean *ayllu* practices of up and down-the-line exchange (Eerkens et al. 2010; Tripcevich 2007). Following Burger et al. (2000), the data for this dissertation (in conjunction with other obsidian sourcing studies) confirm the existence of two distinct obsidian exchange networks: 1) the central highlands (including Ayacucho, the Southern Nasca Region, Sondondo and possibly Apurímac); and 2) the southern (including Cusco, Moquegua, Arequipa and the Titicaca Basin). The central highlands obsidian network was focused around the Quispisisa source, while the southern network was focused around the sources of Alca and Chivay. Communities within these networks would generally preferenced locally available sources (those in closest proximity), and supplemented their local deposits with imports from higher quality sources within their corresponding networks. During the Middle Horizon, this system changes.

Central Highlands Obsidian Network

The Ayacucho Valley was not the only region within the central highlands and northern Andes that was consuming Quispisisa obsidian prior to the Middle Horizon (see Figure 9.1). By 13,000 BP Quispisisa obsidian had made its way north to Jauja-Huancayo and southwest to Acarí (Burger and Glascock 2000; Tripcevich and Contreras 2011). By 6,500 BP there is evidence of Quispisisa on the central coast and in the Southern Nasca Region (Quilter 1989; Burger and Asaro 1978; Vaughn and Glascock 2005). During the Early Horizon, Quispisisa dominated the obsidian assemblage at the site of Chavín de Huantar, located over 590km away from the source (Burger and Glascock 2000; Burger and Mendieta 2002). The distances at which obsidian was traveling prior to the Middle Horizon are no less impressive than the distances it was traveling during the Middle Horizon, suggesting the movement of Quispisisa obsidian was likely facilitated by interregional interactions and exchange networks dating to as early as 13,000 BP. Based on previous obsidian sourcing studies, it is likely that one major interaction network connected Ayacucho, Sondondo and the Southern Nasca Region (and possibly Apurímac) through the exchange of resources from different ecozones, including obsidian from Quispisisa (Figure 9.1). While these networks likely encompassed the northern Andes as well (based on early dates for obsidian consumption presented above), there has been relatively little sourcing work done on northern obsidian assemblages (likely due to the absence of northern obsidian sources).

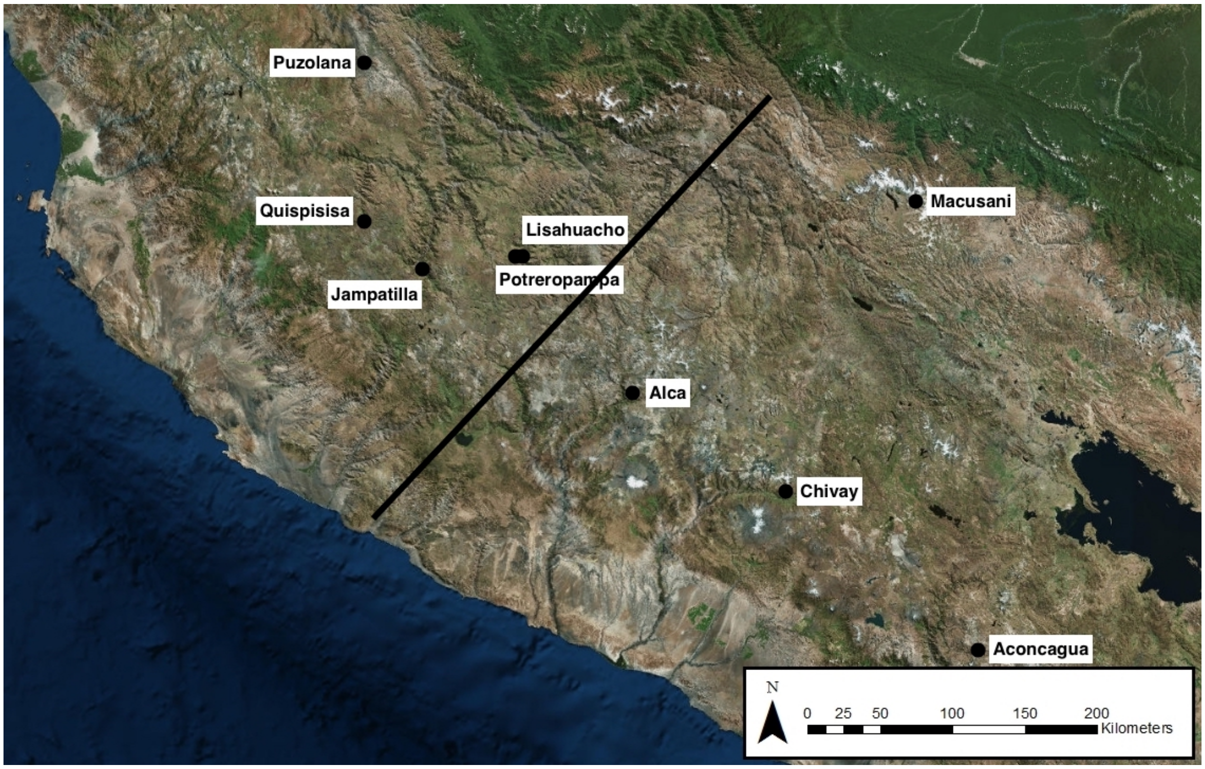


Figure 9.1. Map of Central Highlands Obsidian Network (north of dividing line).

Within the Southern Nasca Region (SNR), obsidian from Quispisisa is the dominant source-type throughout prehistory (the only region apart from Ayacucho where this is the case) (Eerkens et al. 2010). This is likely due to the fact that Quispisisa is the closest obsidian source to the SNR, as there are no locally available sources at coastal elevations. Apart from Quispisisa, the SNR relied on obsidian from other local Ayacucho and Apurímac sources (Potreropampa, Jampatilla and Lisahuacho). The presence of obsidian from highland sources would have necessitated travel into, or exchange with, highland communities, perhaps through transhumance or *ayllu* exchange systems of vertical ecology. And in the SNR, exchange appears to have been happening exclusively with the central highlands network. It has also been suggested that Quispisisa obsidian may have been flowing into the SNR through llama trade caravans (Eerkens et al. 2010; Vaughn 2006). The connection between llama caravans, pastoralism and obsidian has also been presented by Nicholas Tripcevich

(2007), and would have been a likely relationship due to the unique vertical ecology of the Andes, in which camelid pastureland and obsidian sources both lie within the *puna* ecozone. It follows that camelid trade caravans would have facilitated the movement of obsidian not only to the SNR, but across the Andes.

Another region which was part of the central highland obsidian exchange network was the Sondondo Valley. During the Middle Horizon, the Sondondo region was not only the location of a Wari administrative center (Jincamocco), but a roadway connecting the Ayacucho heartland to the SNR (Schreiber and Edwards 2014). This is further confirmed by the presence of Wari administrative sites within the SNR, such as Pataraya (Edwards 2010). It is very likely that, just as Inca roadways were often placed overtop pre-existing Wari roadways, Middle Horizon pathways were also placed overtop pre-existing earlier routes. And because obsidian was traveling outside of Ayacucho as early as 13,000 BP, there is reason to suspect a long history of travel within and between Ayacucho, Sondondo and the SNR. Furthermore, Sondondo is located only 48km from the Quispisisa source, only one to two days of travel (Schreiber, in press). Across all time periods, 47% of the obsidian within Sondondo was from Quispisisa and 42% was derived from the local Jampatilla source (Burger and Asaro 1979). The only obsidian within Sondondo sourced to outside of Ayacucho was from the Alca obsidian source, and was found exclusively at the Wari administrative center of Jincamocco. The importation of obsidian from Alca is likely due to widening exchange networks in the Middle Horizon as a result of imperial processes, and is discussed later in this chapter.

The final region within the central highland network is Apurímac. It provides an interesting point of departure when compared to the other regions previously discussed. As

Burger et al. (2000) note, Apurímac was an active participant in southern exchange networks during the Initial Period and Early Horizon, particularly at the site of Waywaka in Andahuaylas (Burger et al. 2000; Grossman 1972). Simultaneously, the region also relied on Quispisisa obsidian during these periods, although in much smaller percentages (~5%) than in Sondondo, the SNR or Ayacucho (Kellett et al. 2013). However, the Potreropampa and Lisahuacho sources (located within Apurímac) are considered to be central highland obsidian sources (Kellett et al. 2013; Burger et al. 2006), and prior to the Middle Horizon, Potreropampa obsidian is found solely in regions within the central highland exchange network (e.g., SNR, Acarí, and Ayacucho). In sum, prior to the Middle Horizon, Andahuaylas participated both within a southern and central highlands exchange network. During the Middle Horizon, however, Apurímac securely enters the central highland network, as suggested by a significant increase in the percentage of Quispisisa obsidian consumed in relation to a decrease in the consumption of the local Potreropampa and Lisahuacho sources (Kellett et al. 2013). One reason for this shift may be Apurímac's location between the Ayacucho heartland and the Cusco region, which will be discussed later in this chapter.

Southern Obsidian Network

Within the southern obsidian exchange network, first illuminated by Burger et al. (2000), lies the Cusco, Arequipa, Moquegua and Titicaca Basin regions centered around the obsidian sources of Alca and Chivay (Figure 9.2). Prior to identification, Alca was generically known as the "Cusco-type" source (Burger et al. 1998), while Chivay was known as the "Titicaca-type" source (Burger et al. 2000). Both sources produce nodules of a similar size to Quispisisa, ranging up to approximately 30cm in maximum dimension. And similar to Quispisisa, Alca and Chivay were fully utilized beginning around 13,000 BP. By 13,000 BP Alca is found on the southernmost coast of Peru at sites like Quebrada Jaguay (Sandweiss et al. 1998; Jennings and Glascock 2002) and Chivay obsidian was primarily used within the Titicaca Basin, where around 90% of the obsidian used in prehistory is estimated to be from the Chivay source (Tripcevich 2007). In 2000, Burger et al. illuminated the connections between the sources and the exchange relations between the regions of Cusco, Arequipa, Moquegua and the Titicaca Basin prior to the Middle Horizon. Burger et al. (2000) also noted that obsidian exchange networks were often not overlapping with ceramic or other iconographic exchange networks (which appeared to have a wider and more uniform distribution, especially during Andean horizons). The fact that obsidian and ceramic acquisition, production, and consumption were not conducted through overlapping networks throughout prehistory, further confirms the need to understand craft products and resources both individually and within historically specific contexts.

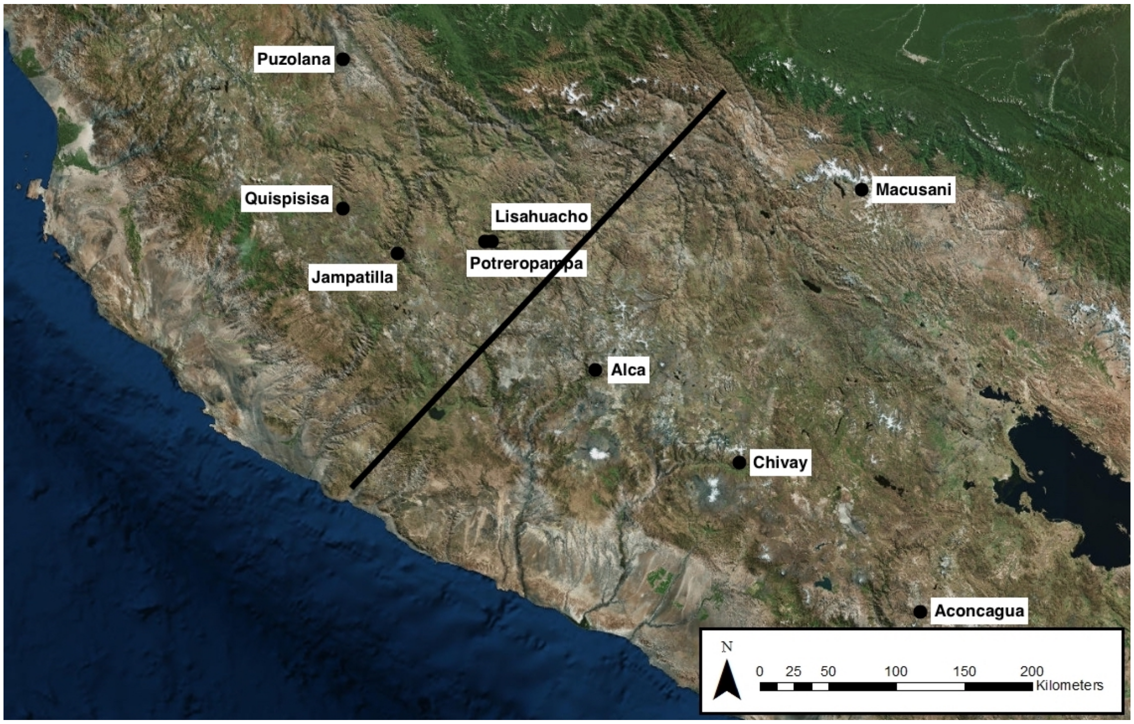


Figure 9.2. Map of Southern Obsidian Network (south of dividing line).

During the Middle Horizon, the Moquegua region does not appear to substantially alter its consumption of southern exchange network obsidian sources. Despite the presence of the Wari administrative center at the site of Cerro Baul, only 8% of the obsidian within the Cerro Baul assemblage is soured to Quispisisa, the remainder of the obsidian is heavily sourced from Chivay and Alca (Williams et al. 2012; Burger et al. 2000). Unlike other Wari administrative centers within the central highlands network (e.g., Jincamocco and Pataraya), the low reliance on Quispisisa obsidian in Moquegua, in comparison to the continued use of Alca and Chivay, suggests Cerro Baul's and Moquegua's continuity within the southern obsidian exchange network and encompassed regions. This may be further supported by archaeological evidence for a connection between Cerro Baul and the Tiwanaku state (who heavily preferenced obsidian from the Chivay source) (Burger et al. 2000). Smaller Middle Horizon, Wari, sites within the Moquegua Valley such as Cerro Mejia and Mejia Ladera, have greater amounts of Quispisisa obsidian than at Cerro Baul (20% and 30%, respectively), but still less than other regions within the central highlands network (100% in the SNR; 47% in Sondondo) (Williams et al. 2012; Burger and Asaro 1979; Eerkens et al. 2010). Therefore, it appears that while Alca and Chivay were dominant in Moquegua prior to the Middle Horizon, they remain so after Wari expansion and consolidation as well. This may be the result, not of a lack of Wari investment or control in the area, but of an imperial formalization of pre-existing exchange networks. As will be discussed below, the empire commonly utilized pre-existing local infrastructure and tailored its control/investment in regions based on pre-existing local, administrative and economic infrastructure (Schreiber 1992). It follows that a formalization of a pre-existing obsidian exchange network would have been a part of Wari political economic strategy. For the most part, Moquegua, the Titicaca Basin, and Arequipa appear to continue to preference the Alca and Chivay sources during the Middle Horizon. The Cusco region, however, tells a different story.

The Cusco region presents an example of a region that prior to the Middle Horizon was firmly participating within southern obsidian exchange network, heavily dependent upon Alca obsidian. Prior to the Middle Horizon, approximately 87% of the obsidian assemblage in the Cusco region was from the Alca obsidian source (Burger et al. 2000). However, by the Middle Horizon, Cusco appears to have radically changed its obsidian consumption, relying more on Quispisisa (41%) and from a greater diversity of sources, dropping its consumption of Alca to 28% (Burger et al. 2000). This may be, in part, due to the establishment of the Wari administrative outpost of Pikillacta, and the colonial site of Huaro within the region. Pikillacta lies approximately 275km from the site of Huari, and had an obsidian assemblage dominated exclusively by obsidian from the Ayacucho and Apurímac regions

(Quispisisa=89%; Potreropampa=11%) (Burger and Asaro 1977; Burger et al. 2000). Furthermore, the Wari colonial outpost of Huaro also was dominated by Quispisisa obsidian at 60% (Skidmore 2014). The Cusco region's general increase in the presence of Quispisisa obsidian and other central highland obsidian network sources, and concurrent decrease in the use of Alca, suggests a change in the economic interaction networks and obsidian distribution channels during the Middle Horizon, most likely as a result of Wari imperial processes. One such process may have been the introduction of roadways from the Cusco region to Huari through the Department of Apurímac, specifically through Andahuaylas. This may also account for the change in obsidian consumption during the Middle Horizon at sites within Andahuaylas, such as Waywaka (Grossman 1983; Kellett et al. 2013), that see an increase in Ayacucho sources during the Middle Horizon. Cusco may have been purposefully brought under/into Wari control, or perhaps sites like Pikillacta and Huaro were (settler) colonial administrative sites, with residents bringing with them their own obsidian procurement networks.

Imperial Processes

The expansion of empires brings with it the development or intensification of infrastructural projects (such as roadways and agricultural terracing), the construction of administrative and colonial outposts, population growth, and increased communication between regions. As a natural process of empire, distant regions enter into new relationships fostered by increased travel, cosmopolitanism, and movement facilitated by roadways. And with travel, comes the increased movement of goods, people and services. During the Middle Horizon, obsidian exchange appears to formalize, for the most part, within previously utilized interaction spheres. For example, within the Ayacucho Valley, Sondondo, the Southern Nasca Region, and Apurímac, the use of Quispisisa, which was relatively extensive both prior to and during the Middle Horizon, begins to take the place of locally available sources (Burger et al. 2000; Burger et al. 2016). A similar pattern is seen in the southern exchange network as well, where Chivay and Alca become more prevalent in comparison to local sources. As obsidian networks began to widen during the Middle Horizon, as a result of the Wari empire expanding and incorporating new territories, it appears that obsidian use became patronized by the empire and was formalized along pre-existing obsidian exchange networks. This is most clearly seen in the expansion of the central highland obsidian network to incorporate the Cusco region. Imperial involvement in obsidian exchange is also seen in the presence of distant sources in limited quantities within Wari administrative sites, such as Alca source-type obsidian at the site of Huari, and the presence of Quispisisa at the site of Cerro Baul. Differential consumption of obsidian source-types within Wari sites throughout the empire will be discussed later in this chapter.

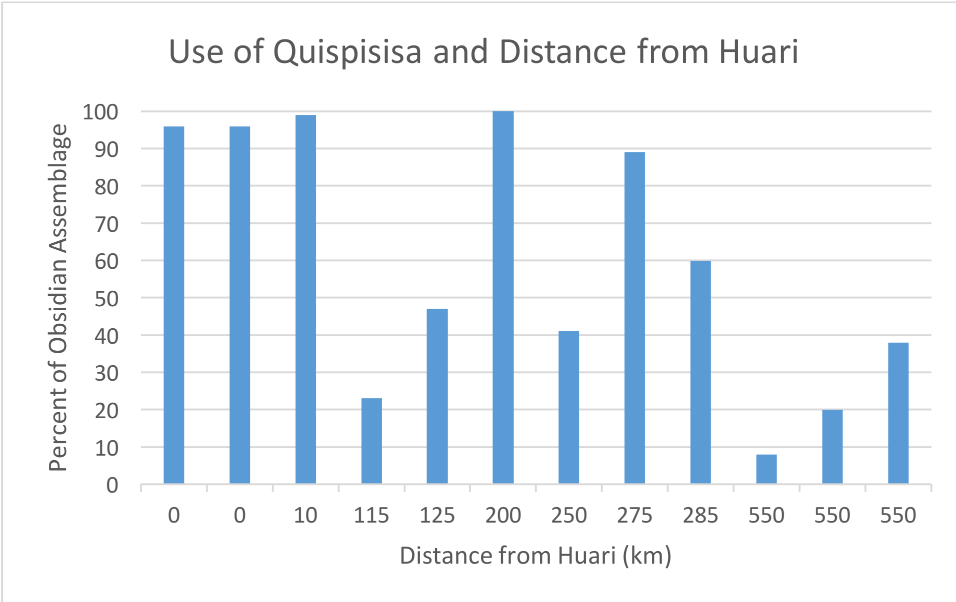


Figure 9.3 Graph Showing Percentage of Obsidian Assemblage of Quispisisa over distance. The Middle Network (275 and 285 are Cusco, and 200 is SNR, shows that its more about networks than it is about distance).

Because Wari was a territorially extensive empire, with a program of imperialism that was malleable and dependent upon pre-existing sociopolitical and economic organizations of hinterland regions, obsidian would have been a relatively easy commodity to transport and manage, as obsidian was often moved as prepared blanks or, in the case of more distant sources, as finished products (see Chapters 7 and 8; Vining 2005; Williams et al. 2012). The wealth finance model suggests that for territorially extensive empires, the transportation of prestige or low transport cost/high value products is an effective way to consolidate power and foster relationships without infrastructural investment (Costin and Earle 1989). One possibility is that obsidian during the Middle Horizon was operating in a similar manner, with Quispisisa obsidian and Alca obsidian acquiring value accrued over distance traveled, which was then represented in their scarcity outside of their established networks. Items within a wealth finance model or prestige-goods model are often limited resources, acquiring value through their rarity (in raw material, production, knowledge, etc.). For obsidian, this rarity (of distant source) would have been in contrast to ubiquitous local resources and seen in the consequently differential treatment of source-types within and across sites. As Jennings and Glascock (2002) state, formal control of any obsidian source would have been difficult without massive infrastructural investment (none of which is seen at either Quispisisa or Alca) (Tripcevich and Contreras 2011). The value of distant obsidian within a Wari political economy, therefore, wouldn't have been derived from specialized sources, but through the difficulty in acquiring it over long distances.

Wealth finance systems are typically characterized by non-local material, tightly controlled distribution and control within one or more levels of the production or consumption of the product. Furthermore, prestige goods are often associated with distribution through limited channels (Ekholm 1972). For example, the Wari Empire appears to have facilitated and/or controlled the distribution of obsidian to both local and distant regions. At the site of Conchopata, obsidian comprises nearly half of all stone tools, 99% of which was from the Quispisisa source. It was formally produced outside of the site and expediently produced in-situ, further confirming controlled obsidian production and distribution channels during the Middle Horizon. And while wealth finance systems typically assume to relate to prestige, or high-status goods, Cobb (1996) asserts that utilitarian items may also function within a wealth finance model. As will be discussed later in this chapter, the treatment of Alca and Quispisisa obsidian is different not only in relation to the use of obsidian at the site of Huari, but in comparison to the varying consumption patterns between the site and its neighbor, Conchopata. As Stein (1998) suggests, one of the best ways to explore political economy is to look at regional variation in "nodes of power", through the differential/asymmetric movements of labor, goods and the like (in this case obsidian) within an empire. As obsidian exchange networks changed, and the ways in which obsidian was consumed and used within those networks also changed, it may be possible to explore one element of a Wari political economy.

II. Obsidian at Huari

Obsidian in the Andes has often been considered to operate within the context of either a prestige or ritual good (Giesso 2003; Castillo 2000; Burger and Asaro 1977) or as a utilitarian, domestic resource. Prestige goods are often associated with limited distribution or rarity, are non-local in origin, and difficult to fake (i.e., require skilled labor) (Ekholm 1972). In exploring obsidian at the capital of the Wari Empire, this dissertation may be able to explore obsidian use at the site as symbolic of a larger imperial program, as capitals often invest in symbols of national or imperial identity, are centers for control, are often more cosmopolitan than other cities, and furthermore can be studied, as Sinopoli (1994) suggests, as “an artifact of empire” (Rapoport 1993; Sinopoli 1994: 293).

The obsidian studied for this dissertation derive from contexts within the Vegachayuq Moqo sector at the site of Huari (Ochatoma et al. 2015). The sector is most widely known for the presence of the largest Wari D-shaped temple in the empire, spanning 30 meters in diameter. Smaller D-shaped temples that echo the one at Huari are found at other imperial sites throughout Wari territory (such as Conchopata and Pikillacta). The temple, in conjunction with impressive architectural features found within the sector, have led to the interpretation of Vegachayuq Moqo as a seat of power within the capital, and within the empire (Ochatoma et al. 2012). Because Vegachayuq Moqo was a seat of imperial power, with architectural symbolic of power and Wari imperialism, then perhaps obsidian within the sector is also representative of Wari political economy and/or imperial processes, or can be interpreted as symbolic of imperial power. One avenue to addressing obsidian within a Wari political economy is to explore the consumption of and access to obsidian as a resource. Differential access to goods is often a material reflection of economic power relations, and the legitimation of the political and economic organization of such power (Costin and Earle 1989).

Within the sector of Vegachayuq Moqo, the majority of the obsidian assemblage was comprised of flakes and flake tools (57%), while only 3.5% of the assemblage was bifaces and 3.8% was projectile points. The size of the flakes and flake tools, with most measuring greater than 12.7mm in maximum dimension, suggest that most obsidian production was occurring outside of the Vegachayuq Moqo sector (Bencic 2016). In her dissertation, Stone (1983) found a lack of evidence indicating intensive lithic production at the site of Huari in general, which may further suggest that minimal production was occurring both within the sector and the site. The limited presence of cortex, or the exterior surface of the obsidian, further confirms that it was unlikely that early production phases were occurring within the sector of Vegachayuq Moqo, and by extrapolation, the site (Stone 1983). What few flakes did present with cortex measured larger than 12.7mm in maximum dimension, which according to Bencic (2016), suggests the production of expedient tools and a relatively abundant presence of raw material requiring little modification. Flake terminations on flakes and flake tools at Vegachayuq Moqo were relatively split between feathered and other forms of terminations (e.g., hinged, stepped, overshot), suggesting that the production of material at Vegachayuq Moqo was conducted by individuals who were not highly-skilled in biface or projectile point production techniques, further confirming the production of expedient and utilitarian tools. Flake platform type also contributes to a picture of expedient tool use at the site of Huari, with an assemblage relatively split between complex platforms (associated with biface/point production) and flat and cortical platforms (associated with expedient tool production). If bifaces and points were being produced at the site, we would expect a higher percentage of terminations and platforms to be feathered and complex, respectively (Bencic 2016). This data and interpretation echoes the pattern found by Bencic (2016) at the imperial Wari site of Conchopata, where she considered the primary (albeit limited) production occurring in-situ to be expedient, from a relatively abundant or ubiquitous supply. Bencic (2016) suggests that flintknappers at Conchopata were producing expedient tools rather carelessly, without regard for scarcity or limited demand.

The results from the data analyzed for this dissertation can now confirm Stone's (1983) interpretation, and extend this interpretation to the site of Huari, where obsidian appears to have been used for expedient tools, rather than formal tools (bifaces/points), and was produced by individuals without a high level of technical skill. The use of obsidian in this manner has also been called "cavalier crafting", and was identified by Klarich et al. (2017) at the Formative period sites of Pukara and Taraco in the Lake Titicaca Basin. Klarich et al. (2017) suggest that "cavalier crafting" conveys an abundance of material for the producers, and perhaps, an elite status due to the nature of that abundance. Their works also corresponds to research conducted by Tripcevich (2007), in which he suggests a transition in the "function" of obsidian from a status marker during the Archaic period, into a relatively abundant and widely distributed medium by the Late Formative period. While this research has mostly been done within the southern obsidian exchange network, it provides a possible analogy for the consumption and use of obsidian within the central highlands as well. The abundance and production of obsidian at Vegachayuq Moqo predates the Wari Empire and the Middle Horizon, suggesting that the empire merely continued a pre-existing pattern of obsidian exploitation and use formed during the Early Intermediate Period Huarpa occupation of the site. Parry and Kelly (1987) suggest that expedient technologies are often linked to settlement patterns and the movements of populations into large, nucleated, permanent villages (Parry and Kelly 1987: 297), further supporting the idea that Wari obsidian exploitation and technology was developed during the Early Intermediate Period in the Ayacucho Valley.

The production of expedient tools and the possible cavalier attitude with which obsidian was consumed and discarded does not necessarily, however, remove obsidian from the realm of prestige good or high-value item within a wealth finance political model for the Wari Empire. Tripcevich (2010) suggests that obsidian may have continued to operate within multiple arenas, and the presence of "exotic" or distant obsidian may have been a signal of alliances, exchange relationships, and in the case of the Middle Horizon, perhaps imperial processes and interregional interactions. Klarich et al. (2017) even go so far as to state that "the ability to waste becomes an important signifier of political and economic status" (Klarich et al. 2017: 157). Because obsidian at both Huari and the neighboring site of Conchopata appear to demonstrate a cavalier attitude towards obsidian production and consumption, any difference between the sites may provide a sample of how power was distributed within the heartland and within two of the most important sites within the Wari Empire. This will be discussed later in this chapter.

Sourcing Results: Quispisisa vs. Alca

Within the sector of Vegachayuq Moqo and Huari, 96% of the obsidian assemblage was sourced to Quispisisa, 3% was sourced to Alca and less than 1% was sourced to Puzolana. As discussed in the previous section, this confirms the work conducted at the site of Huari by Burger and Asaro in 1977, and provides a point of comparison to obsidian analyzed from the site of Conchopata in 2016 (Burger et al. 2016). While the differential use of obsidian source-type within the sector of Vegachayuq Moqo does not appear to be statistically significant overall, there is a pattern in the different artifact types produced from each of the two sources (Quispisisa and Alca). For example, Quispisisa obsidian accounts for over 95% of both flakes and fragments, but only 86% of the projectile points. In comparison, Alca obsidian accounts for less than 4% of both flakes and fragments, but over 8.5% of the projectile points. This may suggest that Alca obsidian was being brought to the site of Huari as a finished tool or a prepared blank. Further contributing to this idea, is the fact that none of the Alca obsidian at Vegachayuq Moqo presented with cortex, while 20% of the Quispisisa obsidian presented with cortex. Because cortex can serve as a general indicator for first-stage reduction processes (Bencic 2016), this may indicate that Alca obsidian was being brought to the site, as stated above, as a formal, finished tool or a prepared blank. On the other hand, the Quispisisa obsidian being produced at Huari was expedient.

The terminations on Alca source-type flakes suggest a higher level of technical skill involved in the production of Alca obsidian, in comparison to material produced from Quispisisa. For example, over 87% of the Alca flakes presented with feathered terminations (indicating high technical skill), while only 50% of the Quispisisa flakes presented with feathered terminations. Due to the relatively fewer amount of Alca flakes and production debris in relation to finished projectile points, it is likely that Alca obsidian was arriving at the site of Huari as a completed projectile point, produced by individuals with high levels of technical proficiency. The presence of production debris, however limited, does suggest that this was not the only way Alca was consumed at the site. It simply suggests that when Alca arrived at Huari, it was more likely to be in the form of a finished product, than was material from Quispisisa. Furthermore, 100% of the Alca material presented with a complex striking platform, indicating that the intended artifact produced from Alca obsidian was likely a biface, or in this case a projectile point. In comparison, less than 50% of the Quispisisa material presents with a complex platform, suggesting that bifaces or projectiles points were not the intended result for objects made from Quispisisa obsidian. This differential treatment of Alca and Quispisisa material within the site of Huari suggests a different value placed on Alca obsidian in comparison to Quispisisa obsidian.

As mentioned previously, the value placed on an object may subside within the distance it has traveled. For example, at the site of Cerro Baul, most Quispisisa obsidian is brought into the site as a completed tool, similar to how Alca is consumed at Huari (Vining 2005; Williams et al. 2012). This suggests that the pattern found at Huari is less about a primary importance placed on Alca obsidian over Quispisisa obsidian, but reflects value acquired over distance traveled and the extra cost necessary to transport material from Alca over 500km (over a 15 days walking), in comparison to the travel from Quispisisa, close to 100km (closer to three days walking). Considering the energy expenditure, food required, and camelids necessary for transport, it is not surprising that Alca material would have been prepared, at the very least, into more easily transported blanks. Its use as a projectile point over expedient tools may reflect the value acquired over distance, just as Quispisisa appears to acquire the same value when traveling to the southern regions of the empire. One way to explore the significance of Alca at the site of Huari, is to explore the presence of Alca at other Wari sites within the central highlands obsidian network.

III. The Imperial Heartland: Huari vs. Conchopata

The capital of the Wari Empire, Huari, lies less than 10km (~2 hrs walking) from the site of Conchopata. Conchopata is known for being not only a large-scale center for ceramic production, specifically polychrome vessels displaying elaborate Wari imperial iconography, but also for being a possible "second city" to the Wari capital (Isbell 2004). Not only does the site have the archaeological features of an urban core, such as dense architecture, plazas, and patios, but also burials identified in 2004 suggested residents of the site may have been members of the elite (Isbell 2004). Furthermore, the D-shaped structure at Conchopata echoes the one within the Vegachayuq Moqo at Huari, perhaps as a symbol of empire (Wolf 2012). Because of these features, the assumption that residents at Conchopata may have been utilizing obsidian in a similar manner to individuals at Huari was tested by Burger et al. (2016). The authors found, however, that the use of obsidian at Conchopata was more expedient, and more limited in source-type diversity than expected.

The obsidian assemblages, in general, are quite similar between the sites of Conchopata and Huari. At Conchopata only 5% of debitage was smaller than 12.7mm, and at Huari just over 4% of the flakes measured less than 12.7mm (Bencic 2016). This suggests that most of the obsidian production was occurring outside of both Conchopata and Huari. In addition, only 21% of the flakes at Conchopata measuring larger than 25.4mm presented with a cortical surface, which would suggest that very limited amounts of early-phase tool production were occurring at the site. At the site of Huari, only 13% of flakes larger than 25.4mm presented with cortex, also suggested very limited amounts of early-phase tool production. This led Bencic (2016) to the conclusion that individuals at Conchopata were only producing expedient and flake tools at the site, and that any completed bifaces and projectile points present would have been produced elsewhere. Based on similar morphological assemblage attributes between Huari and Conchopata, it is likely that the same expedient tool production was occurring at Huari, with more technically laborious bifaces and projectile points being produced elsewhere.

Further confirming the nature of expedient tool production at both sites is the presence, or relative lack thereof, of feathered terminations and complex platforms on flakes at both sites. Feathered terminations suggest technical skill of the producer while complex platforms suggest the desired product is bifacial in nature (biface or projectile points) (Bencic 2016). At Conchopata 56% of the flakes, and at Huari 50% of the flakes, had feathered terminations. Similarly, at Conchopata only 44% of the flakes present with complex platforms, and at Huari less than 50% have complex platforms. These similar attribute assemblages between the two sites suggest a relatively equal treatment of obsidian at both Huari and Conchopata. The cavalier attitude with which obsidian is produced and consumed, and its use in likely domestic or utilitarian contexts, suggests its relative ubiquity for residents at both Conchopata and Huari.

Differential Source use at Conchopata and Huari

Where the two Wari heartland sites begin to differ is in the consumption of obsidian sources from outside of the central highlands obsidian network. Unlike at the site of Huari, where 96% of the assemblage is Quispisisa and 3% is Alca, the site of Conchopata is composed of over 99% Quispisisa source-type obsidian (Burger et al. 2016). There is no Alca material present at the site of Conchopata, which is surprising for a site less than 10km in distance from the imperial capital, even more so for one that has been proposed to be a "second city" (Isbell 2004). Burger et al. (2016) suggest that the lack of source diversity at Conchopata likely resulted from a relatively lesser degree of cosmopolitanism within the site of Conchopata when compared to Huari. The fact that Huari has a greater degree of source diversity in comparison with Conchopata, may therefore not be surprising. As the capital of the Wari Empire, it would likely import a wide array of materials from distant regions, as a symbolic and actualized center for control and imperialism (Rapoport 1993). Differential access to goods and resources is one avenue through which to address political economy and the manifestation of power and legitimacy. The differential consumption and/or access to obsidian from Alca at both Huari and Conchopata may allude to different roles for each city within the Wari Empire and perhaps even to status, power and/or identity of residents within the two cities.

Alca is not only found at Huari, but is also found at other sites within the central highlands interaction network during the Middle Horizon. Sites like Jincamocco and Pikillacta, both Wari administrative centers in Sondono and Cusco, respectively, have Alca obsidian in relatively equal numbers to those found at the site of Huari. The presence of Alca obsidian at administrative imperial sites (in contrast to Wari secondary sites within region (i.e., Pikillacta vs. Huaro in Cusco, Huari vs. Conchopata in Ayacucho) may suggest a greater cosmopolitanism, or perhaps increased interregional travel, communication, and interaction between the different obsidian exchange networks within administrative sites as compared to more residential or secondary sites. In addition, Quispisisa obsidian appears to be consumed at southern administrative sites, such as Cerro Baul, in a similar fashion to how Alca is consumed at northern administrative sites, suggesting that it is not the specific obsidian source that is important, but rather that its presence and/or value is a result of a relatively natural effect of widened interactions, exchange and trade networks operating through, and/or facilitated by, Wari imperial processes. Likely smaller regional colonial sites (such as Huaro, Cerro Mejia) as well as the site of Conchopata, were acquiring their obsidian from Wari imperial networks secondarily to primary sites and regional administrative centers. While this is one possible interpretation, more sourcing work with larger sample sizes would need to occur at a greater number of sites within the empire.

IV. Concluding Remarks

In sum, it may be useful to explore differences in the political economic role of both Alca and Quispisisa obsidian within the Wari Empire (and at Huari) through six aspects of a political economic system: 1) producers- including specialization, labor, compensation and skill; 2) means of production- including raw materials, tools and knowledge; 3) organization- including spatial, social and temporal dimensions; 4) objects- including function and use; 5) distribution- including transportation and oversight; and 6) consumers- including use and refuse (Costin 1991). Within the Ayacucho heartland, there appears to be differential production of Alca and Quispisisa source-type obsidian. The dataset does not suggest specialized projectile point or biface types for each source, but rather the fact that a material is obsidian appears to be more important (Burger et al. 2000). This may be further confirmed by the relatively similar aesthetic appearances of Alca and Quispisisa—only rare blue or red obsidian may be visually sourced and those are limited or nonexistent within the sample from Huari. At the sites of Conchopata and Huari, only expedient tool production is occurring in-situ, likely by non-specialists, while bifaces and projectile points are produced elsewhere. The cavalier attitude with which obsidian is treated may suggest the ubiquity of source material from Quispisisa in contrast to the limited availability of Alca, which appears to acquire value over the distance it travels.

As mentioned previously, material from Alca and Quispisisa is rather similar in nature. Both are high-quality obsidian sources that produce nodules that can reach up to 30cm in length, the largest of any sources in the Andes (apart from Chivay). While the tools necessary for producing obsidian artifacts are not restricted, the knowledge of flintknapping, especially to produce bifaces and projectile points, appears to have a limited distribution within the empire. Because artifacts are not being heavily produced at Conchopata and Huari, and because Alca material appears to have been fashioned by more highly skilled flintknappers, it appears to confirm that the knowledge for biface production may have be somewhat limited, either in geographic or social scope. This doesn't necessarily mean that it is a valued or highly lucrative knowledge base, or that it is conducted by elite or honored members (or even members) of the empire. It may be that certain areas within a site or region are active locations for production (although it is not likely within an administrative site, since Stone's (1983) dissertation at Huari found no evidence of specialized production location within the site, or did Conchopata). In any case, there is evidence for specialized or at least limited knowledge of skilled biface and projectile point production within the empire.

Following a discussion of the limited evidence for specialized production knowledge, it appears that production locations were found primarily outside of administrative or colonial Wari sites. This may correspond to the presence of "doughnut quarries" at the Quispisisa source, suggesting either long-term minimal extractive activities, or short-term high-intensity extraction (Tripcevich and Contreras 2013). While Quispisisa has been used throughout prehistory, there is evidence for increased extraction and distribution during the Middle Horizon (Burger et al. 2000). Considering that two of the closest Wari sites to the Quispisisa source are Huari and Conchopata, and there is minimal evidence of early-phase production occurring in-situ at either site, it is likely that artifacts are being reduced and/or produced at a closer distance to the source and transported in as smaller and more workable/manageable blanks. Tripcevich and Contreras (2011) suggested that this production may be occurring at the site of Marcamarca near Huanca Sancos.

Within imperial contexts, Alca and Quispisisa obsidian vary in their consumption patterns within Huari and Conchopata and other hinterland Wari sites. At Huari, Alca is more likely to be found as a completed projectile point while Quispisisa is found primarily in the form of expedient tools. As discussed previously, this may be due to the value that Alca acquired through distance, travel, and source scarcity, in comparison to the ubiquity of the local Quispisisa source. This consumption pattern is echoed in the southern obsidian exchange network where Quispisisa obsidian is more often found as completed tools, and reserved for select areas within Cerro Baul (Vining 2005). The transport of Alca and Quispisisa obsidian may have been conducted through trade/exchange networks, or through the travel of select individuals to different administrative zones/regions within the empire. In general, Alca obsidian presents a case for interregional interaction at the site of Huari, and a possible, relative lack of interregional interaction at the site of Conchopata.

Conchopata and Huari are located less than 100k from the site of Quispisisa, approximately three days travel by foot. While transporting nodules of obsidian would have been a task (made less so through the fashioning of smaller blanks), Quispisisa was still preferred to the closer (less than 10km distant), more locally available Puzolana obsidian source. This suggests that the distribution/acquisition of obsidian was not an individual endeavor, but a more collective, community or imperially-based distribution program. If Wari wanted to collect larger amounts of obsidian, it would make more sense to intensify collection at the larger, higher-quality source of Quispisisa rather than smaller, lesser quality source of Puzolana. For an individual, travel to the closer, local source would have been more efficient. Because Conchopata obsidian presents with lesser degree of source diversity than Huari, it suggests that Huari was in greater communication/interaction with the distribution networks and the source locations themselves. Alca lies over 500km (approximately a 15 day trip by foot), accounting for the even further reduction of material of Alca from blank to finished projectile point. Because Alca was not moving in large quantities from the source, distribution may be less of an import request from the capital to the hinterlands, and more a byproduct of increased interregional interaction.

The cavalier attitude with which individuals at Conchopata and Huari produced and consumed Quispisisa obsidian suggests a frame of mind that regarded obsidian from Quispisisa as disposable, and ubiquitous. Ultimately, the consumers of obsidian at Wari imperial sites within the Wari empire (both in the central exchange network and southern exchange network) were not the producers of obsidian. More highly skilled bifaces and projectile points (consumed at sites like Conchopata and Huari) were made elsewhere, and likely obsidian repositories for material that could be fashioned more expedient by residents for more daily activities, were present at Wari administrative and colonial sites. Ultimately, more sourcing work needs to be conducted at both imperial, and non-imperial Middle Horizon sites throughout the Andes in order to further our understanding of how obsidian moved through the Middle Horizon as a resource, and product of imperial processes.

CHAPTER 10

FINAL THOUGHTS, FUTURE RESEARCH

This dissertation has explored the role of obsidian as an object operating within the political economy of the Wari Empire. Drawing on original research conducting lithic and PXRF analysis on a sample of 628 obsidian artifacts from the site of Huari, this dissertation has sought to merge original research with previous studies to develop a more complete picture of Wari involvement in obsidian exchange networks and in-situ consumption practices during the Middle Horizon. As discussed in Chapter 9, several patterns emerged that contribute to a greater understanding of Wari political economy and interregional interactions. First, the data support the idea presented by Burger et al. (2000) that there were two different obsidian exchange networks in prehistory, the southern and the central highlands networks. Both networks tended to rely heavily on obsidian from within their own regions, Chivay and Alca in the south, and Quispisisa in the central highlands. The site of Huari, the imperial capital to the Wari Empire, was no exception.

Beginning in the Early Intermediate Period Huarpa occupation of the site of Huari, obsidian consumption was derived primarily from the Quispisisa source, a pattern that continues into the Middle Horizon. Wari political economy, at least as it pertains to obsidian, was developed directly from pre-existing Huarpa obsidian extraction, production and consumption patterns. The greatest change and/or manipulation of the obsidian political economy by the Wari Empire appears to have been the integration of Cusco into the central highlands obsidian network during the Middle Horizon, bringing the Cusco region closer to the heart of Ayacucho, and perhaps in doing so, moving Cusco further from Tiwanaku or other southern influences. While obsidian was arguably not the reason that the Wari sought to keep Cusco close, or vice versa, the shift in obsidian consumption illuminates the close relationship between the two regions and provides a glimpse into how Wari political economy may have been used to distribute resources to hinterland areas, or perhaps how resource distribution was fundamental in maintaining connections to distant regions within the empire. Understanding the intersecting relationships between regions and resources (specifically obsidian), as they are managed through culturally, historically, and regionally specific populations has been one goal of this dissertation.

The second major pattern demonstrated by the research relates to consumption practices at the site of Huari. This dissertation conducted PXRF analysis on the the largest obsidian dataset from the site of Huari, and found that the Wari were relying predominantly on Quispisisa obsidian within the sector of Vegachayuq Moqo, followed by Alca and then Puzolana. This pattern is in contrast to the consumption practices at the neighboring imperial site of Conchopata, which was almost exclusively Quispisisa, with an absence of Alca obsidian. Burger et al. (2016) argue that the lack of source diversity at Conchopata may have been due to be a lack of cosmopolitanism at the site. This may suggest that the capital at Huari was involved in greater interregional interaction, and either hosted and/or sent individuals to far reaching corners of the empire who brought resources with them. Alternatively, Alca obsidian may have been a desired commodity, whose exclusive access was restricted to the Wari capital. This seems less likely as Alca is also found at other Wari sites in the central highlands network, such as Jincamocco and Pikillacta.

Another result, which gives insight into consumption practices at the capital, was the lithic analysis that confirmed the expedient production and consumption of Quispisisa obsidian at the site of Huari. This supports the pattern Burger et al. (2016) found at the site of Conchopata, which they suggested was due to the ubiquitous presence of Quispisisa obsidian at the site. Most likely, Quispisisa obsidian was being brought into Huari and Conchopata as easily workable pieces (either reduced blanks or smaller manufactured nodules). The expedient use of Quispisisa at Huari is in direct contrast to the formal use of Alca at the site. It appears that Alca was being produced by more highly skilled lithic technicians, likely outside of the site. Whether this production was occurring at the Alca source, or somewhere along the journey to Huari, is yet to be determined.

Several questions remain to be examined in relation to obsidian as a resource within a Wari political economy. The first theme relates to the *chaine operatoire* of obsidian as a resource. Along each step in the production sequence, who and/or what social and political organization is involved. At the quarries themselves, how is extraction being conducted? How does the material move from quarry, to the production zone, and finally to the consumption and discard location? What organization is involved? While this dissertation suggests that the in-situ production of Quispisisa obsidian is being conducted by non-skilled residents of Huari, in an expedient manner, the locations of formal tool production sites are as of yet, unknown. One such location for Quispisisa source-type formal tools may be found near the quarry itself. Tripcevich and Contreras (2013) suggest minimal production activities were occurring at the source, and that a possible (and highly likely) center for obsidian production activity was the site of Marcamarca, near the present day town of Colcabamba.

The site of Marcamarca is located at 3,350masl, an elevation suitable to both herding as well as agricultural activities (Tripcevich and Contreras 2011). In fact, this site lies at what would have been the higher limits for permanent, sedentary villages relying on agriculture for subsistence. The present-day town of Colcabamba is littered with evidence for prehistoric obsidian production, and the site of Marcamarca itself has an incredible abundance of lithic debris (Tripcevich and Contreras 2011). Marcamarca lies only 15km from the Quispisisa source, where there is very limited evidence for reduction debris, leading Tripcevich and Contreras (2011) to suggest Marcamarca and Colcabamba as a location for intensive obsidian production. The date for this production is as of yet unpublished, but may likely date to the Early Intermediate Period or earlier, with evidence of intensification during the Middle Horizon as the Wari Empire expanded and facilitated pre-existing obsidian distribution networks.

Another avenue for continued investigation into Wari political economy stems from the observation made by Burger et al. (2000) that obsidian networks do not appear to overlap with ceramic or iconographic distribution networks. The Wari Empire is known for their investment in, and perhaps fetishization of, regional and exotic resources, particularly those with restricted or limited access (i.e., spondylus from Ecuador, feathers from the Amazon, sand and coca from the coast, metal from Andahuaylas). It is also unsurprising that the Wari would have accessed these resources through pre-existing distribution channels when present, based on their regionally flexible model of political economy and imperial administration (Schreiber 1992). As stated previously, complete understandings of political economic systems are dependent upon recognition of micro-level diversity (obsidian, ceramics, metal, etc.) as well as macro-level systems (organization, institutionalization, etc.).

Obsidian within the central Andes was not ever-present, as it was restricted to nine commonly used sources. However, within the Wari Empire, obsidian appears to have been ubiquitous, and consumed accordingly. Expedient production of obsidian at the capital of the empire and at other regional imperial sites, suggests that the Wari Empire relied on a system of consistent and dependable obsidian extraction, production, and transportation. This dissertation suggests that this system pre-dated the Middle Horizon, and that the Wari manipulated, facilitated, and where necessary, modified the pre-existing resource system to fit their imperial political economic strategies. Further research would benefit from comprehensive and widespread comparative analyses of different resources, as well as further research at Wari hinterland sites and quarry zones. The material patterns of political economic systems, or the "things-in-motion" (Appadurai 1986: 5), can help archaeologists to illuminate social contexts and meanings, and to further our understanding of how obsidian moved through the Middle Horizon as a resource and product of imperial processes.

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APPENDIX I

PXRF DATA: TRACE ELEMENT CONCENTRATIONS (PPM)

	MnKa1	FeKa1	ZnKa1	GaKa1	ThKa1	RbKa1	SrKa1	YKa1	ZrKa1	NbKa1
0001a	379.6297027	5623.851931	23.48923688	16.54546466	20.28361988	172.6141529	121.5985703	12.84613031	98.65995331	11.69355845
0001b	317.3337554	5192.113297	25.14467309	16.804935	12.48326635	150.7818451	102.540852	13.29953584	92.17972161	10.23572091
0001c	293.8679768	5590.563353	25.89851719	17.80210289	18.14137172	169.0069727	113.4186992	13.59661587	99.44348587	10.60526151
0002a	335.8670883	5982.585732	28.59633815	22.99908763	19.41949338	179.1959903	122.456908	15.52224697	101.6992158	11.79384406
0002b	322.9436304	6338.997911	26.9763078	22.67498436	18.93874603	191.087227	128.9008386	13.08527175	105.7218348	11.43543981
0002c	348.0475031	5511.360209	27.95887522	18.57018217	16.72301361	168.7693119	113.4634892	11.2319762	97.287172	10.84211518
0003a	422.0653279	7229.188264	34.22823216	26.74133037	18.7712457	205.6564267	141.7290761	14.20347286	111.0950573	14.04401173
0003b	348.9459745	5476.911046	26.71630541	19.37143922	16.81156895	163.0642309	111.1984865	15.05885628	96.95628853	10.29088858
0003c	410.6988791	7115.917206	37.649413	24.39680037	21.92796817	191.8364015	128.2110252	13.99251578	107.7978207	11.5894868
0004a	404.3885995	6573.846659	30.07236536	25.35320554	20.09023808	194.5555941	132.3726457	13.32504927	104.9642869	13.01420592
0004b	342.8745095	5831.795749	27.66932567	19.63541752	18.51439642	173.400265	116.5316449	11.82341114	101.5242438	12.01896191
0004c	380.3938599	5891.557242	25.88435133	21.46068774	19.72523303	172.3074016	121.5654859	14.04254193	98.79171055	11.39329254
0005a	568.0628698	5733.444013	54.72780379	24.98467251	13.10498905	118.8345864	51.76298234	13.19523473	97.49082695	29.47451473
0005b	549.5612938	5776.289221	61.0937121	26.29744531	14.2362558	125.4719716	52.66070403	13.1424206	99.37014681	30.70045213
0005c	536.6513454	5811.056869	53.41742431	25.6586374	14.53014787	124.0938248	52.57271135	13.87652734	96.01225293	30.1884361
0006a	315.5049635	5917.168679	29.33021374	22.07667357	18.32027494	182.623058	127.3701288	14.2154086	102.2467512	12.45125878
0006b	352.8899635	5891.080663	31.0847049	21.01922291	19.98178574	180.9613134	122.7579958	13.56039901	104.8352911	12.30675863
0006c	431.9911205	6459.341464	46.19823502	23.82019213	19.57350897	190.9696831	132.1646796	14.614924	106.2001279	12.71531192
0007a	335.4396994	6886.294434	26.17513295	22.48714516	20.25014221	192.6454152	133.8474619	13.96725263	108.489755	12.0385377
0007b	341.7488654	6388.04615	29.93445944	21.73942376	21.02666459	185.8692625	126.6701357	13.71170703	103.3045141	11.39343161
0008a	332.1927684	5851.737108	33.37776306	19.79508172	16.6627386	175.3593474	123.1725847	13.17846421	100.3972089	11.63962479
0008b	382.4048341	5756.816938	22.95923247	17.11485594	17.4245607	169.9178992	120.3077067	14.30783966	97.65306041	10.98125308
0008c	371.0568385	5969.737696	28.19164563	19.99758176	19.36554465	176.2561137	115.9653854	12.59056872	98.1166543	11.80241809
0009a	370.17005	5738.770461	23.37722638	16.73547205	18.41009664	175.036039	122.0597559	13.22981364	99.08796631	11.18567616
0009b	354.6012568	5741.961534	27.86726878	19.17951334	18.4441366	173.3526606	120.5644528	12.96601811	101.4472567	11.06753441
0009c	368.6572745	5523.756892	28.04713615	17.26120495	19.79362265	170.094612	117.8393759	14.14256501	96.96168672	10.87416705
0010a	298.7093726	5312.637817	28.6710123	17.29087382	17.19760643	160.8084596	109.3649255	13.23256667	91.63025993	9.718737511
0010b	315.2258688	5599.48109	32.25081767	18.73704019	16.37090352	165.1339799	115.726247	14.07138513	96.47090318	10.67240627
0010c	361.5352132	5850.805765	30.83822731	21.78804813	19.65136031	177.842979	119.8497309	12.11170275	99.30123502	11.06608898
0011a	376.1879422	6478.032454	32.57779503	24.07186151	20.41123593	193.3302395	131.0544081	13.50623504	106.3156318	13.45108411

0011b	373.8172495	6491.061554	30.24688398	24.18946325	20.43994452	194.1409528	131.4185822	14.30199917	108.0334987	12.88610823
0015a	367.6452006	5712.207362	29.87843285	20.01742548	18.99976417	178.1353379	121.5812856	13.44268644	101.094348	10.64195772
0015b	363.3600588	6177.284245	27.94390098	21.67966385	17.11809812	177.0274912	123.5790601	13.38777892	102.9652451	11.65336985
0015c	358.816296	6173.08867	34.1655883	23.07160403	18.55242438	181.2168929	119.7123824	12.96470733	101.3153947	12.60093099
0016a	332.2034002	6025.724418	22.83498556	19.45530066	19.11505963	181.5608517	123.1181846	12.4721984	101.3226695	12.5410871
0016b	344.1290037	5935.09647	31.95838384	20.81034041	18.94408686	176.038178	120.5157554	12.55751179	98.73494803	10.98104483
0016c	361.1583221	6355.276273	33.11235931	18.96473768	17.80889167	168.5171401	117.9548668	13.83657396	97.4978662	11.2528602
0018a	361.2361003	6428.205838	30.52890999	19.45333287	18.61217665	188.9269392	124.4992206	12.98928211	105.31487	12.13155726
0018b	404.8866783	6889.95559	43.24968918	23.56775986	18.20741013	197.5183426	134.3574509	16.5413711	108.1743152	12.18184354
0018c	341.4719843	6144.929881	34.49610784	22.72727519	18.85856152	179.1283779	123.7537544	15.76536916	102.2568218	12.16858115
0019a	377.9411917	6664.176162	27.58252382	25.55792254	20.92326127	198.2763046	134.1237366	14.67062371	109.2992319	12.50810154
0019b	358.8050237	6267.027319	25.69241236	22.91016241	19.85589766	189.4663344	127.5089039	14.78681092	103.9628719	13.56560089
0019c	334.6704264	5886.928833	29.15236544	22.82816125	18.81634857	174.0642338	119.8772874	14.44305727	101.0111768	12.14613736
0020a	363.203924	6051.904078	29.05418463	22.93325013	20.43610433	185.3088821	125.8844791	13.38420455	105.2121967	12.19275502
0020b	415.487519	6173.292012	32.91186306	24.03844367	19.06656089	179.6312535	124.4749574	15.10572785	103.6569047	12.08672036
0020c	345.0139279	6245.333581	40.07557054	21.25684252	18.11852958	178.8794288	124.3780392	15.02630867	100.1329368	11.21722932
0021a	366.9031156	6779.283923	38.1770955	22.19045132	20.89404438	190.4654555	132.735506	14.24017503	105.324968	11.48130038
0021b	316.9430436	5890.272283	27.39697547	20.14284636	17.59873223	168.5211721	115.2030402	14.37513795	96.91351722	11.36815543
0021c	427.2791732	6284.138582	28.55925401	18.66241468	18.31477951	178.6515684	125.3439293	15.26507724	102.3458404	12.5217923
0022a	334.7066147	6097.451189	26.80262799	20.88184965	18.27556977	178.7834255	121.5951714	13.28103442	102.8666148	11.23818775
0022b	311.9820093	5475.811372	21.99000262	19.03832473	18.17340391	167.3364372	112.9118333	12.9896863	95.75482439	11.6252711
0022c	359.4668287	5919.04752	25.24260309	18.36995494	17.81452364	173.5907012	119.4682093	14.91359325	100.8206594	11.22486699
0023a	370.4060698	5662.921084	22.99239146	20.23266874	17.26004157	169.462805	117.7650196	13.78092625	97.67194419	10.32103466
0023b	337.7712067	5769.536569	30.75518675	18.04127417	17.68408817	167.4955141	115.0012765	13.36923219	97.50421956	10.88784952
0023c	336.3434151	5580.612268	27.55834047	17.14092136	16.92071391	170.6661626	117.5153418	13.06028943	97.01234888	11.5344063
0024a	221.3972351	4775.929209	23.99464607	14.05305148	15.76992552	142.8540555	96.39026891	11.75264401	88.30334559	8.992495766
0024b	356.4713338	5945.61952	29.93863934	18.00643332	19.85657345	181.0807367	124.5812668	14.70640681	103.0523447	10.95342498
0024c	342.7011001	5662.147429	30.54972709	18.59402074	17.09185708	167.7053058	120.5255219	15.27973858	97.97498961	12.28859639
0025a	334.1735845	5971.716465	29.7892823	17.46095982	18.07923449	172.6023628	117.3243781	13.88065844	97.52799067	11.72954073
0025b	332.7191378	5797.270019	27.08698604	21.7886232	17.1520539	170.5901391	120.4018489	15.93146339	99.63036725	10.65716279
0025c	343.5539668	5844.06995	21.12447393	20.42328603	17.32250213	174.5483669	122.1515829	14.07708375	101.13122	11.83852133

0026a	342.5817075	6043.662158	25.15703917	19.57605622	19.71886011	175.4635995	123.9134966	13.2630979	103.0121593	12.35564758
0026b	370.7534839	5920.338593	23.16028288	19.93187617	18.89814428	182.3716769	122.4698785	13.43101984	103.3023879	11.83696574
0026c	321.0731538	5005.963574	27.03095207	15.1407108	15.95676902	152.7407337	104.5826143	11.49183706	92.65415632	10.83191793
0027a	373.3413875	6172.56814	31.29918144	19.0393282	19.49861297	181.4087289	124.7293403	14.66298609	103.4189086	11.65877136
0027b	340.5901894	5845.125412	27.00498337	18.88761173	18.28477758	168.4128941	117.5243952	13.52337757	97.59746447	10.86097052
0027c	356.2903752	5841.250761	30.00344189	20.18309394	19.70960489	172.9328494	116.3253753	14.92316114	100.4243611	10.96653413
0028a	373.7682461	6675.62557	33.57544666	23.34333246	19.47541751	189.5521719	126.4801912	13.73076517	108.4822843	11.3001368
0028b	397.5090907	6658.734972	34.4293466	25.92097245	20.22588172	194.9392382	131.4184876	14.43792145	109.7936025	13.48797289
0028c	438.0280567	6400.63848	24.2778811	22.47797079	18.28903141	187.7243863	128.4138697	14.08500051	108.0154227	12.98045416
0029a	384.2907219	5915.249137	27.94621931	19.42934296	19.08944581	180.0806409	120.7369613	13.77309529	103.1913433	12.08711109
0029b	368.5957841	5956.664546	25.46201459	21.02618119	18.62919346	183.090673	125.0641413	14.88594199	100.3359375	12.360094
0029c	339.7923784	5785.341434	27.2484266	21.13878456	17.2403251	177.7628584	121.5416235	12.79454962	99.61957366	11.02759976
0030a	348.187163	6281.566882	39.50876314	22.45112779	18.13759017	183.6926924	123.8287153	13.22090985	104.5281556	12.83955603
0030b	387.8915216	6199.824753	34.57220236	22.22572476	18.27216152	184.2764337	128.099416	12.02054212	105.5154843	11.19969927
0030c	374.2424943	5939.842888	32.09824697	23.14823816	18.10565305	178.2319569	121.5331253	13.25814165	103.2903938	10.08916672
0031a	403.0228211	7139.168996	32.66777224	26.63625109	19.75614854	189.7166166	130.3166527	15.60372888	106.5112423	12.95027105
0031b	406.2132049	7685.367167	42.47066312	18.87160671	17.90324448	177.7675736	121.1737372	12.35771078	103.8521728	11.62604403
0031c	410.0654025	6742.34818	29.72784592	23.74563355	18.74348847	188.1807542	129.8538259	14.55214797	104.1055489	12.8266422
0035a	339.0218205	6160.097454	30.70942015	21.95362197	18.83808722	186.4327484	125.203268	14.14566266	107.6158635	11.96327899
0035b	345.2173653	5923.821691	28.02076866	20.84755914	18.33617405	176.8015673	119.928822	11.06039494	98.30580058	10.72352819
0035c	327.0372754	5552.044116	31.85821655	20.70940838	17.21093701	167.1191916	115.2808722	12.83681186	98.14302265	11.02466827
0036a	344.6212339	5860.786609	28.10145005	21.64393298	17.86610733	174.4061934	121.2129704	13.00454451	100.865526	11.09807795
0036b	358.7305715	5681.365132	23.74798746	17.40824881	17.76650553	170.2571982	117.6812447	14.14117403	98.52393668	11.52640978
0036c	406.9188329	6039.922848	28.78091691	19.48690652	19.27429106	176.2126882	118.905306	14.4063969	102.8845003	11.70983067
0039a	362.08177	6345.719529	31.31589972	21.66968664	18.43408226	191.3274669	128.0608399	14.37285657	104.176345	13.19828098
0039b	396.6898195	6451.106781	25.7271217	23.64040331	19.03213646	189.0946446	130.5905835	12.48797966	105.814759	13.20759426
0039c	324.0398336	6827.51673	44.10561849	23.32917378	19.74954914	185.7367276	133.1803317	14.93780352	105.8649671	11.62136166
0040a	435.3832871	5672.183174	28.88210944	19.383404	17.57606259	169.6150364	118.1304978	13.37194553	97.20810801	11.76736626
0040b	331.6711588	5534.186885	28.30326451	14.38442142	17.8416016	162.9806854	111.7979842	13.1056189	95.79977129	11.82710418
0040c	315.1392038	5416.267584	20.72611479	16.42275183	18.05116649	156.5526041	107.6902723	12.47236734	91.92578902	10.31394559
0041a	346.1157062	5877.476484	26.80185052	19.0493275	17.90450067	171.9182484	113.5144828	12.37494548	101.0803633	11.74536098

0041b	349.8910742	5702.131519	29.45619222	19.81908276	16.96443399	174.9641996	117.4617599	13.83537415	97.54031562	11.39148052
0041c	311.3928203	5477.523203	29.62589177	18.79834195	16.17967928	162.7784258	111.1283624	13.32105255	97.87340876	10.55692614
0042a	500.8101528	6476.365824	43.7907122	25.13153806	13.89067486	154.6927456	79.26609919	14.78132387	112.9136899	12.16037985
0042b	508.4320204	6064.00224	46.31186075	19.96138063	14.28857608	146.9186004	79.03975591	14.31484136	106.8738228	13.74912271
0042c	394.2320178	5373.432576	31.71295971	18.58888174	12.19595496	133.5155805	68.75921992	13.19722954	96.59512881	12.48612773
0043a	342.0360385	5905.658163	33.25281643	21.01095954	20.41876245	174.7281367	120.3180616	13.79765222	102.5404608	11.10508322
0043b	363.7903808	6121.596233	36.88817104	20.57458242	19.6871806	181.6698152	124.716447	14.91656409	101.0656154	10.85786312
0043c	337.9923659	6171.265829	26.306346	19.95875157	17.59512393	180.4130716	122.3743822	13.78490895	103.4370126	10.92925476
0044a	379.3193131	6653.141362	34.9772267	26.90425476	20.18432723	198.1217135	135.0630275	15.73592065	109.6214693	13.10442044
0044b	361.081352	6419.716567	31.46294723	24.41992365	19.93003439	200.1583976	136.113084	14.60910761	107.8917542	12.8624373
0044c	393.5483044	6518.935177	29.15420829	25.0130485	17.64716764	193.1862372	134.0693878	15.88552998	109.3384082	12.91487805
0045a	390.9636017	6665.683212	52.11167456	24.57416035	19.79753689	189.1548641	130.8209995	14.2472291	105.4182652	11.33657184
0045b	367.5632587	6532.55872	46.07137937	24.14079352	19.03700954	188.9848624	133.7874067	16.05256224	107.6993541	13.56553402
0045c	421.7390431	6659.129795	53.08993214	25.33537789	21.65295915	188.3197875	133.1111207	16.00562844	106.39328	12.85896278
0046a	411.2627545	6652.82068	36.09620687	23.03872633	20.39742348	196.2556481	134.9806415	15.3542679	105.5889553	11.791258
0046b	316.8570531	6554.775951	32.49869387	25.71309419	19.11118641	194.4930452	131.3228247	15.88575591	108.9586383	12.91187264
0046c	387.640614	6524.656477	38.06284395	22.02345661	18.76445122	187.1541696	126.9097312	14.38784708	104.9760558	12.26425523
0047a	317.8132918	6442.874378	31.49933949	21.17902875	20.16249216	187.1800592	128.3996547	14.43001445	105.0263615	12.94446865
0047b	344.1318962	6306.532606	33.35583851	22.80007118	20.0576717	184.9020592	128.0583618	13.77095723	106.0511921	11.43295145
0047c	364.366721	5974.268534	33.41592091	20.05108158	17.04139091	175.4250454	120.6231521	11.27766916	100.451459	11.01723192
0048a	303.3002485	5588.233428	23.97199155	18.89119508	14.93369712	167.0679712	113.4257744	12.76201116	97.73987482	9.722292377
0048b	383.8092768	6453.340065	35.2827746	25.10430357	17.74554098	188.1735899	129.1615432	13.66365632	107.0348149	11.74423113
0048c	324.445507	5991.178812	31.08201342	20.9441586	15.34565208	176.1516381	120.5912535	13.67924796	99.64666673	12.22893404
0050a	310.6311859	5994.372643	25.73044392	22.13185325	17.80398578	172.8924429	119.6017881	14.29437707	100.7249509	11.28251431
0050b	359.7724791	5663.318688	25.68164567	20.69681195	16.51563689	167.9283881	117.3822992	14.69623014	99.68534788	10.22396988
0050c	366.5529276	5984.165379	26.38548338	20.78757828	17.2815119	175.4342216	122.1191191	14.82672309	98.92709255	10.90847303
0051a	286.9492443	5506.634074	27.14000181	16.88653352	14.52137823	162.9069779	112.110631	13.25079268	94.25829483	11.06664451
0051b	328.7471057	5689.506533	31.63936143	18.98619914	19.21253053	172.2323696	118.3531464	13.90560575	98.27343027	10.46073585
0051c	296.9574497	5181.961204	24.60214214	16.70909682	17.3901774	156.2366612	104.3931079	12.83629861	90.28135824	9.989632356
0052a	334.4807206	5567.128906	28.7088234	18.54793778	18.78608817	168.4370022	118.2522677	14.0307953	101.440461	9.975429035
0052b	387.7829369	5839.690017	34.59338567	18.40214585	16.45119587	159.5696515	111.4183184	12.02406256	96.90591996	9.627217859

0052c	324.069814	5709.690444	26.48099244	20.3961973	17.097096	176.887173	118.0886935	12.91657219	100.5004034	10.79494156
0053a	338.901405	5908.616013	26.80685184	20.29981532	20.09791895	172.2097749	120.6162226	14.60461019	102.3947354	11.17364059
0053b	357.1118482	6193.354956	31.8969597	20.18296857	21.33695902	184.3034676	126.7865353	14.98351624	103.4279457	12.03801616
0053c	339.6981823	6077.592136	27.66947936	19.8045648	21.84101238	180.7567546	122.7216158	13.07333619	102.2788193	12.7587732
0054a	377.1163035	6039.661253	29.74680989	17.07888912	18.27177579	167.1254371	116.6732934	14.94671072	97.70437274	10.81629789
0054b	339.6122975	5571.727256	27.03889559	17.53953181	17.70839357	163.5391796	110.4326005	13.25684082	94.2398369	10.04200349
0054c	339.436836	6303.568842	33.59935143	18.74643203	18.18190431	174.7451018	118.9523445	14.09701047	99.52267974	10.38148192
0055a	287.8452745	5306.063253	27.24238511	17.48672786	16.96811074	156.319654	108.6490334	12.81871994	94.03414829	9.802465694
0055b	281.2278431	5044.123585	25.4743703	15.83668964	15.79731778	150.8035724	102.1677024	11.45712007	87.82646398	9.108322045
0055c	289.3165628	5258.23127	29.60527928	17.04140874	14.17464554	162.913014	109.6126226	12.88132245	96.64871464	11.27245605
0056a	300.566048	5410.322328	24.70759768	17.41170523	18.03734686	159.0403057	113.7320656	12.45451687	94.3892602	9.943859896
0056b	337.1947111	5719.036221	22.73636065	19.99031307	16.65364706	171.6533923	118.0922547	13.66732489	98.45432678	11.57974989
0056c	302.2629294	5342.19627	25.19391894	18.10978385	17.16997291	160.6819356	110.5507777	12.93903704	95.07621606	10.0381215
0058a	319.6338598	6039.045212	28.2335987	21.62944849	17.44923197	180.4175647	124.7328551	13.39275462	103.6796038	13.01539511
0058b	345.3024643	6036.410638	31.10176578	22.74958525	19.02283162	182.7072259	123.0788038	13.44959811	106.3117219	11.77395676
0058c	323.8156926	5909.636424	26.85332404	19.25086745	18.35909918	178.7443721	125.3422592	14.57915418	103.1774269	12.2559985
0059a	325.777418	6141.084208	34.32138484	23.73296682	18.66486155	186.70883	124.3428164	13.46127828	106.2926583	11.19606068
0059b	386.7748159	6931.82705	32.95892289	25.73819182	21.47521125	196.3947243	136.5226728	14.98861491	109.3452919	12.94711167
0059c	419.295784	6633.115708	31.91721963	25.06153837	20.36028525	196.7720903	135.4542053	15.46826022	110.1847872	11.65378204
0060a	419.6305519	6830.829508	41.88361209	22.95676752	19.62680441	197.0616623	130.1228219	13.88133936	108.5332253	12.94510533
0060b	423.3783509	6898.723253	45.54604639	21.98628369	21.4071187	195.5250965	132.0712742	14.73264578	110.6015064	11.81910249
0061a	294.9791727	5194.075471	21.62542985	17.83925906	16.96477621	155.1307146	106.195287	12.62073709	92.36515168	10.24527373
0061b	334.6582398	5675.807276	24.85999036	16.41514349	18.58530911	167.3447983	110.2790869	11.73570381	97.20563102	11.00920745
0061c	314.5191003	5522.482549	26.99501929	19.32627945	19.29489207	167.5089722	114.4818184	12.63197327	96.71218333	11.14420825
0062a	359.1894819	5978.8853	30.47535069	20.76965896	17.70076794	170.2197207	122.3209134	14.47796631	101.2499866	11.63753996
0062b	364.3692173	6058.305701	25.57380594	22.28992995	18.84056318	180.6787478	123.8575677	13.70860624	103.3969837	12.42553828
0062c	310.7942686	5750.47996	23.23644581	19.83718152	18.71609407	171.9280007	115.4560865	12.88888307	101.119089	11.52799584
0063a	382.7554805	6132.189328	32.69009522	21.42760946	18.72565477	183.864016	128.4552377	14.65557599	102.743021	11.98818737
0063b	346.8828494	6545.263966	35.02906482	23.15342322	19.54802686	186.8066294	128.2635532	13.3720337	104.3203313	11.42478162
0064a	316.2430771	5844.984231	29.28533779	20.78651888	18.61982408	178.0412323	119.5521098	14.68411888	103.3588065	11.55804087
0064b	364.5733523	6331.90521	28.06380579	25.79736296	19.9423934	190.1423151	128.2850103	15.43514595	107.2107357	11.83363749

0064c	326.5813504	5739.944556	29.63814451	17.81010613	16.5330544	171.4567114	115.372613	13.67458801	97.32130224	11.47331903
0065a	343.118068	7305.27536	31.55204786	27.00302229	19.9716107	201.1780661	146.504162	17.278728	112.5086707	14.43766288
0065b	407.5446827	6600.492313	39.13240232	25.06205355	20.12154965	195.4246072	142.3541038	14.18974101	110.6993687	11.92592088
0065c	303.138526	5886.111174	25.91546261	21.44838225	19.97580861	174.3811083	116.740242	14.39198295	98.3867043	12.07675429
0067a	401.4431476	5644.925072	29.34338488	17.20784997	17.91796936	157.2819109	116.8772054	13.72632696	96.53626794	11.134812
0067b	393.3952352	5889.217351	25.67817528	20.4585501	19.13366385	173.160323	118.7352102	15.02927599	102.291737	11.80178781
0067c	362.7388716	6034.262582	26.67199497	20.62410739	17.51532051	170.9775673	118.3122507	12.56206023	98.800748	11.80648402
0068a	359.7163369	5960.025647	24.8415526	19.97878601	19.37354236	178.360746	118.9299239	12.83368183	101.6641919	12.03156277
0068b	397.6578657	6712.405643	36.05847694	24.62450838	20.45748496	196.628448	131.7647335	12.91093978	110.1527098	12.62666696
0068c	313.6030093	6331.992056	28.2055363	19.6508058	19.0308046	166.8885552	116.0814129	13.36805394	100.7105658	11.56921277
0069a	340.8199578	5844.954804	24.87045286	16.70808946	17.32071003	172.7108516	120.1833121	13.87309988	99.65350133	11.02989123
0069b	349.081675	6164.326459	28.76821233	22.06739671	19.29458171	184.4540353	126.4487433	13.58198324	103.667522	10.79238626
0069c	344.7367835	5844.065242	24.01154158	16.69780831	18.13034544	174.082162	120.0116627	15.77092275	99.07112968	11.97197271
0070a	326.0168253	6049.392025	27.829351	22.38508866	18.20691884	181.0333043	125.8639946	12.68653749	102.0542111	12.17156845
0070b	377.8090367	6323.395614	24.13957682	22.85451009	19.09412014	190.9268942	128.6267117	13.63722145	103.4121089	12.15280095
0070c	345.4244837	6860.771555	26.27851043	28.47684639	21.90734819	199.4077405	140.7931997	16.30426207	110.1073193	13.66219205
0071a	380.5503024	5882.847491	26.96594315	21.58921129	17.63222877	181.6950128	123.9502876	12.91389905	101.8979586	11.35812416
0071b	344.8789861	5860.064358	25.18212514	19.53185502	20.45693911	180.9278827	124.1989606	13.96811845	100.9305596	10.94971933
0071c	398.2704192	6536.913192	30.58718298	25.52529122	22.43293621	194.0196426	134.7837772	14.91430012	106.7965365	13.33293447
0073a	366.1362936	6537.242425	37.38277302	25.13276353	20.46470587	196.8366177	131.0814262	13.02149971	106.9887039	11.55764078
0073b	381.8219451	7014.900954	28.79901337	26.98843762	21.03713954	204.2773245	134.5039767	15.25833662	111.6230105	13.08195827
0073c	363.8469757	6241.399674	26.25808881	21.85628477	20.01334022	188.3109136	130.0181034	13.4888465	107.4282882	11.99834059
0074a	365.5032091	6119.132846	30.31778548	23.18287309	18.34534102	177.4191187	119.2093803	13.71471156	99.29018215	12.31751152
0074b	328.0660355	5975.551657	29.56986399	18.99469753	17.29668408	171.1485906	117.1559476	14.91835908	97.45414084	11.15501126
0074c	335.8876236	5908.719625	23.91721181	20.04561578	18.05486597	172.9586514	117.185038	13.61631584	99.74476381	12.00431976
0075a	373.4058052	6262.228135	37.51196272	23.33135725	19.79805137	184.6139198	124.820527	15.13555126	103.0289032	11.66727423
0075b	296.9047811	5288.742378	24.91911112	16.80249382	14.22658421	161.9068336	108.8923699	12.33223876	95.3990605	9.826106529
0075c	314.3100236	5941.156927	24.77033253	18.51777145	17.7710854	176.8261119	120.6539738	13.23465957	99.67154408	11.89730705
0076a	343.659155	5712.592658	24.21673365	21.4291033	17.68619732	171.4230816	118.8316774	13.01285129	101.8932514	10.71233392
0076b	317.5323007	6046.270655	31.94795636	22.98665581	18.04154433	178.8607352	121.9357951	12.34919015	100.093457	12.24893404
0076c	278.3463844	5779.300054	31.96095286	21.58588922	15.80930594	167.2906568	120.3684598	13.5903328	97.85645937	11.74973442

0077a	229.5932978	4966.801335	23.38313228	17.73994348	15.42812729	145.2790534	100.0635405	10.93902739	86.24056981	9.694746161
0077b	225.3371967	4636.479789	26.0166251	14.66597667	13.11023197	140.9885289	94.54919336	12.20303266	86.69970156	9.81132929
0077c	361.9831978	5787.334767	30.76179424	19.53895296	18.27936801	170.760191	119.63171	14.80552416	97.90391377	11.44489611
0078a	331.6009638	6090.675732	26.16075124	20.89347385	17.19398639	180.9861988	120.9170945	14.28162415	101.4295708	11.75768578
0078b	367.6622144	5741.638722	28.56887862	18.55026177	18.96842232	174.2940007	118.5601768	13.51673219	98.90303258	11.13774509
0078c	310.7488432	5284.257697	25.2938375	16.20353031	16.14638538	156.5502186	110.4251137	13.33981339	93.63241899	10.61653856
0079a	366.3692066	6186.828325	27.08775675	23.48226523	20.13039443	188.0081886	129.9075662	13.57093377	106.1033491	12.02842184
0079b	397.4846434	6218.493837	31.96803909	21.52884452	19.54089517	185.7635278	124.4270874	14.26031968	106.0424596	12.52450988
0079c	273.1182206	5517.669044	24.71150773	19.40674863	15.28423446	164.3148158	112.7865193	13.1017678	94.75637323	11.30259322
0080a	362.3352352	6313.793607	32.79786782	23.74029618	19.63836711	186.8411746	127.2319396	15.00159919	106.3751623	12.41348774
0080b	264.8933159	5714.0594	21.94927528	20.08348654	16.54542204	171.4783956	117.8057688	13.37708354	101.8299593	11.24833283
0080c	379.8209374	6341.551772	32.10702834	21.17038629	18.696784	184.3073888	128.6715515	16.10964784	106.7007073	12.94131599
0081a	359.9182488	6157.837773	34.33279882	24.17485973	20.28279073	189.298145	127.6994238	14.74236144	105.7010291	11.95372327
0081b	412.7815505	6759.171015	32.36094269	25.07027406	23.1205294	205.3294418	140.4622534	15.33054314	111.7680777	13.08497694
0081c	369.7748942	6070.094203	25.33686053	22.23047268	18.34410522	177.9992834	129.4705857	15.7740237	105.2718276	11.74207389
0082a	296.1972126	5789.349566	26.98877127	17.2387695	18.27449325	171.9442064	121.511267	13.98141724	99.07410189	10.72185824
0082b	392.7166577	8316.039592	50.04710866	28.18816895	20.38842149	208.6830565	139.6275146	15.16468253	114.4836199	13.10501124
0082c	357.5589401	5850.636956	31.15453324	21.21407453	21.19848314	175.9057197	118.9858811	15.17215314	102.155488	11.73858394
0084a	388.2421368	5958.8233	28.91685453	21.15842936	17.60890589	178.1632994	120.8853002	15.73008709	103.2210129	12.19407928
0084b	390.924285	6177.248799	25.31611743	21.6867164	19.94979323	184.3026467	125.431119	12.65226839	101.6659463	11.87864239
0084c	409.1175131	6468.800197	31.94619357	20.64955135	18.7286951	184.8371472	126.6003101	13.11173757	104.2995506	11.02634614
0085a	354.4316744	5682.756077	26.29087134	18.31579615	18.11451049	170.512598	116.1865767	13.96626353	100.7908224	10.78628458
0085b	342.0371048	5702.065535	26.87174051	19.01471479	18.91799169	167.8993817	114.3895753	14.16338711	97.95308615	11.29062807
0085c	363.6249712	5958.435396	32.1912724	16.82152	18.62903667	177.544589	117.8960303	14.59323395	102.2756229	10.99122165
0086a	348.3605959	5927.957866	27.9669167	20.73915447	15.91759376	177.825361	120.9061826	13.90844038	100.8512959	10.06745391
0086b	378.2352311	6224.041219	31.31490923	21.4494688	19.59280171	182.0289792	126.4587303	13.9067788	107.6644857	12.06403979
0086c	356.6651199	5998.656924	28.05017143	20.85958187	19.11869405	179.3579714	123.768284	16.94814328	101.5413233	11.07475438
0087a	442.5311575	6554.948355	33.76571967	26.1724193	12.44916247	135.5376058	79.88556409	15.87192513	113.2952024	12.4794932
0087b	456.3228301	6605.062019	57.08037997	22.20682682	15.58810423	151.9392677	82.78074516	16.55665363	110.8363206	13.84712505
0087c	583.6687155	7276.68746	55.37424787	26.51555072	13.87133997	162.9409986	87.57460952	16.40922218	113.3592876	15.34972474
0089a	317.2252554	5239.062047	25.68249384	15.64553955	17.2624333	155.4510957	107.8373939	12.94961798	87.58464687	10.9556705

0089b	334.7301704	5670.71337	25.51287872	15.06098941	18.92193445	168.6446656	113.2239502	14.28470641	96.92593269	11.25703901
0089c	349.7505661	5785.094139	31.30973123	18.16679297	19.88428297	169.7060318	114.5385423	13.9907409	97.75694097	10.21489361
0090a	339.8047234	6065.750224	23.69694841	17.1763632	16.78544536	177.0751575	118.1244568	15.55626193	100.6169703	11.43113981
0090b	379.4185146	5987.864663	27.67608092	18.90793257	15.72511118	172.4547312	121.2107638	11.24327502	99.49584579	12.28621861
0090c	333.8620476	5990.195918	25.04900482	17.98648877	18.42853902	166.5269227	112.1416591	13.35111844	100.5825745	11.19205417
0091a	384.2121934	5996.725866	30.01634874	19.28748953	18.78866659	181.1561656	120.5998968	14.29594897	102.6324358	12.09004045
0091b	343.6025419	5924.695351	26.34900608	19.15486814	19.7051675	173.2806239	119.1158241	14.59476666	101.2418456	11.58896157
0091c	359.0970532	5457.360783	26.26723539	15.34310073	15.91653866	167.1783607	110.1487674	14.17123701	95.11464464	11.8986094
0092a	388.8589606	6074.777569	30.25026178	21.54731813	17.22445898	178.3538138	123.3105789	13.34492467	102.9082031	13.02871426
0092b	356.1874743	5820.728139	23.89542763	20.89519384	20.83498523	174.0114847	122.092625	12.41078594	100.749504	12.26613061
0092c	357.2995371	6107.726419	27.23041471	20.25796627	17.91902717	171.1372329	116.9020004	13.86636068	98.63790587	10.76222453
0093a	414.2805586	5719.573198	31.24250292	17.58969047	18.56308546	172.6634184	117.3672588	14.23626707	97.76112197	10.52899343
0093b	324.1729235	6023.765353	26.99492945	19.18931503	19.14628068	171.4096287	119.5854995	13.61498141	97.56456693	12.30685727
0093c	312.1351391	5646.786277	26.35935685	17.9199667	16.92554597	173.3783947	118.2479507	15.15495299	100.7811848	12.42453511
0094a	379.1373017	6113.605438	23.20936418	20.58458469	18.10733638	181.789018	121.6194201	14.50657558	101.2243331	13.28963635
0094b	352.5032625	5833.084174	29.09837543	21.16392977	18.44442611	179.672441	123.7706185	16.35723119	102.2863294	11.50642977
0094c	387.3639714	6202.26238	57.101684	20.08742409	18.94060793	179.4088351	121.3905775	15.20073976	100.8051754	11.26981907
0095a	358.6371392	6028.531653	29.52357119	19.62170482	20.46789955	180.6853963	119.7185353	13.44825343	101.5902328	11.57439314
0095b	359.7228557	6116.457058	27.10404738	22.20513736	19.30883138	184.9172566	122.5457474	14.16770971	107.0406919	11.97954554
0095c	299.3874909	5860.145053	25.49743256	19.27530242	18.63093813	174.0050785	119.3417111	11.80795739	98.47927487	12.22689308
0096a	311.810311	6143.928406	19.73796976	23.03369414	18.47664992	179.9395657	122.5982387	13.98132902	103.5498971	11.10708586
0096b	390.9763489	6735.607629	33.91750122	25.28505018	19.71940927	204.9696677	135.4280337	13.0638642	113.3877553	13.86101949
0096c	312.582943	6423.730007	24.92306154	23.40935126	19.88025052	190.8030566	128.0130884	14.34320032	104.4307872	12.2275244
0097a	370.548416	5756.455466	31.19215635	17.65182019	18.11150539	172.7924996	116.1500992	14.50595577	96.29042314	11.48381423
0097b	318.1693403	5828.204212	30.64002463	19.40371732	17.45231698	171.4241361	117.1304222	13.63021733	100.0226591	11.28366556
0097c	418.577376	5684.331509	29.75333753	21.63956326	19.05881504	170.6271346	117.7477253	14.15360804	100.301864	11.82503656
0098a	333.0214141	5721.622862	27.75717286	18.15631699	18.68849729	171.9810946	120.0038234	14.40545879	100.0526274	10.83349665
0098b	342.8381615	6207.865145	25.59498572	19.41106545	20.93249661	178.4685656	123.3515371	13.92600113	102.5833988	11.25406855
0098c	328.7899104	5992.557046	32.06403289	21.51952798	18.75739677	177.0789911	120.181147	14.70727803	99.401209	11.15044151
0099a	356.0748354	6891.796564	30.49555202	23.36977446	20.23956248	203.347863	135.5994324	13.78543657	111.2034349	13.02519823
0099b	373.1514296	6416.491334	34.12734522	23.15536049	19.44223096	182.9397766	123.6882223	15.68114605	104.9176011	12.13618476

0099c	357.7718633	6488.029158	36.3799927	26.12039565	19.27607844	189.4830179	129.8157929	15.10509682	107.9297938	12.71714668
0100a	368.635992	6719.730607	45.81644648	24.3572297	21.59352381	198.6201071	134.7826764	13.75648047	109.259427	12.57929562
0100b	372.4212702	7445.781073	47.11894162	25.64289367	20.74849388	205.0480818	136.8373636	14.42145599	114.6227074	13.00319268
0100c	343.3343483	6355.960872	38.61452076	23.38377921	20.28237627	193.1142795	127.6069144	14.1130924	108.4877247	12.56726476
0101a	358.076731	6134.328631	34.06269021	22.28515487	20.32613371	184.7220126	125.9935176	13.12141885	104.0378868	11.77645665
0101b	423.7888787	7267.384809	42.86775719	29.71655302	20.59975083	203.8114425	141.0523539	16.09865217	109.2396688	13.47921215
0101c	337.7231541	5347.667623	25.89980645	18.94374899	17.53558431	160.7665051	113.2249175	13.83640587	95.98004432	11.87179933
0104a	348.4856579	5877.677673	29.17076358	21.53756454	19.77590249	180.3337687	123.8047831	14.35586957	104.9716701	11.63652564
0104b	381.6802134	6091.880523	27.3345087	22.64643281	17.13500915	182.5636353	126.8224604	15.6771145	103.5284828	11.58262151
0104c	360.0240158	5960.512682	26.32195635	21.06249815	18.81713073	177.4927529	121.9982078	15.88428666	104.7938318	11.79509143
0105a	290.4367702	5358.372348	29.45078989	17.07128797	16.80234276	155.255876	106.6820063	11.33629271	92.02215448	11.30241647
0105b	322.4752338	5803.142052	30.59993377	19.33439304	20.30940865	171.9982415	119.5787481	14.39015494	98.68540257	11.42722312
0105c	311.3993153	5959.09376	38.89947184	20.64499102	18.14760464	177.3126859	122.9232876	14.64189995	100.636022	10.84317644
0107a	364.150198	6135.708459	29.10432923	22.32815189	20.3347598	186.541071	127.6437005	13.34080695	105.7629062	11.80009717
0107b	415.7591959	6473.029499	32.26853726	24.49711282	18.39472701	192.788761	129.5181969	15.6075259	105.4697019	12.37095814
0107c	417.8059467	6597.357272	34.00935395	25.82849118	21.29776516	197.5301409	134.6576307	14.57018576	109.1929322	12.94739865
0110a	336.2461169	5747.428267	25.80239279	17.51510911	16.72540215	173.3958438	118.9674147	14.30372674	99.98089591	11.40142036
0110b	299.065246	5742.463326	28.57050393	17.86180847	18.71008677	168.3623506	116.8890557	14.86411173	97.66469373	10.66999375
0110c	360.9941397	5635.417544	26.20252961	16.72338892	18.16987628	166.4582117	115.7942003	14.34812041	99.04601287	11.39116381
0111a	399.9895749	5930.778922	25.30808435	19.22419764	19.33890641	177.6171919	123.3511892	14.67221372	104.3107419	11.53054932
0111b	348.4161231	5642.378713	28.99676134	17.51630978	17.86891739	169.0210857	114.8816248	14.26880782	101.3230739	10.09778328
0111c	350.8636336	5813.648311	24.06432434	21.88991291	17.83189118	174.7602414	118.8071823	13.36507716	101.8088352	10.74389201
0112a	304.2177713	5746.452008	23.29108929	19.03388299	17.1553959	172.9648739	117.9263967	14.61071824	101.4724308	11.86810509
0112b	317.3665653	5717.825574	23.87209239	20.34480386	16.29429258	168.5430877	118.3043495	12.97709993	99.14424855	11.00747652
0112c	359.8938612	5757.020747	28.43226771	18.99503919	17.75957122	174.9862568	119.9458348	13.49197606	100.2756699	11.66375061
0113a	312.4040121	5925.99275	26.31759039	21.98295524	17.57924257	180.1217303	118.3881999	13.07901948	101.0398553	11.93723543
0113b	367.3480704	5587.621767	28.70934946	17.07498969	18.24821022	171.3276159	116.9310573	13.43637441	96.77368348	10.58892913
0113c	339.8272334	5845.631882	27.06956204	17.33533772	18.53623144	175.5920674	119.8217587	12.87862111	100.666434	11.46943937
0114a	349.611718	5870.050236	23.99364086	21.14714843	17.52344894	174.0859571	119.9603031	14.2223388	100.3230901	11.47822527
0114b	391.5736295	6059.08599	28.02626177	20.63725436	20.52360561	178.1133941	122.094552	12.84031052	106.2517302	11.92526909
0114c	326.225384	6057.972863	30.82652419	20.49764058	20.60357634	179.3056153	126.9740719	13.96185243	102.1550256	11.77504673

0115a	404.0216506	6004.1788	28.02737087	22.93685133	17.07950295	183.5506546	124.899618	13.6747807	102.7623715	11.84000733
0115b	344.9756536	5869.296176	22.9848443	20.75904765	17.49242507	180.3993599	121.1671391	13.34337775	103.7149645	10.86190509
0115c	384.074694	5992.461744	26.98954886	21.98680374	17.78747134	181.1744886	121.6569905	13.65520208	101.233254	12.12762705
0116a	473.7577098	6202.200274	34.68956604	22.55473432	19.20151627	191.4157115	129.4507504	14.53269223	106.5039187	12.18498703
0116b	458.8506107	7094.638483	37.69566707	28.75530753	22.124452	213.0814705	143.3485556	15.16615759	112.6777146	14.00708646
0116c	423.242871	7713.584259	48.87790895	28.34284807	23.19353234	221.9147808	148.501937	13.78953064	115.6138551	14.22257777
0117a	377.6096854	6401.040835	36.52880998	23.64912682	21.59476749	190.5381876	131.0537535	14.43030934	108.4555319	11.18634917
0117b	372.1541833	6512.397224	39.95119323	23.62886998	19.05290446	191.9988869	130.7872726	14.98218545	104.7600746	11.4255885
0117c	350.0319168	6022.001084	33.85911019	23.94768009	18.60705798	180.5402361	124.1527902	13.43217769	101.2995045	13.01105767
0118a	348.0905321	5967.355436	36.3822338	22.77161009	17.40622998	184.1634963	122.8254534	10.35248957	100.2082303	9.609888088
0118b	439.4661837	6726.732418	36.80206628	23.71178234	21.8342531	203.2548506	137.4994255	15.48808092	107.3755137	12.27944735
0118c	310.9396098	6403.239201	45.28795068	22.22234332	18.25861098	184.2314416	128.5628713	13.92895915	104.2444638	12.01682718
0119a	328.4212433	6190.999062	29.98356022	22.95432316	17.10999549	186.3872307	123.0990277	14.05509733	104.875295	12.00537959
0119b	433.008294	6761.44846	40.14252685	26.88457978	21.804115	199.6302306	137.4503848	15.51491865	108.2813893	12.00989582
0119c	299.8633513	6060.720309	26.28108525	22.64591448	18.8995652	182.6881922	122.0517119	13.75701626	101.5436777	12.33234706
0120a	351.4206411	7208.777744	60.31840588	26.66190901	24.20022665	194.6518646	139.5435985	15.93457646	111.34696	12.36540959
0120b	407.6030045	6749.357041	58.6300519	28.753593	19.58037449	196.2061715	133.6488969	13.9389004	111.3188886	13.13328619
0120c	317.1453014	6469.04626	46.59470964	25.49100405	20.2416485	192.0393321	129.1390282	13.27267821	106.0343321	13.04697647
0122a	347.3466337	5792.738951	30.54306159	20.36491115	17.36535925	173.7756908	118.6214598	11.84285371	98.83145859	11.57395046
0122b	333.9211372	6160.926267	30.85352819	17.60937297	17.44071025	172.3812254	115.5933144	13.05125091	97.82409271	11.35689675
0122c	322.1170489	5720.20221	29.53365303	18.29018831	16.46917522	173.0284779	114.8551455	13.12571811	98.37263055	12.60252393
0123a	365.685688	5788.259093	19.83418927	20.99811328	19.06645666	176.2155665	120.7701615	13.57371142	99.48620533	10.55080675
0123b	393.9840168	5797.477523	30.62807622	19.32333831	17.28675138	172.078142	122.3476417	13.5100688	101.8748269	11.87464248
0123c	315.0868474	5570.538838	27.70884588	18.299964	18.47277411	170.3992763	112.6901333	13.99278261	99.54828092	10.94120185
0124a	292.0268473	5793.792767	29.82967535	19.5301649	19.03337201	170.9506683	119.477061	12.99023179	99.21445956	11.37859695
0124b	322.604614	5667.702018	26.38510687	17.59806189	17.1743523	171.2692444	118.4869985	12.97346239	98.52993	10.92367173
0124c	339.4481805	5770.921708	25.6982646	19.51131159	17.06630811	171.6988092	117.5044712	14.44318482	98.56805118	10.98508745
0125a	348.4927169	6013.541354	31.93853553	19.11268367	22.08380691	182.2525778	120.9766631	13.22263634	103.930383	12.70449635
0125b	355.3128644	6063.538109	29.37580979	20.79101587	20.01234298	179.9884118	125.1700008	12.06997896	103.0230073	12.27594412
0125c	373.0549472	5907.713142	22.81317985	21.20054817	18.47106402	181.029227	123.3393554	13.43117394	105.3803148	11.31803428
0126a	347.988174	6452.330258	33.94998432	20.83219776	18.84440673	185.4936426	127.0693973	13.55476178	101.5212797	11.73330761

0126b	390.6653175	6162.424057	21.20918186	21.91374846	18.48357585	186.9707385	125.858643	14.80042372	105.633226	11.40334183
0126c	296.4148193	5594.35565	28.39843718	19.01171013	19.31359536	166.2426568	112.8996373	12.86137922	96.76317687	10.84215111
0127a	348.0306939	6308.552314	32.11773192	19.55517326	17.34428673	183.0555199	123.4831089	14.09557666	103.5300672	12.12506078
0127b	330.865185	5476.536079	19.25503313	15.71817856	16.74807606	165.8808531	111.3045507	11.6969078	96.12548189	10.69845061
0127c	394.1350336	5740.05641	31.03709679	18.13274862	17.69836172	170.5916933	118.2246007	13.97044127	100.7446671	11.02032331
0128a	399.0374201	6052.313341	21.3883798	20.45931735	18.30966128	177.833441	124.0352339	14.11094982	103.5170751	11.43803828
0128b	309.9450602	5898.445055	19.73839443	20.96591034	17.42281156	177.7082312	120.4298894	13.16490006	100.7090038	11.84484362
0128c	313.3380675	5711.973245	35.2809734	19.75006435	18.71273574	171.5225029	118.5284178	14.07458292	98.52933858	11.10600831
0129a	423.5629274	6591.343004	40.89002777	24.55061843	21.03219246	192.9026354	134.7434382	12.31308473	107.8212245	13.21587644
0129b	362.8651427	6675.380011	43.34720297	27.64836663	19.3208346	193.8331612	132.6593117	14.25070897	108.8463681	13.74487098
0129c	424.0523983	7033.515953	43.87114635	26.48237824	18.77843668	205.2098812	137.2983987	14.62544611	110.049524	14.21561276
0130a	371.9135702	5975.89434	25.14071815	17.52097916	17.09979153	171.0293352	117.5654191	15.64467815	99.36257471	12.38628337
0130b	340.4805483	5998.430486	26.5970225	20.84348858	17.8942491	176.9209948	118.8884249	13.84958529	101.12551	11.46008534
0130c	354.2016603	6239.424572	25.44279806	20.75109952	18.04489632	180.2985523	126.6048692	13.00190145	104.6922965	11.69684518
0131a	354.1035395	5686.074593	26.54103257	19.18765207	18.60414167	170.8898807	115.4875742	13.44166853	97.95100017	11.33122155
0131b	375.2385377	6086.940466	32.42411801	21.40966055	20.06888175	177.9015439	122.201682	14.01099156	101.4394578	11.58187479
0131c	386.1778251	6412.110968	32.34314496	22.36441233	17.69000055	185.651009	129.3597544	14.26487921	104.3893281	12.47815809
0132a	352.4336023	6188.785452	29.96937223	22.94327661	19.37193859	185.4041163	126.7987246	13.86780994	103.9989631	12.29005306
0132b	384.8188984	6517.269832	33.29323695	20.16081462	21.09459132	189.9068684	131.365062	16.01570089	106.6070118	12.81711323
0132c	331.000342	5925.60856	24.4604016	18.81922241	18.28920972	172.566364	114.9301626	12.86328509	100.3738071	12.08917216
0133a	421.7282522	6765.123956	43.37394896	25.90261426	19.06616129	196.4583838	133.1876197	13.84410152	107.4233344	12.26329081
0133b	363.9673666	5960.565066	34.01894294	21.41831427	18.49700289	182.2685965	120.0068163	12.79002816	100.1769997	11.4314554
0133c	348.7240272	5847.817419	21.24992747	19.99034001	17.96518795	175.8012147	119.8435645	14.28784577	99.96900912	11.96005555
0134a	361.3743943	5926.484215	29.9625766	20.30557658	18.86206117	179.5892176	120.5649547	13.77205182	101.6740412	11.20621754
0134b	343.3462713	5887.971189	21.7182906	17.675933	19.25671599	177.9127589	119.4047892	13.65884434	99.99166384	11.62211335
0134c	388.6839793	5808.570801	27.94247191	17.44822444	18.73457206	176.3822679	119.4573487	13.75613949	100.7164635	11.23330014
0135a	372.0615669	5824.53984	34.34431899	20.28908704	19.5479574	174.9019493	116.5838789	12.37083343	98.37185975	11.55301573
0135b	349.6952538	5933.052166	28.70849754	20.65451791	18.81390212	174.0458933	119.7240276	11.59938702	101.2546923	10.51741047
0135c	376.1015487	6127.893479	34.37697501	20.64094531	20.54967773	180.7092357	124.2854202	14.38276992	102.1198762	11.69135422
0136a	357.2152607	6592.041171	32.97319296	24.65291634	19.93649873	188.3620914	129.1959183	14.0272101	103.8247892	12.00684407
0136b	362.8516895	6068.847877	31.02552329	22.43585253	20.27604718	183.2402671	134.3061348	14.67305065	104.9555587	10.99034421

0136c	365.4713369	6078.234207	24.96922833	19.69828719	19.00876309	187.9441372	124.2876543	12.42975531	105.5812014	12.318502
0137a	395.0656427	5674.888756	26.18416177	19.89357788	16.39096849	176.4072213	119.7576133	12.74312533	101.4906791	10.7983934
0137b	366.6674335	5721.259845	24.3103578	20.02575535	15.74300251	173.7879538	118.6508781	13.51587436	100.1547752	10.82368026
0137c	370.1251114	5565.041752	23.64256101	18.72501047	18.82020915	170.2290378	115.9444125	13.073391	101.4155233	11.64565605
0139a	428.0935603	6666.923906	25.86855045	24.82975447	19.84548246	190.904892	129.5293652	14.00657637	107.0534579	12.36385253
0139b	360.9582336	7025.760999	34.06249934	27.07821078	18.81542762	204.3390881	140.5349832	14.83555364	114.1755584	13.75941739
0139c	359.6464715	6071.421098	32.22879673	22.19347722	18.35423183	180.6173937	122.6894741	13.40972076	104.2955393	10.67098617
0140a	323.536917	5771.635282	34.15454444	19.70223031	16.75576037	172.2858736	116.5423654	13.4054403	99.47976432	10.57473151
0140b	389.2458827	6099.69003	28.70516506	23.23642096	18.65658541	183.9716916	124.3055804	14.71058723	101.3378609	11.10089115
0140c	334.4838451	6218.671286	28.45902972	19.37211907	18.21886629	183.5842743	125.7875726	15.87703735	104.0275711	11.37112359
0141a	348.0581261	6077.516941	27.37388334	23.03150417	19.15963077	180.308941	126.6710038	13.97062828	104.0321687	13.1826778
0141b	342.8989036	5639.026068	24.12128207	19.4103624	17.48864254	168.8001584	121.4281714	14.88257857	99.01438459	10.63021438
0141c	393.1787342	5729.083644	29.04293389	20.38493092	18.87872435	179.0971376	124.6761791	12.50043747	100.3212593	11.98811783
0146a	357.7025706	5691.568206	34.19705323	18.07281095	17.35241411	168.1428936	115.1421622	13.2238498	98.14771603	10.36714864
0146b	388.8318028	5938.643406	29.43337826	19.59186192	18.74501513	169.3145692	114.9422355	13.24803902	96.39198069	10.92090797
0146c	320.9960149	5639.379381	23.44824867	19.54331692	17.40449986	163.4386623	114.5908154	14.09218376	95.3271817	11.55533889
0147a	369.7265202	5760.631909	29.09893029	19.05092064	18.20546412	170.6627389	115.8317998	14.00118742	99.31721009	11.69566599
0147b	328.059768	5429.643111	29.97551495	19.17982387	18.09953903	160.1849706	112.0175874	14.27634344	95.80946793	10.48711933
0147c	373.8935719	6334.215357	31.65126577	18.97804699	17.21278367	172.1045713	118.693835	13.03882044	99.2506194	11.50522319
0148a	411.3349475	5416.469554	38.72632848	18.07137591	11.96592296	124.3039758	67.30314862	12.77782784	93.09649684	11.62961657
0148b	425.5687078	5103.272686	33.49745816	17.68226646	10.8282581	122.9994829	67.10767266	14.61305329	94.6262046	11.54807396
0148c	447.9683784	5502.690861	32.08822589	16.54151851	11.66243698	130.8858039	66.66995291	14.05673803	100.0464341	11.47451355
0149a	478.672667	5929.238324	42.55645061	20.46582881	13.67745663	142.3117229	75.86334392	13.81977186	106.5590478	11.94598797
0149b	456.1111433	5622.480332	42.29175374	18.42723512	12.86951892	134.5484148	73.02429234	13.47884211	98.86020541	12.31854003
0149c	420.7630218	5351.118002	42.92446381	19.9334369	11.28945841	124.6945541	68.27434505	13.19641169	96.71343971	12.26000997
0150a	305.8884286	5465.033321	28.19542274	19.48467132	15.70376217	158.9715367	109.9525451	13.21300828	92.60023309	10.46552362
0150b	311.1632404	5972.90567	31.01223917	20.67200048	16.91467814	168.9965571	115.5091979	15.21142085	99.15052371	10.94522494
0150c	379.7504884	5878.836684	32.0541737	21.31928637	18.68143783	177.2937248	122.769084	14.52716751	102.9731505	11.60378047
0151a	312.7296577	5775.014992	24.83046484	21.04176259	19.62083281	174.3559337	121.4046622	15.16777802	100.7977736	11.19832879
0151b	328.6598286	5529.942733	24.27280293	20.36856698	17.33316285	170.1189069	116.9999453	12.52408533	99.11797068	11.0678446
0151c	349.5831919	5779.562221	27.91411109	20.5592222	15.55220318	167.0531244	114.7842945	13.14714865	94.99701808	10.43886185

0152a	368.9680146	5816.642621	23.08776907	18.26563151	16.32367561	173.9011693	120.1799101	13.0958528	98.66816677	12.31869522
0152b	326.243389	5659.085884	29.09668127	18.81144336	18.2299961	173.3176013	117.7329839	14.07272171	100.4295457	10.6306892
0152c	379.1284084	5801.139013	26.95524805	17.74756751	21.34208088	172.9259469	119.4447359	13.28654092	101.1054077	11.69754004
0153a	357.5959986	6427.808117	30.14511861	20.94066188	20.42185225	183.6480818	125.3967106	14.32493136	104.3093944	11.75500513
0153b	346.3667159	5652.312371	29.61915478	19.79503152	16.55794558	166.8994579	120.4940029	14.04588598	97.84503839	10.84172342
0153c	380.9338151	6205.973891	32.25687444	21.91902774	19.06738026	186.4360172	128.6686659	14.60478797	105.535298	12.00779331
0154a	345.7072281	5654.627849	25.72553391	16.6489858	18.83815137	167.3731576	116.2647138	14.49038259	96.56301539	11.17316473
0154b	348.3115446	5832.643297	21.96276566	19.30018169	18.44873762	170.4974385	120.1076676	12.31867882	99.06528003	11.21765771
0154c	377.6469836	5656.105449	33.31269464	19.26853341	17.55299412	167.8557297	117.9086377	13.03428025	98.70229094	10.73057142
0156a	327.3413962	5843.276292	27.42847402	21.36347448	19.23334016	180.2518926	120.8246237	13.56409876	101.4053286	11.72825513
0156b	350.957399	5954.65378	31.73711341	19.21145923	17.26966728	177.6930262	119.9629619	13.55621716	103.2022531	10.68412995
0156c	384.7282236	6115.330527	31.7429755	20.54496318	20.66492801	186.0344092	126.0261366	13.43879452	105.1678041	11.0688379
0157a	318.8889571	5532.054609	24.60668835	19.18425767	17.10059302	169.6263634	112.5971128	12.57943148	97.80835232	12.52397935
0157b	350.8864916	6009.086729	27.78764178	18.8661435	18.17785202	175.164961	124.7146187	14.02881862	102.5283115	11.7919531
0157c	363.2725329	6152.544397	28.43698521	22.57815717	21.23476827	186.9121319	128.7227056	15.21401397	106.7093329	12.27734121
0158a	363.1290978	5775.886761	23.12876628	17.67312975	18.04069484	167.6462368	112.9616961	14.02303079	96.86453697	10.59328059
0158b	395.6634285	5933.338141	23.81177029	20.38292283	19.16142488	174.4635067	122.2220701	13.85293074	102.253277	11.0253813
0158c	371.5444037	6403.597011	24.54235366	21.49797729	16.53156512	175.2017041	122.340266	14.51602306	100.7236478	11.99257333
0159a	341.7470571	6364.875931	27.44013462	22.70786331	18.0010603	189.4378271	128.8611153	12.90075027	104.5978047	13.21672364
0159b	417.8297412	6777.512079	36.72309234	25.05403549	20.8823902	199.2858515	136.2148934	12.6989121	110.3566499	14.56158559
0159c	422.6640414	6876.940809	38.43635421	25.11538173	22.89973318	201.6748938	138.584202	15.33258788	108.8292619	12.6749334
0160a	411.9531483	6083.927898	29.25865444	19.60170054	20.01926827	179.5596045	123.4231445	15.54105506	101.9978442	11.13225758
0160b	320.5424186	5993.094066	30.23131287	20.38209004	18.43132688	178.9864792	122.1315621	13.64283148	101.5208574	12.06681417
0160c	427.9275607	6896.904593	34.86955633	22.22264737	18.84617821	191.3621614	127.8905586	14.75207905	106.0954614	12.37960641
0161a	340.3673393	6065.94449	23.64491046	20.32492123	18.9932058	179.6663419	122.1958371	15.37116089	103.7070205	11.67362136
0161b	318.5702053	6239.313202	32.14999982	23.82827428	18.24289087	187.7927905	129.5608111	14.29156042	105.1892186	12.71479914
0161c	323.7809019	6373.728058	30.11057135	23.07874908	19.33086485	189.1758091	127.1778799	13.05518492	107.9823128	12.72503773
0162a	346.7553624	5768.545178	33.185272	20.83468132	18.08355744	169.2480682	116.3241407	12.51317022	96.93170426	12.62789158
0162b	291.4993781	5492.885346	27.9068459	18.57464761	17.24041643	160.6859871	109.5490604	12.63570123	93.40434419	10.69549522
0162c	358.0319078	5918.925206	30.546751	21.68431194	17.31190949	176.2609871	118.87283	13.95476522	102.3776671	11.07075664
0163a	361.6171675	6245.884154	34.14894516	21.79922182	19.46066925	189.1454785	130.7460609	13.69531172	100.9197813	12.01122598

0163b	352.7228684	6173.773103	27.25027924	21.3109299	19.48674484	185.1170313	122.8617031	14.70119067	104.4033676	12.81422122
0163c	330.2252224	6096.5903	34.01126984	20.77464832	16.39926555	180.4132727	122.0662305	16.60560059	103.110192	13.49320265
0164a	378.1979853	6128.268055	28.00053279	21.49632876	18.25127577	186.085738	127.2823034	13.83386916	105.4487597	12.74646718
0164b	333.3730511	6002.690702	32.29433232	19.57031533	18.05550628	177.4464505	120.109354	13.31446651	101.206216	12.34864957
0164c	338.9790176	5994.385943	24.69615249	22.7189292	15.97564564	179.4061363	124.54565	14.45631575	103.0326224	12.15863076
0165a	518.9417012	6426.051262	46.69401015	26.04900122	11.76722669	156.8463572	83.14843558	17.00953185	109.4741842	14.08677766
0165b	535.2614571	7152.245803	56.9395042	29.29224537	12.4418059	169.1180663	85.28802377	14.95878631	118.5276991	14.81965253
0165c	509.0825152	6372.581447	43.53558776	23.76749315	14.8331279	152.9517353	82.05884326	15.41596535	109.5340432	14.02922275
0166a	340.005353	6117.166616	26.74589757	20.5237639	18.92284593	183.794543	127.8265697	14.27879017	106.3133621	12.65991117
0166b	389.5368003	5880.511427	23.89079251	19.77835598	16.5316053	176.8580089	124.9608166	13.65919235	101.4114731	11.37706901
0166c	376.7776209	6813.711776	24.81104053	23.75933038	19.11652225	183.7508926	127.4540369	15.98657201	104.9206447	11.10577231
0168a	327.2449665	5816.374849	35.63609022	18.23779017	17.0974511	169.1382782	118.0859358	13.68790588	99.45911929	11.23977228
0168b	343.0387244	5682.059817	19.85103768	19.17757945	16.35031561	161.847126	111.5089585	12.84613387	94.89873497	11.1246327
0168c	357.7865059	5503.466293	27.34208911	20.81554806	17.39703468	166.8307912	112.835225	13.72575398	96.99059469	10.49579022
0169a	349.9389508	6138.00299	30.46380717	22.85868692	18.32914894	186.9756538	127.3121704	14.46714795	106.9147425	11.33108113
0169b	379.6237501	6567.051581	39.56218693	23.00198406	20.35794097	196.3398763	134.5973524	13.0735736	109.3417922	12.78385702
0169c	372.6798727	6229.195162	27.13463555	21.05362699	21.72080722	180.8854271	126.4720171	13.78977683	102.4275856	12.64610142
0170a	362.4383876	6189.24653	27.67740325	23.71816758	20.35054349	190.0114502	127.0394001	13.42456813	107.8293265	11.97762995
0170b	338.6083675	6605.532614	32.37268233	22.50196978	19.29157661	196.641971	128.2238451	15.09051772	107.5990118	12.20769857
0170c	421.7293116	6706.489949	30.78130719	24.77441163	21.35694486	198.3128698	132.7013982	14.13006884	106.2742112	12.75208687
0171a	401.7633101	6307.874003	36.80974656	23.70529161	19.01923056	182.8140372	125.6150645	14.27044813	103.6618774	12.16606238
0171b	333.5843006	5909.005035	42.23175297	22.63555418	16.58864007	170.050676	117.457734	13.93420638	99.68766249	11.47867622
0171c	405.9529881	6743.67542	34.98259804	26.43368352	21.96823501	196.4308798	134.2281992	13.43862646	112.3338522	12.90789561
0172a	417.5908967	6300.076354	25.59124149	22.15302262	20.87114667	191.2627751	129.3380064	16.27773187	109.5775236	12.62975355
0172b	400.3215249	6696.766181	44.38793974	22.20731586	21.46972415	192.5108761	131.5048013	15.09452369	110.4277135	13.14366161
0172c	345.4153528	5928.356583	31.11058702	19.08827192	16.33489255	173.1516782	119.2937377	13.21157782	102.3634077	11.82369871
0174a	405.5237455	6188.594788	31.99868831	20.67904088	15.30735531	182.1460085	127.3450761	15.20017187	101.7569552	11.49886493
0174b	330.9305636	5742.616156	28.05445964	19.86302738	19.68991043	177.3227465	119.4746878	14.18160712	102.2215326	11.73474598
0174c	316.7515841	5980.454902	33.28092201	20.67354267	17.60142665	179.1400118	124.17804	13.73899746	101.6722843	12.69931783
0175a	346.0257772	6051.00092	24.59936551	19.83581447	19.02343161	181.1052249	125.5699707	14.73986402	102.9139048	11.5109084
0175b	325.2278353	6462.666538	31.03349362	24.05749283	21.06817348	194.8052103	130.6572198	12.40913303	107.4420819	13.39207203

0175c	384.447704	6278.9959	31.21187003	22.22590321	18.85136049	190.3405734	127.1130707	14.82314694	106.2640255	11.531757
0176a	375.1001687	6850.388617	36.95614573	26.7144806	18.916609	194.9645133	137.5376861	14.18713768	105.9552439	12.74925386
0176b	335.4522812	5920.185478	30.91775686	20.97600356	19.14565915	173.3772561	121.4837015	13.54104366	102.0918637	11.30483105
0176c	287.0203543	5940.531804	36.10699319	22.27954638	17.77206238	173.9096631	118.9599492	13.5274557	102.5303621	11.64763106
0177a	396.7156619	7420.126513	47.01565314	24.87185088	21.31931961	204.0412427	139.312789	14.97200415	110.8411602	12.37297473
0177b	292.4873599	5860.571238	30.60983452	19.46642764	16.98471108	178.2538986	122.7476348	13.09314473	103.0933288	11.40513419
0177c	267.2730126	5451.656845	25.19610593	16.74534242	14.50510276	154.8006753	105.4724528	10.66894452	92.05804846	9.791844287
0179a	356.7716478	6824.420822	30.4607921	26.73462933	22.32007081	203.7646279	137.6732063	14.94066313	110.375043	13.73168372
0179b	294.0327114	5788.233052	28.27786645	22.92389641	17.71638135	176.6695891	120.7262825	15.10414901	100.2027993	10.69528738
0179c	360.1428746	6317.319823	36.28397377	23.5134976	19.7135403	193.7055171	128.3489738	14.81675882	108.8855541	12.27156561
0180a	335.9302623	5671.079514	24.58042664	21.01366226	17.38931796	170.9323728	115.6638782	12.80217148	99.66992599	11.40087938
0180b	344.7547357	6135.309091	36.62471324	21.90536117	17.57943192	180.1259175	123.4375706	13.89672261	103.8768216	11.8712195
0180c	399.3612076	6754.660263	34.56058576	25.71421684	18.56961813	190.8083263	131.4465915	15.33574872	106.4456131	11.44210623
0181a	382.2861225	6854.030222	41.58562694	25.76278157	20.22722842	189.9327069	130.4984173	14.67228188	108.4986444	12.38013663
0181b	446.0514293	7303.229373	35.5954283	26.63982511	21.55549988	209.1412397	139.6022665	15.75709169	111.1546842	13.78004067
0181c	324.3670359	6388.060103	42.7881353	26.45953338	16.30321414	188.3317099	130.1191189	14.79816194	105.9003949	12.53718998
0182a	338.5584727	6199.668202	32.53496114	17.3739666	19.24577304	181.7469674	121.5902061	12.86731064	104.0315732	12.240721
0182b	349.795995	6070.824238	24.47011438	19.63588332	18.13602271	179.4763791	119.9449427	12.65153451	103.8763142	11.89684743
0182c	398.7843184	6167.213466	29.38152323	20.79866886	21.47921014	181.5427269	121.3335891	13.34129741	101.6678869	11.25025613
0184a	388.8484788	7727.527865	53.98382372	24.89969584	18.31029839	189.8578156	138.812318	14.66117652	109.219542	11.42636007
0184b	378.2104885	7478.691543	59.79932721	24.97800474	20.16538667	190.4356675	139.4006286	13.64712117	109.1770973	11.70814826
0184c	377.7295674	7532.912953	56.87158296	21.31340914	21.19104601	186.9953737	134.2788624	12.98445225	105.0819462	11.95882958
0185a	403.915406	6633.137556	29.06971457	22.97250742	18.64178417	189.7496463	129.2766175	14.25897535	108.9173175	12.25912438
0185b	408.8071065	6988.704091	37.45257086	25.69800811	23.15101515	198.8908765	138.1722991	15.63234891	109.8831016	12.91670551
0185c	373.6870203	6646.185292	28.82249681	24.58319652	19.72028123	194.3544234	135.9237734	14.44081435	109.6772952	12.69001529
0186a	501.0660069	5395.207628	40.18409732	18.07542952	12.43788002	132.3587615	68.47076114	13.08027508	95.91219915	10.66849666
0186b	437.4891691	5049.539536	34.90714151	16.55462383	11.39492719	121.1185496	64.84663678	13.49668254	89.93979443	10.39515752
0186c	439.4503794	5550.088512	38.50703361	18.7883304	9.447310985	130.9546028	71.46177613	13.42143437	104.0856797	12.26365484
0187a	346.821613	5439.479703	29.08118636	17.74504256	17.06561355	164.3781079	111.8794753	13.11738375	95.71067712	10.69928572
0187b	342.4493618	5873.158386	26.76003994	21.0871465	15.88228021	176.7515958	121.4762347	13.86923815	101.2610437	10.88950772
0187c	319.1739465	5382.696265	23.10149803	17.83003858	17.92631151	164.8928463	110.2952978	13.77235256	94.36476706	10.42616246

0188a	385.6596854	5752.615857	27.1646673	18.60801662	19.45205765	171.4656768	118.1774676	13.56811456	98.83909355	11.02576939
0188b	314.7933897	5704.403287	23.98760917	17.47005183	16.73022537	171.8719807	118.5517162	12.89840025	97.0713143	10.18553454
0188c	340.1563476	5709.016008	26.80526635	17.93135719	16.0509662	168.2060417	116.7926599	14.7915569	96.07473123	11.45710784
0189a	363.5898308	5715.069733	24.29756528	16.63945814	17.21976356	167.5378717	109.7349829	13.27468485	94.34340681	11.38658365
0190a	375.5510392	5861.293607	27.79193587	19.68877842	20.56291735	175.8903662	121.5759336	13.85504055	100.7703162	11.03919792
0190b	344.6141352	5386.324828	27.27639336	17.29676873	16.36148955	158.7151659	107.0082379	13.46546553	93.69145546	11.00265914
0190c	316.2927587	5369.886563	21.2292351	18.34727153	14.85460208	163.8088192	111.2041907	13.95331225	94.11613746	10.81698778
0191a	400.7467573	7904.00696	27.7720714	23.34280111	18.26597097	189.0133016	133.5031873	14.54054737	108.7119968	12.42120903
0191b	350.3116419	6342.396717	32.2940917	22.58975966	19.97237087	178.0709082	124.5628836	14.5151391	104.0453567	11.25326626
0191c	386.8719628	6275.98231	36.06282489	22.4089334	19.51775937	178.9164659	123.7868355	13.19919314	100.4764504	12.85258804
0192a	352.0170866	5828.660393	25.02146187	20.05404254	19.63477252	181.3945059	120.5632992	14.30784606	102.3238819	11.86249835
0192b	384.3913021	6056.839518	26.3969335	19.44876466	18.97520148	182.2704645	122.3259579	15.15911871	104.5063494	12.12046111
0192c	386.8541949	6292.036368	26.41192327	23.61610367	18.84390698	187.0686628	128.6481622	15.00797855	106.5212552	11.70846899
0193a	382.5591872	5953.234328	22.06046778	18.4955654	19.54322209	175.3612852	123.3126272	14.66246854	99.55380547	11.57314795
0193b	343.2220892	5835.211826	30.64017524	19.09249948	16.97558758	174.9189823	118.2434335	13.18252528	100.9507409	11.7361979
0193c	211.1224124	5833.918716	24.46518674	23.82944595	15.89793839	184.5583576	128.6374163	10.99456664	101.4272038	11.0962965
0194a	289.1340201	5451.565131	25.46577761	19.59356054	17.14437676	168.1289288	112.2064274	12.50156847	96.45771271	11.28320739
0194b	311.2665013	5499.414583	25.59265831	17.05523107	15.16385422	163.6122028	113.9082112	13.43794091	96.22692092	11.07897019
0194c	400.5007557	5997.7969	27.16048494	17.87751682	19.37355585	174.3654619	117.7220564	14.18593724	102.3830531	11.19677209
0195a	266.2030923	5840.490981	29.41052044	21.25783561	18.27539351	171.1184573	119.715658	14.16099782	100.7144835	12.18993781
0195b	313.9774411	5528.904876	26.64182339	16.97355667	17.89071954	167.8773655	116.658811	14.98269809	98.65651444	11.06591562
0195c	336.2371152	5628.711352	28.80189505	19.53778744	18.91513799	170.0467995	118.2440604	13.46328371	100.9514124	10.83783484
0196a	426.8777524	7209.15835	35.88604251	27.14375677	21.82079092	212.7657018	144.6556723	15.97802441	112.9794761	13.43069657
0196b	378.9694846	6084.734264	25.14188665	21.95524358	18.16879356	179.1949386	125.5991132	13.84877793	103.7283781	12.29016812
0196c	351.1271633	5780.054462	22.08121794	20.9044824	17.40608193	171.4411818	120.2441357	12.7857903	99.03839311	10.67210813
0197a	324.0506404	5644.658541	28.87831967	19.37468547	17.60916353	171.6596141	117.5032398	13.26355462	102.3927639	11.61313899
0197b	338.595521	5766.073537	27.29900277	20.68036063	19.24047711	172.847405	118.1712095	14.123158	101.4222312	10.9540544
0197c	262.9121577	5487.301095	24.54875947	17.45357948	16.26743757	166.7777465	114.6482339	14.60491121	96.12310714	10.97210964
0198a	392.213959	5843.921951	28.12361588	19.13980563	17.87922352	175.4532677	119.355547	13.63799556	101.5622751	11.11896299
0198b	293.1388869	5555.996503	28.1188359	17.68589592	18.76901107	163.4410652	113.9175692	13.3672414	94.99390585	11.11886902
0198c	384.9892525	5904.429597	26.05944597	16.91492127	18.91844428	172.5652003	120.3801571	14.21806427	100.00696	11.20856095

0199a	366.5337658	5602.382815	24.60132711	18.68465365	18.20920801	171.4232942	118.8373647	13.03475822	100.166594	11.23831915
0199b	311.5207296	5610.986779	24.10986164	17.80806751	17.76175183	169.9394582	113.1069068	13.63072905	98.82482214	10.38052511
0199c	346.3465397	5460.361119	26.2970607	17.05553882	18.95434135	171.6084259	118.2220485	14.87922338	100.3007915	11.44162188
0200a	341.8879401	5746.051255	27.33487239	18.69671026	19.40937295	172.4660996	117.0157516	13.36900118	97.45887726	11.39268892
0200b	296.4464649	5683.407896	26.26032537	19.04712095	17.22224983	170.1690781	117.9116994	12.50855144	99.56868568	11.28667678
0200c	384.9903354	5725.955498	26.51368184	19.82517866	18.49509492	171.4689417	117.1480635	12.9214476	100.6662502	10.67485518
0201a	350.4083045	6175.878251	20.95303356	18.84296678	18.10671423	169.2171431	117.0019609	14.64699736	98.29319435	10.64591148
0201b	342.0366916	5624.030906	20.33048746	19.05911032	18.53069132	162.6539542	110.5424523	13.12059486	97.95077456	9.60623822
0201c	300.4354793	5239.491801	22.84830521	15.28647578	15.40285698	156.1634171	101.4704597	11.76094528	91.9042376	11.09039835
0202a	378.0390893	5927.997191	31.29260653	20.74550892	17.91106891	178.2348003	119.7957056	15.14510881	103.4555229	12.35208714
0202b	391.236915	5758.462658	32.15806614	19.81475313	19.85724375	179.9606419	122.0873502	13.80462598	101.3006823	11.51666456
0202c	362.4388951	7259.717491	35.54047605	25.56055454	18.60719652	199.2133444	129.6753881	12.82849809	105.676575	12.6649088
0203a	304.7242484	5369.79727	23.09690347	17.76565291	16.97502762	159.7663095	112.5596294	13.16572078	95.77420665	10.98714622
0203b	336.8593051	5665.065432	25.64240335	17.84197015	17.06626309	166.6389486	116.1042808	12.67922786	97.63268922	10.49047245
0203c	394.854301	6218.262565	30.72524652	16.24344401	17.89248217	166.110853	115.9759204	14.13043289	97.39488466	10.39406644
0204a	374.5353444	6054.740872	21.36765471	20.42510658	19.53727442	177.9465307	119.8901611	14.46542459	103.3022053	11.48542479
0204b	367.9312427	5696.40742	26.57243972	19.40619878	15.58655015	164.380472	110.4614144	13.19658945	96.57545188	10.44664462
0204c	336.5274826	5670.923517	27.07910369	18.23764699	17.50950436	163.2785736	113.0772857	13.35196545	96.52525889	10.68412244
0205a	312.4998436	5550.263243	26.71328532	20.28013441	17.82625122	169.3734635	113.0100307	13.689928	99.48736261	10.83336076
0205b	331.0645334	5744.89717	27.77350661	19.71253986	19.1812762	175.1535691	119.5088076	12.9860814	99.06605723	11.93564848
0205c	324.1744196	5788.745179	24.41192781	20.27517643	18.38205322	173.2184359	118.5013001	13.35867487	97.15508132	11.33436662
0206a	328.8624926	5787.455181	28.7408043	19.1304848	15.02244622	171.2733895	115.0897322	14.33797645	98.48657483	10.32962997
0206b	376.1260212	5724.299891	26.68396425	20.51756292	16.72898167	171.3756706	118.480231	14.36881857	100.4879873	11.33248093
0206c	307.9878019	5737.775466	25.49853826	17.7524279	19.03111788	173.1919201	121.9029169	12.88164077	102.3851575	11.41113904
0208a	348.0379199	6035.149358	28.85615118	21.48558505	20.58638715	185.4743662	123.7712746	13.56513295	103.5014797	12.11048917
0208b	325.490854	5853.806175	21.58543127	18.7223316	18.03485606	176.9486883	121.3538284	13.76686927	102.100849	11.85637021
0208c	329.9556779	5821.037582	28.18161305	19.0186767	18.7564271	175.0366523	118.277089	13.72573366	98.95471679	10.71767097
0209a	346.4602186	5775.253742	30.11314592	19.74449294	17.5429783	172.5967431	120.4309683	12.3998549	99.7300107	10.86475779
0209b	352.2842908	6227.479266	29.90942474	21.54584712	20.00160606	183.0283368	123.516166	13.5596662	102.0377275	11.93546226
0209c	306.4479906	5399.6643	26.32715432	17.15377747	18.57730045	157.2425697	109.32404	12.3753577	96.85555902	10.35695825
0210a	320.8046362	5564.860438	21.61679548	20.2821326	18.2207855	170.8091602	116.2245948	12.71909408	97.75987762	10.32650638

0210b	274.0775151	5870.235263	27.75747275	20.15778144	16.34667825	174.3203986	122.8730377	14.61195186	102.1276881	11.19144747
0210c	342.6058122	5571.422531	25.27387448	19.87301844	17.80289075	168.2525868	115.9565721	13.25462689	98.15296613	10.15026576
0211a	351.7516872	6574.442978	27.03843884	23.93898825	22.588363	191.4005792	131.8456275	14.26914588	107.6564702	13.27287261
0211b	438.166617	6587.104447	27.62310926	23.3788844	18.53578605	197.7985127	132.4642635	13.82978299	110.0638245	12.9092226
0211c	373.800091	6130.512952	29.73808343	20.6626562	17.95181872	182.3887887	127.4640802	14.11014963	104.6321445	12.54387826
0212a	435.9541287	5676.320908	37.00729693	17.92620079	13.26188996	137.1817313	73.64676721	15.32407572	104.6935415	12.47553508
0212b	493.1870195	5498.575159	42.24107613	18.48681784	12.91498447	131.5579587	73.82113489	16.01388074	100.9519126	12.05464401
0212c	514.6108421	5907.036153	38.72447442	24.00636634	13.3876931	143.9020647	79.74187033	14.92295644	104.9851048	12.57742043
0213a	361.4161631	5892.178613	27.61288253	20.00829592	18.53190366	177.6000477	122.0943776	15.54027897	101.0393335	11.39307313
0213b	360.5742165	5846.294293	29.57067937	20.40405621	18.67111935	176.1660908	117.3253018	14.01073169	102.7960574	11.59381248
0213c	401.2565636	6345.206612	30.33688041	20.63475433	20.9538831	188.9718266	127.7798037	15.9067125	104.9743964	13.06726578
0214a	363.4399832	5982.607629	27.00355275	20.33930078	16.56394025	179.7636855	117.6023682	13.72861894	103.1741088	11.66334385
0214b	371.4818249	5941.169669	26.98214339	19.66653227	18.93059125	176.7569704	123.3551511	15.42526006	102.2528964	11.96133088
0214c	384.1409595	5787.223046	26.14685938	19.22493688	18.67377513	177.1740965	119.2155249	13.63038673	102.1020036	11.51873988
0217a	568.11347	7985.718916	53.96480285	24.55425183	23.73285635	207.1241208	139.9995993	13.61256264	112.7923628	12.23699277
0217b	399.8733397	6812.930584	40.27901436	24.51630475	20.90942589	203.4012055	135.3965527	13.68130742	109.9181982	11.83463277
0217c	338.4158772	6314.491794	34.41146825	21.59435801	18.83274541	185.2915876	127.3032205	16.16904869	107.1787667	12.38763904
0218a	416.5564987	7343.331485	36.19295302	27.72101883	20.42657771	203.7104318	141.3741271	16.01748137	112.1730864	14.82500806
0218b	377.0865086	6443.620498	33.80323292	26.71631074	17.85053922	190.4226683	129.5395581	14.32767274	108.9278249	11.84770364
0218c	321.2548101	6365.768167	31.48677349	22.96109425	18.42920826	189.7801622	127.8199737	14.45236638	104.5208028	12.06166747
0220a	362.5609897	6479.261029	43.92110511	22.57571199	20.57672662	189.3000833	133.71288	14.24184685	107.0944804	12.18649843
0220b	381.082195	6882.64943	35.08808011	25.78202871	19.87850066	206.2720433	140.5318544	14.08890258	109.7114997	13.20150863
0220c	492.7486807	7432.884448	48.90927317	28.76680715	21.44268678	206.1888654	142.2659562	16.21540537	113.1031136	13.67153199
0221a	408.8984551	6143.857026	30.7197399	21.42863891	19.010284	177.327573	123.2473885	14.24873065	102.5451518	11.47465278
0222a	328.4486583	5548.29196	26.14040212	17.83091371	15.95833453	163.5302075	114.1383171	12.94542406	97.04145751	10.87004956
0222b	318.0030364	5885.208055	30.96107774	19.97856453	19.61037189	177.5935134	120.1577995	12.2933952	99.61132225	12.78110104
0222c	389.8063409	6366.032262	24.19962338	21.30389006	19.903472	180.7318113	126.363537	13.82268634	105.3952451	12.16671086
0223a	327.1294242	6353.844517	36.11114352	21.6465489	18.68339429	185.0658577	128.8912244	15.57491291	106.3096618	12.54523773
0223b	342.9115639	5865.824477	26.08631998	20.28485925	16.43593943	167.5776437	118.449432	12.80749407	98.47711583	11.94794421
0223c	353.958083	6217.1582	28.85960037	22.18168861	19.02447451	183.3072428	127.9166804	14.83310377	102.8138707	12.1621827
0224a	329.9422514	5798.659789	28.70713397	20.39639661	18.97576596	172.1243512	120.6017961	13.89051497	99.79409157	11.58923204

0224b	303.2218679	5762.176418	26.88033283	18.79999354	19.42566399	169.3151086	116.7030293	13.8985809	99.17586973	11.66209219
0224c	368.7216199	5876.811845	28.46041301	18.63185296	19.81573961	176.3936205	118.3811219	15.10888292	100.3250538	10.98899094
0225a	352.1847025	6021.04555	37.85925859	20.80549385	17.61975049	175.9058835	121.4038726	11.29150388	98.57059863	10.82978091
0225b	388.0097403	5940.607281	36.65023846	22.13486108	19.37277279	180.1652132	119.6498409	14.1137208	100.6530222	10.91339148
0225c	362.934702	6201.699645	34.06595643	20.44372151	19.13781533	185.3295277	126.487971	15.28336049	109.0854155	10.30705535
0226a	385.5068908	6263.78244	30.62900353	22.56162691	19.19082341	186.5943534	125.0017447	14.21018404	105.9154176	12.40450619
0226b	355.4253723	6855.931266	38.83631749	25.48656972	20.75957797	196.7609889	134.0644156	13.07938164	108.5012568	12.95913225
0226c	337.3239753	5492.331971	29.90432611	18.35041332	18.1226482	167.2743248	113.5892751	13.42961691	98.89146712	10.87415761
0227a	338.806508	6317.49694	31.72106532	23.8358074	20.1627066	183.4748027	127.077583	16.53792421	105.6599959	11.92169037
0227b	473.8907452	7413.167796	54.97767277	27.34723261	21.56183177	210.7720029	145.4213697	14.30951978	113.6809065	14.39161317
0227c	392.1867882	6389.221681	37.45691944	22.67459645	20.41717844	184.7325305	127.286232	14.23933014	107.5796613	11.85280054
0228a	352.0060201	6297.508988	36.00101043	24.20114769	19.83480305	190.8798565	131.9829592	14.69033712	106.5660268	11.96738707
0228b	318.3608474	6502.520422	31.86349216	20.37918315	18.95101358	177.1778973	121.4815633	12.86278022	102.2000678	10.99503986
0228c	371.8635051	5430.138301	29.6776815	18.3204874	16.80199879	166.0898964	112.9407122	12.31859902	98.13092637	10.73862166
0229a	334.5314055	6061.107734	30.62566248	22.36971429	21.46303528	182.5165048	124.1049058	14.98030274	105.5653088	12.15138851
0229b	369.7737656	7236.408823	42.47047907	28.3737366	20.33243419	202.7992318	137.0450645	12.90908059	108.9458012	14.14555536
0229c	356.6032764	6268.703273	30.54419321	22.74071878	20.89290319	185.2892551	125.24378	15.57919923	105.1664252	12.27975309
0230a	355.0921925	6299.595501	30.17634054	23.02031226	19.81282606	179.1457623	119.812108	14.2656301	102.8851178	11.64943885
0230b	322.4338342	6062.09241	35.81726286	22.15725456	18.16462729	179.4079056	125.0052148	13.7044944	101.8374769	11.06958757
0230c	336.7795499	5993.571749	28.26073415	20.70170644	20.12865425	179.8008991	124.6663886	14.31246297	102.2294978	12.11433025
0231a	388.8095984	6255.964703	34.77828731	20.87960654	20.61206303	182.1596221	127.6712139	13.63855679	103.4095108	11.57377336
0231b	401.1191847	6555.0382	35.10296999	27.99141647	19.77543952	195.3471517	132.5473669	13.86083561	107.6868185	12.4893985
0231c	332.1346281	5714.407564	30.33065107	20.00816122	16.55002085	167.2867726	116.7214221	12.99708854	100.0056986	10.93453893
0232a	417.6367081	6004.46389	29.9905916	22.17732539	17.59210058	181.0913014	124.9595112	15.04900909	101.5470187	12.68356141
0232b	411.6248648	6994.276459	41.68159122	25.52096159	19.77682645	202.1352786	138.1784923	15.89143121	110.6371449	13.07021913
0232c	414.3289364	6961.652253	44.04580118	26.85370636	21.37413376	205.2045679	137.0814532	14.10154287	112.7819556	12.94960464
0233a	393.457636	6176.933752	32.58120052	21.46737187	22.03246825	184.2971754	124.8202203	13.81380365	103.1439196	11.20740537
0233b	383.0586255	6702.95431	35.12790049	25.28209502	20.29111052	189.4209213	134.3317982	17.21888467	109.0557956	12.61500679
0233c	409.0151008	6625.275645	37.27113693	23.23503907	19.65725474	194.0385624	131.5898519	13.15337098	107.7336526	12.59990738
0234a	383.5470991	6123.713384	31.79549761	20.44922887	19.38002278	184.3249661	124.2306996	15.42165859	105.374349	11.84256432
0234b	305.6760306	5908.181288	28.22385873	20.52251252	17.78600576	177.5713764	120.2440759	12.90984485	101.3431404	12.20745795

0234c	339.9223791	6410.978584	41.84091072	24.09225981	19.7156162	183.5199098	123.8916298	12.73711189	101.8011211	11.27491908
0235a	364.6767905	5825.618667	26.33555858	18.37593091	18.88735658	172.2028042	116.4191897	12.66171573	98.58503692	12.25551092
0235b	377.2760009	6622.239173	31.3878862	18.76077026	18.2068975	177.493054	123.8152522	14.93486302	99.40743522	12.21111586
0235c	370.6283154	6600.013941	27.44947269	20.0122644	21.02801365	178.6770374	126.0029266	15.1757335	101.7251948	12.11196399
0236a	386.2305899	6121.713078	23.19448393	21.11672479	19.62989126	177.8939371	121.3828374	13.10204728	101.6394518	10.89549255
0236b	314.1945304	6423.054876	31.59510744	20.28851561	17.28344099	167.7244195	115.1017463	12.69316038	97.8239097	10.35132346
0236c	286.5292105	5275.154547	31.07535419	13.02170152	14.06270809	144.0501043	102.7023023	12.29042931	86.79494256	9.346785026
0237a	384.0523286	6530.440386	33.62092934	24.09836497	19.17824029	189.8584992	129.2736631	15.41840295	109.9635314	11.77548943
0237b	371.3461129	7656.166545	43.03750245	28.33885784	22.21850905	213.6049383	144.6415436	14.4726466	114.3516519	13.33122896
0237c	324.3574211	6215.781072	26.66213311	20.98693242	21.02722912	195.889939	125.5473163	15.24555905	108.2723872	12.58287009
0238a	384.7659409	5896.446582	25.31021209	18.48212179	18.57967373	172.4873226	123.1187612	15.00439383	101.2917885	11.6320547
0238b	340.9459238	5895.966554	27.72252744	19.45008983	17.77975371	174.5819819	121.4273158	13.11880647	99.29580018	11.50361127
0238c	340.4189906	5847.671419	24.06898678	18.88904001	19.47755144	177.934652	120.2890954	14.57155824	102.1715216	11.24497862
0239a	382.8116384	6381.64175	32.92852468	24.86316099	18.9929646	190.1562314	130.8645085	13.39876814	106.4484925	13.63387725
0239b	298.3002157	5871.738085	30.50082478	22.95038918	17.30129078	172.8428815	117.8578392	15.22126331	102.7403558	12.48330204
0239c	357.8609733	5709.75716	29.35227297	19.19229583	17.88788128	162.8794938	116.4194974	14.21038649	95.52003159	10.75844151
0240a	345.776765	6563.514248	32.68271879	23.87967174	23.37359251	196.1697968	130.1400211	13.8255529	105.4599059	12.25249381
0240b	375.4283494	7135.63253	39.42613699	28.1565591	20.8725973	209.2667885	139.566507	14.45373386	111.5787882	12.85462597
0240c	364.5819174	7191.376611	36.12976639	26.89764581	21.25055548	210.7708804	137.3510099	13.04219244	113.3267225	13.77262904
0241a	391.6581884	5838.333417	27.22647386	17.30122532	17.25820193	175.0166612	116.5850989	13.6592345	101.714744	12.00585809
0241b	370.4594278	5996.450707	28.9221714	21.37969932	20.68608508	179.4933035	122.1776776	15.21429995	101.8694299	11.51078079
0241c	344.1491278	5945.171072	28.61774723	22.03374233	18.87706067	173.8834689	118.584783	13.6885355	100.4202573	11.86442206
0242a	377.9301359	6428.88592	30.40669221	23.17798899	19.67932563	192.9859294	131.5639553	16.04579309	108.2169932	12.63458188
0242b	366.926177	5919.554511	29.55771702	23.53904854	15.22110124	180.6018341	122.4968862	13.20749606	100.8121033	11.79125221
0242c	385.5151154	6357.024477	37.50863498	23.51187312	20.27060397	190.6123256	128.2718465	14.40047437	106.8079194	12.8148372
0243a	315.8934789	6182.111907	35.31105533	21.70970126	18.28197001	182.127862	124.6690354	13.99975397	103.8140313	12.16290896
0243b	347.7298763	6526.498801	38.04982937	23.1404562	17.13538105	190.4956734	129.5196494	14.02311027	104.9403774	12.41111288
0243c	351.0088177	6493.23356	37.31624478	22.70976876	18.76952206	186.6888715	129.6545395	15.22210767	105.489368	12.1349025
0245a	335.0408801	6754.681849	32.72103188	24.04924723	20.43875037	196.2506288	133.0775379	15.77270305	109.0779532	13.28149245
0245b	463.1532331	8252.776516	41.68987187	27.9955478	25.00010814	227.5689918	152.9591577	16.1940781	117.0008796	13.61691372
0245c	350.3262202	6394.225575	32.82115174	23.0425338	18.11437845	190.9439689	130.0609066	13.89178146	107.4379937	12.12354458

0248a	400.4096664	6007.36635	26.5846591	22.25459055	19.09419798	180.5448408	121.3228652	15.08388404	101.8261282	10.6032947
0248b	378.9698511	5987.640156	24.45319447	18.76018955	20.06415592	179.1271854	125.3204312	13.95902093	100.2929059	11.87926703
0248c	359.3223294	6538.228199	33.38084502	22.41725036	18.16607414	184.6116826	121.9766592	14.11813171	102.1111761	13.22616025
0249a	356.4315268	6069.653511	26.96356863	21.96956965	17.91915373	180.6599169	121.6302683	13.64519622	105.0212206	11.79469175
0249b	290.9735625	5709.920565	26.48222241	20.62746768	18.55932127	176.8305741	119.2728796	13.38912829	100.2924636	11.80902849
0249c	377.527066	6318.686759	26.56406802	20.30669003	18.17404913	183.9201381	123.2708329	13.829838	103.6778216	11.72689816
0250a	338.9789919	5924.672119	26.52771144	23.44375442	19.66051345	182.5858787	126.1341411	14.45533616	102.8332842	12.46688815
0250b	397.9109513	6604.652077	40.43985271	23.14115378	20.14206567	194.0002867	131.1736952	13.42819557	108.6782138	12.67934078
0250c	321.8723165	6084.521893	31.87662905	23.68333281	17.56619841	181.1240107	122.9649218	15.19980982	103.7554614	10.84951554
0251a	395.3132205	6119.52504	26.31541101	18.38954639	17.56016351	172.9468275	120.0374154	13.17475607	101.9991804	11.29874181
0251b	351.9724596	5099.993833	23.1551139	17.82592394	18.79201927	154.331478	104.1888466	13.5050876	92.97350345	10.15763124
0251c	447.2305322	6553.515615	34.74915032	24.72156584	17.77600345	189.4579608	128.0304241	13.13984149	106.5465126	11.77734398
0252a	342.1071605	6038.747686	24.91717185	20.59664177	20.37622134	181.7305198	121.4830889	13.60080683	102.5327668	12.46002783
0252b	356.431783	5842.800903	30.71128277	19.63466229	18.83847985	174.9494278	120.481385	15.89372611	99.70421813	11.42252243
0252c	366.8269989	6316.892989	32.65304516	24.41041295	18.14854596	187.2304454	127.3185774	13.77674813	104.8631439	13.11540327
0254a	359.4660103	5966.419753	24.51006249	22.16003732	20.61543803	180.7830103	126.7824457	12.61805168	101.719801	10.99869109
0254b	465.1967312	7376.156446	33.99932653	24.06836939	22.24497022	198.5341287	139.8399275	15.94744786	111.9048625	13.99707079
0254c	349.885517	5914.442216	21.58883116	16.65626613	17.46353915	175.2710249	120.8333945	13.51240522	100.9711849	10.50538284
0255a	398.6416681	6768.711661	28.69408901	26.27593503	21.9742097	202.9832736	135.7027819	15.25375861	110.4293114	13.09221284
0255b	384.7173271	7307.171665	32.54422523	26.48233287	22.63704837	208.125212	144.3917772	14.66180323	112.1236208	12.84809044
0255c	407.8971477	6460.905683	28.40316484	22.74830736	18.85664122	188.828979	125.7758065	13.94058269	103.3035501	12.38481871
0256a	347.8873162	6140.952317	33.31871071	20.45918062	18.27885604	182.0813821	122.8093725	14.38572601	104.0267245	11.18727357
0256b	320.2555844	5670.205733	26.98784901	17.72559477	18.88608134	176.2642626	117.2127285	13.48381896	98.47810493	10.57003318
0256c	367.9119192	5923.652805	30.48198538	20.78073219	18.67679772	175.3712643	119.9560207	15.98834665	100.7411702	11.4663518
0258a	398.7544494	6120.323952	29.23813898	21.62532565	19.82919676	184.3013028	125.7080049	14.2508615	104.0725013	12.16068413
0258b	380.3392263	6298.579635	35.96873976	19.46419025	20.57024307	180.4823173	124.1768729	13.65015515	103.6503656	11.08783083
0258c	388.1518962	6711.406934	33.90942154	20.77431477	18.82338383	192.3277582	129.8671483	16.26722305	106.9409862	11.90754737
0261a	394.0552259	6220.833581	32.95473911	18.66971265	18.02261237	180.4590326	124.1665882	12.99765485	103.385783	10.45130534
0261b	352.2869043	5818.885322	37.53470064	19.52614477	16.75305748	175.4413671	116.0319504	12.93144758	97.41852111	11.66756231
0261c	368.9099639	6305.302605	36.2822688	23.7882062	18.91192116	189.0950385	131.0884714	15.47691886	104.5414483	11.64696749
0262a	371.7896329	6094.644534	34.52334844	19.51464117	17.96517179	171.4736751	117.0432994	13.12032179	99.09901416	11.19872995

0262b	384.8834603	6833.661097	37.20389391	24.53285662	19.84738005	185.4145317	130.1829474	14.53947194	104.4457121	12.71826585
0262c	333.9931838	6314.784282	35.03775734	23.90155071	19.43587979	192.5970755	127.1640634	14.99340654	105.7778615	13.06769135
0264a	392.3309099	5999.428959	28.67669244	22.4188029	20.4464722	177.6262876	125.2556297	13.31818977	104.8022916	12.17478851
0264b	380.793215	6126.306938	28.18210754	23.51879718	18.50255724	183.1550881	123.7092797	14.3727574	105.2621035	11.5382583
0264c	324.9027287	5720.235432	28.35084325	18.18083152	19.30867443	174.637351	119.8433699	13.01411741	102.2438653	11.63615855
0265a	364.9352464	6070.07064	31.17393547	20.86498512	17.24734053	180.6458243	119.7803379	11.93040551	102.2244352	10.8305979
0265b	366.938903	6657.169799	40.32605355	21.50119513	19.6321686	189.7659893	129.5891561	14.21540018	104.7184404	12.47237807
0265c	395.4470644	6399.050157	28.03071522	23.86948405	18.14319161	179.9830391	123.5726521	14.85630162	104.0642864	11.41709837
0266a	413.2565513	6553.396849	28.39604398	23.86432054	22.26358029	195.6171853	135.920672	15.9489102	110.4329447	12.01253615
0266b	380.1609062	6505.491115	33.89186244	23.02495619	19.2015277	184.4025013	128.5278507	15.12902316	105.7357514	11.98868091
0266c	331.8897881	6147.947144	28.82478976	17.03726195	18.9379817	179.7619047	121.3340408	14.37993614	103.577998	10.98391044
0267a	368.8797588	6215.736452	28.97052976	19.04960999	18.99191654	181.8917283	125.7380254	14.85893203	101.2470964	11.87776266
0267b	397.456335	5854.700994	29.26045833	19.63460232	18.72068233	169.9218347	119.1632151	14.21904938	100.7050609	11.98914463
0267c	381.9516253	5727.512006	30.81745436	18.80454898	15.649095	167.5594538	111.512308	12.41296604	96.44058247	11.03177407
0268a	405.3940976	6638.914331	32.91254447	22.02685994	21.57319665	188.9857592	133.4592463	15.48165258	106.0823964	11.39920698
0268b	410.1337163	6884.473637	34.3871362	23.66606741	21.455968	197.2807449	134.0795956	15.14508152	109.8539345	12.36979421
0268c	374.5603966	6598.936566	37.83667232	23.10470102	17.79501894	191.085099	130.4866148	13.78825692	106.7893446	12.34409303
0269a	399.7103548	6860.984844	44.51477505	27.93274146	21.06551501	196.8301961	134.8861163	13.99410268	109.4341713	12.64099065
0269b	440.7534505	6663.608776	33.23161322	21.33401503	18.16943472	187.8028065	129.6514784	15.03129016	105.255371	13.0416546
0269c	373.7727636	6601.401615	50.13143747	24.91624483	23.30340724	194.6541133	126.3125803	14.40120797	108.0214834	11.92740065
0271a	354.3747805	5822.207802	23.722374	17.0559845	19.919504	175.7607399	118.7677875	13.26241887	102.1530542	11.32187961
0271b	349.6042358	5652.582878	31.28508474	19.09267371	18.9181313	167.7280899	113.2856201	14.49180561	97.45332834	11.10045541
0271c	346.3800747	5655.020638	29.50135323	16.98770518	17.2104329	170.6647212	116.8758168	12.88880362	96.91409604	10.32236118
0272a	342.5878455	6392.722977	34.31720902	20.66924047	21.56329371	188.2389835	125.3928568	14.632638	103.0799081	13.0609018
0272b	440.1750725	6357.22608	30.66504742	21.19405172	20.65020157	184.3726807	126.9491403	13.22950173	104.4361796	11.20365885
0272c	378.5632982	6234.159245	32.4928025	20.0346798	21.30722845	181.9252179	123.7336911	15.82190689	100.9957508	11.24016917
0273a	322.9158465	6086.295869	34.44996001	21.09453028	19.14485388	180.8368812	120.1226042	13.83164313	103.5964181	9.778604549
0273b	356.4692212	5871.211761	33.40444134	19.86192754	16.58188849	170.4199638	121.9695652	16.29395399	101.771224	10.69367191
0273c	387.4334801	6170.392222	40.63998887	20.0287714	19.52546848	179.5604197	123.4241786	14.53000683	100.2577747	11.49638621
0277a	395.5694989	6966.775205	32.19774024	26.49630097	20.02140702	199.4280079	135.4418954	13.4710771	111.608244	12.97130323
0277b	331.3441068	6405.669556	29.59000513	22.11826368	19.15525775	188.1911794	128.8045667	13.6026272	107.3309466	11.16865936

0277c	384.2092673	6605.09544	29.70048488	25.32619075	22.07285783	196.1843453	132.0327695	15.58241776	109.7633925	13.06073322
0279a	386.6090592	6702.797039	39.47239133	23.42942075	20.28005915	188.5001512	131.5343249	13.677557	105.3060069	12.62164584
0279b	427.0648175	6657.86136	37.37062814	22.44121465	20.02496992	195.756151	134.3310135	14.04979425	110.1594413	11.84296017
0279c	485.2919812	6780.343718	42.18214268	24.08806897	19.6852496	197.0461225	134.110754	15.64300901	111.5431619	12.79434528
0280a	412.4148373	6389.752558	42.4094914	23.20084396	20.72957761	182.1967467	124.0618554	16.60917748	106.4399861	11.57504479
0280b	361.405102	6566.759534	33.72173804	21.46525736	19.46032552	190.5003881	130.0357299	15.27423504	109.6449725	12.76701923
0280c	394.1564771	6058.232136	29.30067909	18.78257487	19.52490135	175.2678608	124.8585554	14.38814276	103.0630122	11.42951673
0281a	287.9624832	5922.871063	29.17343896	21.32194983	18.54425748	175.0371933	121.5582387	14.03775691	103.1302801	11.43399335
0281b	370.9532315	6128.021542	28.1708833	19.17938483	17.6780883	181.5062608	122.2477756	14.89713852	102.1712009	11.13493053
0281c	339.3381447	5977.350172	33.36019349	23.30142824	18.89562456	181.0835344	123.9930966	13.58373654	104.4282775	12.18040499
0282a	348.0704811	5878.87814	29.58853079	20.46616083	18.63355075	177.0951463	122.3182353	14.09186248	102.5625224	11.15921769
0282b	332.4047426	5721.080014	21.71366015	21.53031382	16.03291695	172.5532089	120.2541793	13.30949551	99.11377857	10.60755946
0282c	363.7956888	6067.094942	24.46210582	21.70581477	19.16543591	178.1057625	122.6418297	14.63665249	102.9263125	11.83904134
0283a	375.8903794	5967.971087	26.70168188	18.36538635	15.5459376	165.2625918	113.8637166	13.96948119	97.50814322	11.18798041
0283b	350.8743226	5636.485066	24.35956826	13.77324452	16.32336254	159.7445732	108.5916277	11.86749167	94.35291589	11.02578921
0283c	429.6666621	6402.893701	95.92271823	21.96290772	19.70961504	183.1160676	120.8861658	13.76933215	102.6188353	11.71424393
0284a	333.0480216	5705.480961	26.90117245	16.39908974	17.96308585	170.853891	115.4885298	14.45433966	98.62046095	11.17450219
0284b	359.1053106	6041.46221	34.64150255	22.10103751	16.92102821	178.2991427	118.7030845	14.91546156	101.3837143	9.881273262
0284c	355.0339983	5841.531228	150.2622278	18.93497253	17.45758632	177.4088122	120.8187847	12.84674641	101.7437676	10.96545279
0285a	393.6761064	6486.922799	27.65769816	22.2462885	20.82040467	187.8316837	124.8519719	13.36936789	104.610278	11.55157253
0285b	348.9196166	6108.920643	27.7702464	20.76410824	18.53887096	176.8112505	122.5380168	16.86216763	102.7271431	11.24286384
0285c	314.5140784	5734.930658	30.86892903	19.0525131	19.31112587	164.3341602	114.4314287	14.01944653	96.70623584	10.85648208
0286a	351.9681849	5907.41252	62.72232018	18.64853183	17.87406118	176.1620002	118.8573743	13.74035129	100.7151035	11.51512733
0286b	383.8111203	5705.585233	24.39538488	19.16593422	16.90807476	173.7042372	114.8137324	12.34011641	98.33185929	10.47538235
0286c	367.965024	5656.867526	26.49913107	16.50901757	19.59089938	172.3581042	118.7967061	13.31463335	98.77621548	11.28836526
0292a	420.4890706	6597.239718	30.21285063	22.59158745	20.36023191	195.7842547	127.6254852	14.59983965	107.9476362	12.07970926
0292b	392.300684	6330.243491	31.162255	21.31514284	20.17665409	187.927328	126.9863281	14.09626842	106.4076384	11.92299198
0292c	396.2616458	6327.147787	33.94241008	24.27026535	19.42826248	190.2205206	128.5014816	15.81188136	106.5827678	11.96532185
0293a	313.2538153	6399.254992	31.69948016	21.45580111	21.9947013	189.8096177	131.1760638	15.83095335	106.8925135	12.07201572
0293b	378.2206909	6129.243143	31.36411961	20.73898428	20.68799188	177.4451857	125.3656555	14.11547985	101.0404415	12.18631963
0293c	348.7521968	5992.415561	27.52562742	21.7396188	20.41287638	182.8500905	121.5348533	15.05269252	104.4742178	11.62338991

0294a	333.552108	6120.106007	28.77612821	19.79290995	19.7690536	184.8925186	123.2665183	14.13162539	102.9323276	12.28967806
0294b	333.7282917	6117.390952	27.82890945	19.7552175	19.40714092	176.6982839	120.9565691	15.65662961	104.4132277	11.91842677
0294c	338.3878782	6759.982466	39.68297415	18.71884524	20.32128196	183.6959012	126.6604464	14.26949841	104.2030385	11.68122672
0295a	446.2727779	7225.501956	37.78338344	22.58934668	19.60339641	187.3520573	127.748176	14.49466776	103.7018223	12.43761177
0295b	429.9927222	6433.14009	29.12845075	21.41207888	17.30962638	172.0602638	118.445993	12.02883558	99.16435053	10.84149847
0295c	388.8105907	6369.85698	30.06972646	20.8415116	16.94309523	174.6471973	121.6179867	14.01037234	97.24746944	11.76422434
0296a	370.7052035	6207.911556	30.79940718	22.73871141	19.20161067	182.6649396	125.5531559	15.42677011	102.841958	10.90932563
0296b	382.7185608	5903.432534	26.73757565	19.90475008	18.95714509	176.7607708	120.53652	13.63333328	101.4367275	11.16685952
0296c	265.6029527	4923.610155	32.74748317	14.68194178	15.15555156	145.968493	97.2827898	13.8114227	90.22009324	9.096076065
0298a	396.0579545	6387.868663	28.40517069	26.01874296	19.73913016	191.878998	126.5865194	14.00229299	108.4666347	12.88695272
0298b	302.1292203	6327.883577	28.46651048	24.2360155	19.06638173	174.2219365	120.9598691	14.11848239	100.2981938	13.28333144
0303a	352.9437254	6114.813489	26.45406104	24.64428949	19.77981225	183.5220967	128.6889698	13.64543912	105.7342402	11.45830551
0303b	379.0807513	6587.63546	32.92511993	23.87240785	18.95742272	189.9200988	130.0081402	12.76548196	105.6078807	12.13147562
0303c	402.8454464	6547.063411	33.88640115	20.99225111	21.03532071	189.8790202	127.8679625	15.84041996	105.5052824	12.17348607
0304a	415.9246749	6636.688332	37.12048965	25.24224654	19.47728878	196.8145278	133.7183635	14.5968232	110.4364658	12.96275081
0304b	392.6190054	6202.033346	35.24701604	19.99485554	21.08159403	188.1287266	123.9969976	14.94189949	103.7406646	11.51374564
0304c	407.1930477	5972.459415	42.43750747	21.46080456	20.38443449	181.0702289	122.1869411	15.22961738	102.9126344	12.05430113
0305a	332.1772693	5933.769601	28.95645998	23.21301432	19.02833306	183.2690483	122.2658426	12.05625068	103.9230928	11.75368058
0305b	337.3838965	5930.560693	29.4165542	21.99394098	17.02053138	178.7200883	121.80028	13.85956281	101.3670034	11.50285436
0305c	281.4569548	5827.408303	22.93736509	20.84439545	17.37496373	178.1262171	118.570611	13.64856875	100.0963279	11.54972082
0306a	393.9483414	6732.219566	35.92539532	24.83308065	19.17958812	201.0657895	135.3657461	15.2418124	109.6321972	11.65933654
0306b	393.0686047	7150.242382	41.25779668	30.87660021	20.43290737	204.250173	134.9207943	16.01061845	112.7760078	13.28432148
0306c	459.7249202	6938.974776	34.39625054	27.65225701	19.5230549	206.4840592	139.7532916	14.23702181	113.2254394	13.17965848
0308a	355.6320536	5963.990009	21.96458011	21.83034158	19.12624871	180.4007138	124.3670558	13.39193501	103.0414611	11.09072583
0308b	342.1775159	5947.736267	26.04120454	21.21075023	20.2291773	176.6845963	119.67912	14.84273733	101.8134645	11.66934642
0308c	331.7447601	6085.914356	27.30422438	19.89534957	18.63980746	173.8405339	124.0596678	14.06175554	100.6952891	11.05368314
0309a	390.3277808	5537.958569	30.98192505	15.32122753	15.9986426	148.865687	127.5295525	14.68376154	108.4039874	13.15304977
0309b	504.1773379	7425.365206	36.36882501	20.14275369	19.62565664	166.1805257	148.5872975	17.70112093	124.9391526	13.99199496
0309c	468.86022	6678.194243	38.30610508	21.45819678	17.38190404	161.6745369	142.6842707	14.88101135	122.3888893	13.30707083
0310a	421.9062227	7332.44594	31.58465981	25.98541074	18.79348772	192.8804644	136.0252211	13.43936274	106.1751955	12.84709858
0310b	319.0299221	5671.579049	29.99495648	20.39265757	18.64545074	169.3723549	121.4085496	12.4914249	98.97398524	11.30679474

0310c	368.3035349	6115.809668	280.790247	20.63107956	18.56219682	176.9116063	120.2450692	14.55670148	103.1093802	11.38614791
0315a	351.5106278	5752.260211	30.01388464	18.93809711	18.26276877	166.8259409	116.3075664	11.3820835	98.1093995	11.71030904
0315b	373.3895531	6010.24377	29.22862072	17.63500881	19.54796246	172.6788014	120.2103794	13.20317335	97.77737092	10.59690906
0315c	365.5085144	5813.645907	24.73258176	17.03471786	20.27750741	166.8694715	111.9548509	13.51485009	97.43261443	11.12220919
0316a	386.5140361	5782.692549	22.59495631	21.26741761	19.68507826	174.3850371	118.6900814	15.58485412	100.5013954	10.89462953
0316b	338.9301122	5301.528203	22.50967831	15.3397416	16.4736605	151.5432011	105.0165349	13.02418886	91.68962968	10.68629117
0316c	355.0472225	5233.171666	25.14472366	15.49216876	16.75724903	157.4018476	107.7922557	14.46249222	91.74361527	10.89932076
0317a	419.9203085	5798.944773	29.503768	18.71334284	17.98013075	173.7917465	120.7668469	14.32889551	100.9553464	10.67168428
0317b	319.1805648	5814.546605	29.06243375	19.62577775	16.03418476	172.8446306	117.6105843	13.86221031	102.5970063	11.55869589
0317c	322.4847031	5925.358624	27.9865078	18.45828895	18.69872662	176.5390408	118.8171261	12.55691213	100.1923414	11.87452108
0319a	350.6176444	6671.728238	43.80025318	22.4906152	20.29756482	193.1548883	128.9239949	14.52649889	107.4675568	12.61953499
0319b	410.1936274	6413.417845	283.1544177	19.51493937	20.24726795	182.2409996	125.3278103	14.23190284	101.273449	13.63913138
0320a	319.9960962	5707.085235	23.70050989	18.14876853	19.80854596	167.6581942	112.6584909	14.24036952	98.37359097	10.1182446
0320b	419.1591102	5706.083236	29.6288474	16.74758022	18.19760438	172.7045323	117.7283066	14.5845749	99.90552681	11.66330479
0320c	281.9081839	5553.808613	22.01361444	15.49330311	18.0502016	161.8831148	112.5227932	13.28527458	96.06007181	11.62204041
0321a	358.267989	5941.929217	27.32515226	19.03605767	16.29343506	176.5507952	122.8969842	14.859376	100.6939829	11.8661598
0321b	427.0422014	6900.376646	37.68194055	21.3207995	22.13203462	196.0281216	129.9662027	14.50932378	107.6883399	12.3987372
0321c	416.4706608	7007.079743	39.27506223	22.13191452	20.79482382	187.538731	134.4014343	15.97550943	104.906669	11.92158394
0322a	361.0682935	5889.658875	28.63830074	20.14179777	18.42356804	181.089698	121.13635	12.43962619	102.8808203	11.30957317
0322b	402.3369743	6058.2771	27.61600429	21.88567359	18.61729827	180.1792739	122.0105232	14.90518728	104.0575538	12.29859089
0322c	383.8088576	5840.949334	25.28117395	20.45719473	18.4523035	177.8674941	123.8811073	15.34799948	102.2170761	10.74567566
0323a	328.1990633	5909.583895	23.57680544	20.83958782	16.70153803	177.4378284	118.5907156	13.72250519	102.3531087	11.68161509
0323b	319.4995677	5822.20139	21.36585156	21.88396139	17.5259076	173.7540846	118.5422567	15.40929081	100.3300153	11.59482986
0323c	384.6163392	5869.316171	29.50006203	20.8958556	18.98810716	175.0806416	120.4202716	12.96984345	101.7213197	11.00808299
0324a	366.4095793	5813.575685	28.21588657	18.35035286	17.68673758	180.7896841	120.8265315	13.52089116	99.98522098	12.42526399
0324b	370.2474255	6073.479971	26.98859337	21.77911625	17.54115766	178.3400152	120.5158649	14.99211484	101.9788503	11.50288832
0324c	328.5858235	6107.605009	29.54942729	21.6431271	18.16879386	178.4230297	122.7936118	13.13665793	100.4509079	11.68015955
0327a	498.0998153	7209.680489	37.4074167	22.95906357	19.69003535	195.0139407	132.6437609	13.52928608	109.5324097	12.10893245
0327b	335.9381199	5864.139227	26.27998356	19.86169728	18.66615069	173.5975595	120.2452032	14.14881174	102.5848992	11.45635677
0327c	338.6331904	5851.338353	29.9951919	19.36598251	18.0813735	172.8507604	118.1298156	12.44703763	97.5060436	10.95051731
0328a	393.9294245	6939.051447	35.1061017	25.70168283	22.21661845	203.418029	137.7747534	15.13670832	111.686217	13.19734396

0328b	315.7508766	6140.131135	31.22524675	21.72085872	17.93283	185.4024419	127.1071674	15.124098	106.7786239	12.16972866
0328c	335.1828772	5684.723296	25.09272123	19.66842539	18.60874138	166.6475391	119.143722	13.93024643	97.76917443	10.28808468
0329a	314.153003	6041.217774	32.8402223	20.08119079	18.41477264	177.851042	127.0929269	14.25698707	102.1663808	11.61847911
0329b	256.972306	5966.410531	28.67950497	23.62853586	19.71699432	177.6546999	122.6107806	14.01788159	100.0843434	11.38227728
0337a	445.419454	6386.142653	34.58980791	23.26244886	20.29321273	190.3745964	128.5706022	13.9298822	105.4227694	12.87147982
0337b	342.6355392	6207.784482	27.93506902	22.27202811	20.94977986	185.1150775	126.2334646	16.1618194	104.1848716	11.58185729
0337c	365.2272748	6116.098866	31.95305094	21.38696896	19.61873325	181.5285541	124.6885434	13.85599897	103.6554743	12.04375437
0338a	318.4790051	5941.155667	26.68635599	17.69424899	19.98254928	173.5837257	118.5091234	14.74636723	102.3437208	10.56451825
0338b	379.0319562	6042.01488	29.79995725	19.16898964	18.09336841	179.6074712	121.8353691	13.38461577	102.6628765	11.5281719
0338c	292.2912406	5684.003229	33.22839253	18.24595017	16.86432127	168.3650452	114.4178295	13.53386251	96.75812738	11.19912152
0339a	405.3561202	6947.888173	37.57784257	22.57079317	18.35108552	194.5493808	131.3738108	16.33548163	109.5088667	13.81078604
0339b	389.2430798	7205.171085	37.5903104	25.93975174	20.31899691	197.6960364	132.300437	14.92164473	108.6316543	12.40055057
0339c	362.8682562	6250.045652	29.69122849	23.78198658	20.33847757	187.7978461	129.6004869	14.32209812	105.9380265	11.9859709
0340a	367.573102	6526.720411	26.07048728	22.65818122	19.71622046	185.5808732	126.228151	13.73541898	107.8457804	12.15693889
0340b	347.0524501	6502.695424	30.17055111	20.15177173	19.94508601	181.26911	126.0427192	14.63362165	105.4754367	12.39012787
0340c	355.733202	6305.866418	29.20259191	20.14292844	19.79301501	183.8418845	122.5829995	13.80026767	103.5338593	11.59433653
0341a	388.3344161	6090.385066	30.32268729	19.76635701	18.08197153	181.1013338	118.8786328	15.5497045	105.0786309	11.04992523
0341b	353.0878102	5800.23074	26.84677947	18.59065898	20.94827184	174.2087932	115.4214566	16.71643185	99.16174317	10.8214483
0341c	356.5614263	5993.780271	1095.391739	21.16584761	18.74129089	178.7725051	119.1716817	12.55643321	102.3193525	12.60358971
0342a	481.3232231	5654.082467	42.77785191	19.50531719	13.6206604	137.1530688	72.3162858	14.42564496	102.3227763	12.84687172
0342b	528.2431662	6896.196796	538.9145469	28.80735318	15.08211366	152.1844743	85.71680084	15.1727873	111.3022292	15.16930424
0344a	346.406315	6098.734154	29.75366057	19.20330972	19.19828039	176.7310189	124.4692148	12.9385684	103.0778446	11.56819147
0344b	370.2038192	5781.343956	28.9992444	20.78434215	19.35489065	174.0849487	119.3619754	14.08226995	100.5906458	11.57064685
0344c	331.6315084	5775.988022	24.40048738	18.15651627	18.88456721	177.8777638	117.3667213	12.85484552	102.7874136	11.44883674
0345a	406.7883964	6486.579452	28.27917518	19.86664966	20.26292786	181.3839271	125.5323272	15.04749943	104.1450838	11.58496164
0345b	404.3782549	5640.341561	25.65318133	19.07812548	18.50491241	166.5466062	119.580799	13.03028758	99.48584042	10.71355783
0345c	373.0867068	5711.708029	29.40910039	18.58771129	19.00534029	172.6713742	118.6063921	13.64527587	99.69673849	12.04827151
0346a	414.2282034	5869.379084	32.98081389	21.16022809	18.15942505	180.7457443	131.2445649	13.32516053	102.7438439	11.97871416
0346b	328.2645464	6237.507569	29.12753538	23.87059766	19.25547858	187.9303436	135.6422245	13.16652583	107.9910659	12.39518812
0346c	301.5696667	5575.055414	31.29588282	18.28636682	16.84546225	173.5069893	124.8403493	14.29098339	100.1795747	12.00067612
0349a	353.3451173	5934.241784	27.5343877	19.07325958	19.23378384	178.6458296	121.7550426	13.16104852	97.15476205	11.03709962

0349b	353.4577498	5750.947778	26.49061982	19.96517929	18.41972301	172.2261173	116.9055274	13.01950297	98.28968241	11.21489917
0349c	363.323787	5718.70955	26.48211716	19.45128533	16.9815811	170.9472814	119.9493155	12.94118888	96.88882633	11.20034005
0350a	354.3873529	5841.529178	29.03095918	19.86023514	19.70119248	175.3816493	119.7964375	14.88818639	100.2564749	11.74424557
0350b	351.9841508	5956.882952	28.72706136	19.68659292	17.56011546	178.8926666	121.8421531	14.05175509	100.245176	12.55734424
0350c	333.0851233	5730.89388	29.46622193	20.46193538	16.61224357	160.1746729	113.6713071	13.02818886	95.8250878	11.42368276
0351a	380.9496521	6468.995468	21.3754885	21.70606979	20.03908692	182.2716383	122.3665617	12.960445	102.375852	12.45074429
0351b	361.8965489	6043.771389	25.49597111	17.3774521	19.00250201	170.2410143	115.7722091	14.79841365	101.1004274	11.61152369
0351c	330.0118779	5754.040848	25.3551404	18.41181101	18.2782348	168.9977439	117.0039458	13.48867566	101.3913945	10.9545653
0352a	454.0440119	5890.701837	45.4188585	20.98093967	13.64029057	136.8950977	75.67249586	13.98115427	103.7138846	11.79343127
0352b	501.4984056	5765.629485	39.01589214	19.30932428	14.86817537	135.6562119	72.49057005	14.9991091	104.3242192	12.23268391
0352c	466.1618498	5703.195235	36.82831924	19.04349186	11.46110281	135.7816102	72.30161323	12.77297763	100.733727	12.33272399
0353a	346.1578271	5868.798247	27.23955214	19.9323972	17.58405257	175.5956408	122.7466895	13.94845765	98.00784964	11.09428883
0353b	404.9462275	5697.822164	26.64203629	17.10474313	17.86530502	171.9115392	118.9299738	13.26598767	99.52509885	11.35814164
0353c	331.2240343	5696.844572	30.36826156	18.46448045	16.87895752	169.0543341	116.4928182	14.35835173	100.2389244	11.34683443
0354a	332.8742904	6010.812419	27.08775638	20.83508645	20.03411637	176.4337777	125.2530944	13.21623731	101.486219	11.30368639
0354b	299.1498384	5973.525375	25.43461747	19.65981043	18.929576	172.086116	118.4212522	14.69159462	98.91975795	11.76246079
0354c	335.1622705	5883.357081	26.22606365	17.54327133	18.93560344	176.2175398	118.5449127	14.77955332	98.85750188	11.36004414
0355a	330.0977402	6266.510778	36.22657296	24.53028361	18.14390412	190.9245252	128.8406498	12.49847388	105.7836627	12.68257767
0355b	360.1873776	6009.866359	29.83072382	22.20686232	17.98473719	186.1288528	122.3998978	13.8483386	104.4845254	11.68414845
0355c	357.7334852	6365.016143	28.01599664	23.66231061	19.29163837	191.1050976	127.4785433	12.97244964	106.6704793	12.53964196
0356a	355.737641	6263.151483	24.37702473	21.41561521	16.96402523	180.1861132	121.1648876	14.25366283	100.4673059	12.0096515
0356b	366.1582907	6174.665724	33.74603765	18.92560742	18.8403284	180.0682533	124.9319585	13.57076302	102.8614257	12.09684136
0356c	349.4358571	6156.389183	32.11085014	22.04375858	17.59592626	176.0297236	118.8154746	13.6548887	99.75007846	11.50604497
0357a	415.0451767	6399.556249	39.77173998	24.80471839	18.67251597	181.2035412	124.6921762	13.77592961	104.3174502	11.81960295
0357b	316.1751574	5916.122416	29.1402047	19.11169894	18.64357175	175.614858	119.7294221	13.48287279	97.10434294	12.22061694
0357c	318.365623	6240.962515	30.23753473	21.94960226	18.87074657	178.0144182	123.8931452	13.28043314	102.3143934	12.25932797
0358a	313.2445885	5822.883939	28.59500503	21.01576804	17.31582084	171.4281196	119.6677402	13.77318362	98.59946224	11.76348303
0358b	369.7937218	6377.162818	34.98518897	22.4495109	18.20300481	184.7897775	121.2930676	13.62293041	106.3911924	11.94529339
0358c	319.3535449	6291.816545	32.06582232	20.89775808	19.58284841	183.5286086	129.4210937	14.11923792	102.7078196	12.05768295
0359a	355.4440291	5805.831341	35.80513283	18.77893063	17.49105348	180.2511893	122.2660819	13.81605126	101.4800113	12.2502345
0359b	353.6150865	5102.639779	24.85081075	17.0603788	17.73186427	159.8577787	109.5678501	12.19778634	93.02967068	11.34470083

0359c	386.3162119	5440.634724	23.12646436	18.47835152	16.50652955	164.6099323	112.688974	13.39026903	97.27345027	10.69110832
0360a	348.5057811	6217.073008	33.06250439	22.02952344	19.68810502	184.3308752	124.1213707	13.2805161	103.7381792	11.17547454
0360b	354.1690252	5990.199017	26.33517522	19.38230977	18.18731344	176.2793325	119.898993	13.62871467	98.7996965	11.46881206
0360c	333.8312007	5937.464694	27.99021629	21.78559072	18.61526081	176.471672	118.6064003	12.85066087	101.4161082	9.420132809
0361a	372.6680551	6093.962609	34.75409396	23.07193026	18.89195451	183.8709964	120.8588878	13.91505813	104.2276258	10.65372658
0361b	371.4056767	5656.774473	24.43085614	19.48863235	17.23391733	167.0877862	116.5317857	13.13215852	99.43461522	11.05838793
0361c	333.937469	5707.308827	27.59443564	18.88481782	17.2646493	174.9505834	119.1019411	12.58677869	99.35092453	11.32791205
0362a	348.3288743	6044.303428	32.00356055	19.9742814	19.63854319	180.3849165	122.1177929	13.05651303	102.1123155	11.07195294
0362b	308.5073001	5547.575442	27.66836855	19.15070016	16.43251468	167.1610291	118.5606601	14.34146965	99.02913054	11.2216886
0362c	296.8994433	5303.687939	26.41369705	15.13273541	17.33450943	159.0686845	113.7389807	14.35411153	97.39317927	11.28720871
0363a	342.1872922	5856.412778	26.3428231	21.96723472	20.08907745	176.2308756	120.9184651	14.71803853	104.083682	12.16114494
0363b	326.4881523	5659.773126	24.49113579	19.6443482	19.34245347	172.4994274	117.9991191	14.38319287	100.1584596	10.4192181
0363c	379.9909586	5742.977498	27.67619104	18.84535896	17.2276423	171.9856394	119.9912566	13.62999899	100.6845234	12.3532772
0364a	353.7217887	5754.131696	30.4454227	21.2219808	16.07770217	169.9989755	115.3766081	13.46260069	97.30017273	11.1448028
0364b	344.7977997	5866.184468	25.16566062	21.83938478	18.82579607	177.9636469	118.869304	12.40779449	100.8169849	11.10001851
0364c	306.1075423	5562.278116	25.37415696	17.1562741	17.32681185	159.4911197	108.3724887	12.955974	93.81848748	10.20471018
0365a	302.9422301	5499.011632	26.32715841	20.55313961	18.60374402	166.7681623	116.4540493	14.31774432	97.7912887	10.50146025
0365b	327.7078378	5471.308843	22.69687096	19.25508797	15.89012331	168.1897172	112.6101652	13.0125853	98.70147869	10.97970697
0365c	353.3314053	5892.278339	23.48959282	17.70038302	17.36870112	172.8638053	118.771027	12.83120588	99.53405817	11.47458849
0366a	332.0708733	6926.38272	32.1263359	20.59274493	20.9198524	183.8835543	124.1504943	13.26624389	105.7323673	12.03636261
0366b	355.7810649	6062.605188	25.96606968	21.41694126	17.44806293	186.2384538	124.8343303	13.1350368	104.2389197	12.69976884
0366c	369.4262884	6969.978941	29.13817033	21.56120477	20.2505835	181.8876698	126.6542431	13.05147649	105.6327905	12.24517998
0367a	372.7711792	5726.980677	23.86871562	16.36319671	15.97377288	167.6379618	114.9791078	12.96218958	97.90405103	10.99862638
0367b	365.7686924	6354.471636	29.39922747	18.03020683	19.8727464	177.2383483	123.2891269	15.67741729	105.4027371	11.94119141
0367c	389.8714	6316.014993	27.53154472	19.02412869	19.82624444	180.766461	124.2991253	13.26911211	104.4664676	12.01592247
0370a	402.3544305	6611.412489	32.83898592	25.03684149	19.91339381	201.144838	135.384836	13.39789645	110.2213143	12.84477625
0370b	321.2407493	5952.038647	31.8068779	22.71330561	18.11828789	177.2078542	123.4424601	13.82044414	102.9479847	12.1003726
0370c	363.511648	6455.221137	24.73454117	22.27423462	15.98910211	183.3047573	127.971869	13.91630422	105.9392974	11.06033881
0371a	369.9926364	6140.436072	34.43824504	24.99433022	19.74077968	184.5535159	126.6786721	15.25091868	102.6174571	12.88753573
0371b	320.840243	5994.85557	31.88513673	22.44787618	19.28384392	182.6405897	121.9763774	13.93588959	103.3612263	11.75583564
0371c	314.9872903	5989.049559	30.95726444	22.74960966	17.4754315	178.3596375	124.1898787	14.50901665	103.989068	11.76677945

0372a	409.3289741	7404.682289	42.08985588	27.05328502	20.48743215	205.6841937	143.4641647	15.65229093	111.8775153	14.00331628
0372b	432.0368694	7076.859219	35.11295666	24.63022835	22.78197241	203.3797884	138.8762074	15.12786154	110.0043761	13.0697393
0372c	394.3402098	6591.986568	38.751696	25.32074887	20.54993171	183.3333379	128.2129474	15.99614462	104.6771431	12.92285835
0374a	375.3123006	6291.995574	33.10970875	21.41188305	19.15195263	184.2126261	128.7971364	14.72280538	102.1318872	11.22959115
0374b	381.7103619	6379.304456	51.26572989	20.58201074	18.25932102	176.6584717	121.0099845	14.72515278	102.0801309	11.3695891
0374c	326.7139926	5429.206813	26.88309158	19.30733495	18.28842274	162.2553048	112.1246673	13.43010361	95.87587625	10.79768482
0375a	424.7416201	6785.063894	40.91999818	23.35675764	19.02657241	196.6702775	134.6481469	13.6925409	111.2951574	13.3830608
0375b	351.7286478	5790.614741	32.71236251	21.75449114	16.6641547	170.8751792	117.2159257	13.20077293	99.41422972	10.87388885
0375c	445.932371	6716.101248	34.88241783	25.37796415	21.4785117	192.2611412	131.7413845	16.24143496	108.3269789	12.04484183
0376a	356.5635784	5862.91052	26.46916458	18.84535514	18.72407033	173.0036698	120.811049	13.69683474	99.12494008	10.87872804
0376b	369.4096301	6032.668975	24.80238926	18.67288491	19.69071879	176.1405148	122.5822455	14.00899469	101.7752289	11.74951236
0376c	374.2929146	6349.721516	33.37382557	21.05840659	19.66521773	185.7613398	125.9250556	14.39835131	102.7446231	12.56166264
0377a	355.3383785	6468.941824	32.61671004	23.67602299	19.1022656	189.4088037	132.312575	14.93239251	107.0971673	12.57875847
0377b	372.8954253	6444.686346	38.35932236	25.36273351	20.49679371	190.2179855	129.8398171	15.62749957	108.4449162	11.65465964
0378a	544.8696872	8704.576418	47.92200955	30.30389329	24.46167316	236.4030188	157.6675538	14.81415856	119.3095407	15.03150922
0378b	549.8611823	8949.532109	53.3147031	31.56707302	24.89268701	243.4442042	159.3549304	15.41079505	122.0916786	14.3849651
0378c	549.2997988	9132.485977	50.42826425	32.1964932	25.33451292	235.2818413	153.2058726	14.59705207	119.0577817	15.84677176
0379a	438.5939193	7133.262366	38.28694382	26.68887562	23.10005749	210.1504373	141.0613855	14.32812153	112.8140258	13.65670781
0379b	391.3673045	6763.57548	31.74052058	28.16007857	21.09276415	196.4134665	137.2440383	14.91494336	108.7152927	12.89893842
0379c	443.8597199	7596.377819	35.38081069	28.47124222	23.30072033	213.0326076	143.7204517	16.66990474	113.049927	13.31021191
0380a	469.9595532	8422.877597	44.06569169	31.60445801	25.88318668	229.9032972	147.7486398	14.02899754	111.7828538	14.20281013
0380b	474.1800785	8302.829133	47.96706724	28.94322798	23.08225124	223.7078071	147.9653537	13.74458532	114.5984378	13.35254107
0380c	369.2959118	6205.73954	32.94583909	23.9822095	19.30714561	181.452029	122.8427433	13.35550636	101.2697543	13.27138298
0383a	340.4089871	6028.689482	27.55736763	20.61250871	19.69855048	177.3466134	122.0929853	14.66688874	101.8329997	11.62353288
0383b	349.3666227	5841.615151	29.1446674	20.31501361	17.19109132	174.9428051	119.0129269	13.45815668	101.232971	10.60828441
0383c	316.824999	6081.941787	25.84734927	20.2314498	18.97753428	179.781003	119.7797156	13.23538183	102.5954052	12.71913337
0384a	371.0008723	5757.445084	26.73254124	17.1965966	18.81162475	173.9007492	119.6514818	13.71007691	100.357989	10.25699342
0384b	375.081423	5701.912479	28.23298706	15.67939858	17.47731868	170.8911344	115.6575616	12.38491911	98.08622685	9.907588349
0384c	348.1816017	5464.068352	28.83922896	18.38820227	16.61630871	160.6550797	108.4976837	13.59556527	96.10574533	10.48541944
0385a	296.5916688	5948.217552	30.84464342	20.27707865	18.22280537	174.6579797	119.5076714	15.296144	100.9479362	11.40610643
0385b	388.5612306	6136.643653	27.35151877	22.14565978	19.93289122	181.1891639	123.4217439	14.98763645	104.4239045	11.62353987

0385c	313.7324336	5846.223805	28.00115307	18.4605776	19.22945311	176.56538	119.1064672	13.81950383	100.7357384	10.86914995
0387a	499.7198946	6169.354879	46.64494944	18.05862793	14.7971867	142.8177112	76.9181325	15.63093819	105.1328848	13.20468385
0387b	462.5687983	5539.405107	37.03253881	17.85526279	14.41550109	135.8921186	73.11002662	13.68932372	100.2416738	12.19341544
0387c	421.0585462	5783.99199	43.05875215	18.1537816	12.94157974	132.3498411	68.5589719	13.43163446	104.9357899	13.20812138
0388a	456.3224902	7702.194328	48.5769437	28.30208326	21.13931362	219.5051872	145.7473824	14.96396315	116.7503334	13.86914478
0388b	411.7902284	7373.483994	46.82062077	27.47459289	21.11425826	207.1757685	138.8763073	14.86108262	111.876035	13.03206749
0388c	403.3565996	7337.895897	45.0921679	27.64887311	23.10561678	201.5851587	135.6622912	13.83367212	111.8338812	14.03979854
0389a	363.3357658	7365.167585	326.2468695	26.49210753	21.60168054	205.1618464	136.8818744	14.65048143	116.0774226	13.21093074
0389b	359.9138179	6635.65743	285.4490676	22.91090104	20.1083109	192.2071795	132.8966083	16.4531036	108.273256	12.50707762
0389c	454.8189852	7167.282224	43.6808454	25.47848154	22.48819194	211.1090699	141.5601275	15.83251095	111.3349249	13.20425907
0390a	379.790442	5765.802084	28.28126822	19.39944138	19.134187	174.0774717	119.2533167	12.64844517	97.6950337	11.55436692
0390b	356.7912649	5717.440942	26.63455671	18.70411291	18.71632746	171.6537816	118.1822443	14.19684491	99.38358842	11.19650449
0390c	410.492512	6122.005675	28.44620739	19.52249179	19.44044169	181.0657933	122.3651011	13.63195276	101.814615	11.33849931
0391a	361.9191598	5854.595657	36.81218638	23.36074173	18.99584492	174.7188893	121.2156697	13.94122777	101.6514269	11.48870056
0391b	310.7506307	5451.327917	32.06512544	20.85204764	15.50343836	169.507999	115.5487674	12.78747381	98.47812514	11.47477356
0391c	276.2599591	5483.043274	28.70175527	17.44346201	15.92969175	169.2515172	116.9270312	13.6617072	96.13919647	10.91296464
0392a	281.4016473	5754.724857	20.61806181	14.82570366	16.25925015	152.5009121	116.784755	12.23738803	89.01847201	10.39310012
0392c	371.6182699	5743.840737	27.29789406	18.44706172	16.66861969	170.0804151	114.4324023	14.28709192	97.14298749	11.40325468
0393a	358.2251398	5684.281439	30.66901529	21.59949917	17.95198788	174.6605684	115.6560813	13.12322672	100.797299	12.04509372
0393b	381.5367116	6179.029381	31.55991873	22.18495586	20.29526576	182.0922343	124.9246648	15.3276716	107.0008065	12.21125317
0393c	420.6524768	6040.762133	35.00397681	23.19269315	18.25687638	183.7986894	124.0337578	13.96594383	102.3803987	12.85577504
0395a	373.9857146	6457.432941	32.69271301	23.90850119	19.96328195	190.1445347	126.9499701	14.66253968	106.9716225	11.66538994
0395b	354.0213914	6144.716807	27.14906528	20.30549543	18.57092861	182.6994647	125.7761547	13.89373662	102.6695112	12.19859716
0395c	300.4296741	5912.466249	26.88540575	20.23725797	18.5858224	179.3922406	118.3148609	13.01696096	102.2926376	11.70256462
0396a	372.9182606	5848.41519	31.65245153	22.85338736	17.04256598	178.9624507	120.246047	13.42563299	102.7122166	12.10765377
0396b	402.5423938	6292.93504	25.9158731	22.28172123	18.10081305	183.5409893	124.0001226	13.47563745	106.6279509	11.7829775
0396c	429.7452859	7165.386436	43.23809819	26.13431872	19.32357991	200.0449998	135.9992222	12.92588578	109.2684064	13.59301424
0397a	405.4615095	7416.323882	41.03136304	30.20802878	22.2714858	215.4641873	144.2583358	14.0195631	116.8336839	14.59455245
0397b	444.9898407	7371.615888	38.72409212	27.99813147	21.40215503	212.99486	144.3527356	15.38696605	111.7936217	14.76574303
0400a	392.1214868	6875.001383	39.44756903	25.4650391	20.11039408	203.5389716	135.9185649	15.4715865	108.3718932	12.64478052
0400b	414.16595	6898.299275	44.15793597	26.68585732	19.22241756	204.9182305	134.7474194	14.5742966	110.1464348	12.27571091

0400c	430.024393	7312.308031	43.55056649	23.0266563	23.00494306	197.341913	134.0099742	16.19720434	112.1076839	13.05163219
0401a	362.6817922	7060.57923	38.78630974	27.89698691	20.32188987	202.6196769	137.6929715	16.12117795	110.8596999	11.6481302
0401b	457.1187138	6414.177885	28.01445487	22.62519937	20.43745926	192.2640086	131.5535592	12.56621131	107.8818214	12.76063895
0401c	402.5974863	6728.403784	32.24776606	23.64846437	22.73621091	199.7847275	135.7802517	14.08636711	107.9880363	13.14473618
0402a	355.6714248	5450.255969	26.72898132	18.78401189	16.63775978	167.7831195	112.8549948	12.96100439	97.72007082	10.86564446
0402b	370.2672027	5581.317078	25.25892724	19.708276	16.88712615	169.3905087	113.172815	12.35094374	96.05382546	10.29755037
0402c	343.3131512	5489.969336	26.94601223	14.7056044	16.23778437	166.8872993	113.1237886	13.28073132	95.25543293	10.48058026
0403a	355.1484019	6144.091289	24.65335176	19.36342505	17.52480373	173.4983558	118.3495325	12.92565319	97.75960055	11.00484566
0403b	288.6847016	5846.936231	25.38905978	17.90210321	16.43761278	160.3953818	109.993605	11.75155716	95.46229798	11.21187445
0403c	356.671063	6565.823634	35.41475336	22.19011235	18.96507456	187.1148172	126.1381794	13.77611336	106.1259903	11.86135141
0404a	330.9002961	5773.905965	28.93714533	16.20335289	18.38172611	171.6714556	117.5741945	14.58846389	100.7642415	10.32937176
0404b	327.1415154	5889.156765	28.8670207	20.16145541	18.92170172	174.0610317	115.7150868	14.42391207	98.92909697	10.63421429
0404c	306.7106374	5671.142343	27.02406038	15.89421774	18.18746803	162.2976595	110.5624475	13.5606723	95.74242513	10.99845082
0405a	379.3487163	6218.271324	28.63997593	18.9630726	20.30573541	179.7245804	124.4699038	13.04262447	99.4462835	11.97228145
0405b	372.5287025	5740.069278	24.85670235	19.62645766	17.06608093	176.3834043	117.72597	14.02528408	98.49319236	10.98742844
0405c	359.0935447	5747.835993	21.18862954	19.08171173	18.1531745	169.0535284	115.8912313	13.44478485	95.46419289	11.64940227
0406a	346.5060615	6021.668836	28.10506718	19.64924001	18.52309486	176.1936815	119.6567377	14.707882	100.8763345	12.04341804
0406b	335.3095423	5635.891926	28.33498004	18.77562924	18.40402654	168.881441	115.9137878	12.48173815	101.1152671	10.18813119
0406c	345.0475557	7028.151259	32.49317414	20.81696973	17.72711895	181.9678004	121.2107314	13.89841995	102.9662452	12.48303599
0407a	414.6409647	6757.509576	35.64699033	24.09781065	21.26633901	194.9629531	129.7187484	12.64448537	105.7262609	12.3335604
0407b	347.459421	6182.422775	27.40167238	21.69357995	17.20567107	180.3505785	123.6478854	12.42452354	101.8517451	12.76443556
0407c	279.6345419	4785.903935	26.0005847	17.36330493	14.35361522	152.2038949	103.2753939	9.747438743	91.40319169	11.1638115
0408a	359.4131465	6227.080508	30.38531286	22.66568493	19.33075071	184.8434185	126.6173804	15.01738189	106.6100618	12.23169583
0408b	332.3213729	6361.695438	29.49397419	23.16721172	18.59827464	190.4056137	128.8851706	14.39625411	105.2942165	11.45935864
0408c	385.2635014	6188.473321	30.03285683	19.81193889	19.83948856	180.6101609	124.5091867	13.60177377	104.8010738	11.02363281
0409a	426.2289792	6429.839865	34.64570198	25.37627628	20.70630701	183.8055451	127.8801206	13.93251485	102.9935931	11.95951035
0409b	407.5581196	6333.414974	31.2307713	22.68467619	18.45636949	187.5276572	122.9151587	13.89002657	104.6280537	11.22085759
0411a	414.0581681	7171.897914	41.63336411	24.4870342	23.98234758	208.5195091	141.1801754	15.43762318	113.051675	12.88724852
0411b	390.9727087	6674.005368	30.55074903	22.89986871	20.33096607	198.0380735	132.3208789	14.66640404	110.944066	13.03783989
0411c	310.9243902	5938.185895	27.98961225	20.53395561	17.8465142	168.5358048	115.5928599	14.68154006	101.8813099	11.16993597
0412a	393.5624984	6230.658123	36.60850456	23.34242975	17.97154981	182.9366846	125.7634903	14.24273096	101.3615618	12.41140317

0412b	370.7649806	5862.860517	27.72954274	22.13166669	16.26396843	170.7503069	119.7376545	13.68645213	99.85966971	11.67476687
0412c	328.1592971	5534.162593	28.52306271	20.58641423	16.53662669	168.6945554	112.4248962	14.0264842	100.0274129	10.72228188
0413a	457.2112964	5629.017113	32.25587628	16.122922	12.52434366	128.0109055	72.40755729	15.25074461	96.30200441	12.60155444
0413b	372.000002	5174.438882	39.45656586	14.41494796	12.80111615	117.8282303	62.99688915	12.91969917	92.91388885	10.45606492
0413c	425.530396	5322.633063	32.7345577	17.416531	10.07519949	125.1060273	66.63292365	15.21559485	91.64823393	11.25638973
0414a	457.3163181	5488.001489	40.68898306	18.40435854	13.48606906	130.1721647	71.22502437	12.84551102	97.33667208	11.93528339
0414b	421.8221662	5581.189623	43.3688314	20.76592177	12.70152095	131.7545827	69.81561949	14.82512151	101.4944719	12.89033657
0414c	401.2611628	5660.040353	198.7915245	21.69301658	13.64704918	138.1328079	73.8426565	15.84181	104.9684872	11.97168909
0415a	357.7986102	5564.273954	23.7080153	17.4475081	17.41501127	165.9399483	113.672992	12.6743397	97.71203569	9.787371279
0415b	366.9361231	5823.144907	29.64566375	18.91738041	17.45396322	169.1545337	118.3894895	15.06254042	98.5919484	11.34677859
0415c	294.7463089	5792.268949	33.28404879	15.98657262	17.06752024	172.4589843	116.998744	13.82742938	98.35469517	10.74060725
0416a	313.200315	5512.05155	25.91262333	18.46022514	17.8808677	164.0129826	115.6720407	14.572895	95.85967963	10.30386957
0416b	355.9270791	5709.193008	22.6230171	18.61152641	18.6948552	170.0902511	115.0828584	13.75794299	97.28466501	10.59604929
0416c	352.9178552	5535.66148	25.05855053	17.70635562	16.88340883	168.0549752	113.31125	14.73617472	97.35431617	10.89123389
0417a	335.3162345	5810.129449	23.86136438	19.88933883	17.76629645	165.5338862	111.5758977	14.68371034	96.16034328	11.78313918
0417b	380.8025871	5452.259725	30.21681345	14.65639358	18.4955279	164.8173759	110.5604703	13.53021707	94.98355428	10.85798822
0417c	363.1908138	5244.6754	28.78967354	14.32548508	15.35965826	153.3855396	105.791432	12.34325112	93.15170314	9.766095217
0418a	277.9202443	5614.988938	32.10211559	20.11276693	15.58104115	165.6655268	113.3621984	11.48041664	96.93400172	11.39656485
0418b	329.6668186	5769.394051	29.21785481	18.64864845	16.44928821	165.026588	110.4810674	14.60065203	95.70237337	11.65538029
0418c	352.4938989	6120.254791	25.01189386	18.69148065	17.45290858	174.4402876	122.2885697	15.16094928	98.60602499	11.54235177
0419a	421.1127792	6501.089954	33.66663133	21.81982141	18.41192322	183.1025219	125.2112908	13.9836646	105.1483273	12.7527798
0419b	332.9857958	5661.327452	25.87489469	17.68237673	15.84131089	172.8718089	116.165407	12.56667177	96.17394351	11.18616591
0419c	378.246933	5798.878598	26.35541985	19.26236473	17.50650482	177.06536	118.3969198	12.3736365	99.38375408	11.27009367
0420a	353.8976922	6043.972965	33.28642456	22.25252378	18.62040557	174.4751563	120.8845974	13.65754827	103.5497407	11.95254173
0420b	351.4918581	6168.243792	33.85198873	22.27097623	20.24403076	179.4088828	125.6595579	14.58900504	100.7902583	12.32419004
0421a	351.3454395	6135.688545	32.1223289	19.21173413	18.59985348	173.7636556	121.5959012	12.31725766	101.3749489	12.10233302
0421b	356.7169183	5896.257177	28.1246835	18.47644031	18.95124208	169.6397138	118.1313692	13.72866114	99.73906853	11.30464893
0421c	399.7048806	6637.966804	37.23496164	22.01859611	17.27624236	193.59323	130.2018676	15.23971432	107.7116236	11.85216815
0422a	343.1497259	6233.039197	31.90137648	21.05936831	20.25303168	183.5400893	124.6814509	13.85211852	102.1409798	12.11735731
0422b	277.8761279	5518.187415	31.84055926	20.55977195	14.45820675	152.4591039	106.4923267	12.51198713	92.21857995	8.896336615
0422c	316.0851702	5587.600308	34.0141122	19.28399206	14.18256975	153.8279733	107.2649057	12.84681237	91.25140745	10.44144187

0423a	382.3088052	5785.536324	24.07077956	19.77571589	18.70251364	174.2013026	120.7348252	13.02060092	102.1807642	11.11120995
0423b	342.598066	5799.757326	22.11879053	18.95721599	18.79436692	176.0784392	119.2197474	13.06655992	99.80296724	10.48168698
0423c	361.2671148	5719.348901	29.71880299	19.77910086	17.94876704	173.0479725	121.2919829	12.03106262	101.1413747	10.92939017
0424a	401.4905327	6627.115084	32.37577159	26.1603184	19.55693248	189.5072982	130.0811362	14.67400483	108.279478	11.92123399
0424b	408.4654652	6143.502159	32.18422645	21.23805902	18.27421918	184.6051352	126.6704845	12.71825682	104.8430768	12.13697711
0424c	397.1023124	5814.968337	26.07392636	22.2331008	17.27772289	172.489507	118.1170189	12.83316611	99.58367124	10.99776967
0426a	371.4540551	6733.323619	33.63577222	21.63045735	19.77372031	189.7068665	128.0116777	13.5899677	106.8260496	11.40630561
0426b	323.0318139	5745.83395	23.57005728	19.33535553	18.42707127	172.4582683	120.8535356	13.43865842	99.42887151	11.02455633
0426c	275.6533438	5828.566506	28.15041072	18.63671573	19.74407023	169.3871188	119.283093	15.0982169	99.73715266	11.9245185
0427a	419.542266	6579.772984	40.08918405	23.45439785	17.69326975	192.943761	130.3165776	13.30420735	106.2607458	12.02849677
0427b	341.7891163	6418.393208	41.56729575	23.10418756	18.03449744	190.2533983	128.6541395	15.52871418	106.2739722	12.25224375
0427c	393.4280442	6502.352729	31.73027865	23.44075233	23.02712838	195.8755333	133.0807273	16.38014733	109.1241803	13.29978783
0428a	402.9510568	6361.94419	33.64858636	22.29352257	19.37854241	190.4237999	127.9274084	14.20931405	106.8677044	11.76528854
0428b	379.9350651	6371.662512	34.51633394	21.75734055	19.29266758	188.4360756	128.7718191	15.68277319	106.827112	12.6688245
0428c	437.8269145	6362.984327	37.04655413	22.5206127	18.52089065	186.4942314	130.6574201	13.31537143	106.1096161	11.97029524
0429a	384.5629182	6442.010347	27.28136428	21.19736374	18.85980854	188.3291881	125.0695638	13.461029	107.6127835	12.86482045
0429b	316.9287061	6088.358338	37.10720896	21.05258622	18.01746411	177.9942843	122.9758606	13.21202556	102.5519779	10.634483
0429c	333.2374984	6578.590951	29.95358273	23.1396282	19.13390524	196.5251315	132.8437974	15.34285472	109.2235659	12.61917128
0430a	395.6748474	7389.780171	37.36379993	26.06069184	19.48368885	198.9743909	134.4403515	16.3216512	109.5449354	11.65874178
0430b	328.7387143	7420.194544	37.20460294	24.22377336	21.17594379	203.5866995	138.5781786	16.60454819	109.9676496	12.9936518
0430c	353.875545	6530.045785	27.65792061	25.63153757	20.99505663	191.7610076	130.8667694	14.71935437	109.5442975	12.44566984
0434a	398.1636766	5859.63101	26.33705331	19.15735596	19.34175654	168.8597478	121.4288136	14.19122373	101.0750584	12.05627771
0434b	332.0464563	5691.05969	27.75590579	16.88631477	17.15519943	165.762652	115.2833967	12.75160687	97.2328663	10.70722489
0434c	406.7440695	6356.889533	28.39613001	18.37632036	18.5047865	175.6040684	121.6691519	14.57765235	100.949497	11.00710516
0435a	395.5611974	6663.16338	45.62814317	25.11910482	19.23790455	183.5278165	127.0058789	14.55250332	105.0697563	12.85354468
0435b	341.3194503	6087.615843	29.17282444	18.95993328	19.0198577	171.9481086	119.5897838	15.5664305	100.0093326	11.65629094
0435c	406.9076991	6253.986185	27.17059604	21.08411353	19.71135645	180.1794461	123.7731501	12.51430983	102.0744295	12.12493187
0436a	355.9250549	6015.288006	25.49540215	18.57490281	19.88725297	173.3084034	122.0237106	13.31441169	96.30929437	11.59790966
0436b	374.431654	5630.205684	25.23744696	21.49573207	18.0822082	168.9111647	113.3577624	14.36493442	97.36928855	10.82636326
0436c	283.097455	5436.888069	27.23300642	17.58527357	16.28636248	151.9148239	106.8412009	13.43826291	90.30071741	10.04624538
0437a	339.842225	5787.325541	29.65730411	19.752059	17.82134727	168.8211094	113.2063093	12.81685818	99.23519718	12.59100663

0437b	325.1582753	5493.928025	24.44691339	16.02566476	16.7994381	164.1884521	109.3672819	11.69329033	92.06213939	10.43589519
0437c	363.1311783	5787.093171	22.08314603	15.26068457	17.68582983	171.8674222	114.6464352	13.49484342	98.9192915	10.25380777
0438a	339.028641	6150.603986	29.25758964	22.54916279	18.14065596	184.1466118	125.6895608	14.282806	105.2809941	12.34182938
0438b	344.0041159	5834.104505	26.8599131	22.12289256	19.3600206	172.8753697	119.4209956	14.37702568	104.0206721	12.33211762
0438c	354.9072773	6376.848938	27.52712923	24.02183672	17.50531406	185.0494274	129.5553919	16.08493631	104.9298723	10.84658317
0439a	350.6527233	6134.523247	25.02879961	19.44185893	16.32692155	159.4816436	122.5002296	12.29967679	95.76899223	11.29006787
0439b	344.4716183	5910.701719	26.61206612	20.1452142	18.36608291	179.7383341	120.7744888	14.08927836	100.8235453	11.57304358
0439c	398.3476893	7029.052712	37.32765252	23.30015391	21.13647309	195.9253897	131.9235349	13.25942872	107.4346649	12.92897985
0440a	381.2553738	5928.896542	26.51895517	20.18170256	17.39381042	172.2325953	118.3332983	13.19350932	100.1735296	11.00671969
0440b	363.0449256	5845.6196	23.57424063	21.02230368	18.59863037	173.4217217	119.6149014	14.79930909	99.94883446	10.59462723
0440c	339.802942	5806.369266	18.98492685	21.80421756	17.36692354	174.1906815	120.8847336	14.79117983	100.8961207	11.7323272
0441a	355.1686815	5856.633373	28.44172711	20.79399409	17.25255268	176.4996438	123.5534685	12.37131762	102.0535233	11.59145909
0441b	408.3376567	5983.365262	24.10300804	23.59085522	18.24242653	184.7784053	124.6000842	14.30961188	104.139354	11.852561
0441c	384.6818026	6068.06201	28.32918441	19.04968868	18.54661863	178.6240283	124.4269086	15.47936218	104.3151494	11.96094949
0442a	360.5888314	6603.471933	34.57615205	21.66093203	21.52059564	180.6266838	125.6794441	13.58523932	101.7374228	11.00528136
0442b	438.5859861	6644.608404	30.50630903	24.63909945	18.46066384	192.4530486	128.4612651	14.49107005	108.8112225	12.61355953
0442c	327.1343878	5738.404177	23.36053348	20.16814474	20.08412254	175.060489	118.089563	13.46302216	100.9575818	11.72214588
0443a	386.2743459	6945.21405	32.65146893	26.97761546	20.56547787	189.9122985	143.2964063	14.05492396	112.4294557	12.81009429
0443b	448.8282246	6425.90789	30.37418791	23.99889912	18.61201997	188.6384697	134.2337927	13.56402176	106.0537687	11.75189154
0443c	343.3304221	6174.670275	24.40534139	22.84819376	18.51853355	191.9357288	123.5946375	14.12416308	108.2195751	11.34290355
0444a	379.0075677	6143.194934	28.04157588	22.38159991	19.26326826	183.2246947	125.1519027	14.08191645	101.7918525	12.49377641
0444b	355.9154396	5685.561582	23.02019389	18.71299015	16.46035413	171.9419017	118.6473561	12.68667132	99.77528499	10.70206861
0444c	344.7111367	5660.82335	25.49833236	18.01677696	20.04856395	173.1478881	118.0302872	12.38555056	97.88144681	10.38074442
0445a	351.1950489	6142.013999	27.97281323	19.9460646	20.12725647	182.9577533	120.7103682	13.47128634	101.8598942	12.92788168
0445b	376.9784332	5883.846061	31.01196721	21.18569799	19.55915789	173.3161615	118.4846142	13.69364517	101.2462164	10.54584767
0445c	292.6833372	6562.344327	24.87515473	21.40770424	17.51669652	168.1396642	123.5476807	12.39740546	99.13255908	10.31236255
0446a	386.1722061	6490.026781	31.23733127	24.19857187	21.13599349	193.5581618	132.7749854	12.78216052	108.1666779	12.40970579
0446b	303.394208	6215.382802	26.55705183	21.39230833	20.23936291	185.7435003	129.5676218	14.2885022	104.0046221	11.9384437
0446c	348.1444833	6559.208111	32.72830143	23.83284935	18.12114338	184.3755296	128.669719	13.7181204	103.5878541	11.63747622
0447a	309.7006239	6201.328797	37.90555104	20.80798082	19.4449815	178.7037159	117.8533084	14.34483044	98.38538436	11.7021241
0447b	380.0191702	6089.834149	28.19770215	19.85776202	15.84878265	171.9867129	118.1029974	12.08405225	100.8259952	12.29987779

0447c	350.9310399	5890.529479	29.84733267	20.25329659	15.80305618	173.6015762	121.4036498	13.4646741	100.4415607	12.02381355
0448a	401.2680794	6569.861713	28.2594089	22.15208991	21.70182102	193.7343675	129.2036304	15.15865046	110.9459558	12.2098897
0448b	356.2837247	6076.453115	28.96058433	19.4661688	19.66277774	177.9703889	125.7828044	13.88189775	108.7900005	10.80010175
0448c	377.6968874	6498.371067	32.1384388	21.95434158	17.37428033	183.1709543	125.7706918	14.13977889	102.1718756	11.43025858
0449a	337.5394477	6070.276804	32.49719595	25.42199672	20.2874733	180.8297022	122.7653748	13.59301818	99.81465359	11.76187696
0449b	348.1089398	5711.218935	27.77501888	19.67668092	17.93162285	174.3278928	119.2917102	13.04451889	100.5824854	11.30795985
0449c	337.3913392	6379.908252	32.61317886	21.34271112	21.32961945	186.8632443	126.2428865	14.04957116	105.0526518	12.38312346
0450a	367.4032354	6368.699237	32.94307593	23.67145117	18.31061477	187.0859896	128.2319225	12.30498314	103.5558959	11.89625784
0450b	378.2105192	5803.590512	31.22824347	20.28908901	16.35199254	174.3296157	120.4937202	13.35332662	99.89054489	10.99073132
0450c	321.3542953	5996.709497	24.36431062	21.487205	18.5307748	173.7165754	119.7296456	13.05331341	100.8733711	10.93843037
0451a	355.4023468	6151.517369	31.39024843	21.43634862	18.82374037	188.8932569	127.7241364	13.4740632	105.6014773	12.06486309
0451b	346.7693354	6157.791954	31.49561121	23.40065615	19.25858896	185.4248065	127.4941059	14.9859118	104.2426569	11.69271888
0451c	329.4849894	6290.452636	24.23271656	20.34431018	22.00014687	188.7274822	124.6469794	13.27555788	105.5498601	11.92545898
0452a	367.0379576	6853.265809	37.4985592	26.43214068	18.66403383	193.6471771	136.1103065	13.1897119	108.5644875	12.64375795
0452b	343.1066508	6338.811076	31.80626662	19.50542427	18.24553097	176.9615618	121.7851142	13.88344542	102.9813542	11.58373603
0452c	309.8260736	6810.275248	30.36513203	24.91998581	19.98761844	194.7966897	134.3898209	12.58965182	108.2417396	12.12247599
0453a	418.9182815	7171.030492	35.3222586	25.054075	21.3203494	206.7546959	136.7578258	14.26204626	113.4925146	13.22858907
0453b	377.4138256	6237.916957	27.12127577	20.14886439	18.43382027	179.6454405	124.1169906	14.94261089	101.7018624	12.34032181
0453c	368.7064605	6423.311816	28.87051722	23.5356741	19.65240723	186.7568649	128.2480807	13.08013263	105.9645137	12.24263572
0454a	308.6946543	6128.401929	34.82914042	19.16423869	18.73840336	183.2344499	121.9652295	12.74220613	100.2147952	11.72062273
0454b	373.1274712	6104.011981	40.99086461	20.2383505	17.36435656	173.2517866	118.5136056	12.43093293	100.3029241	10.89642638
0454c	342.2577648	6148.961701	36.91938376	22.59433688	19.64360292	175.5676501	121.5640285	13.57376999	99.0791507	11.21458715
0455a	237.4450449	5045.166767	31.85616125	19.10425483	14.30991729	149.4017859	105.0608765	14.11106507	91.68671853	10.40226248
0455b	303.050157	6660.435564	39.40083238	21.52243034	17.42443132	182.1471115	119.6137018	14.20536244	101.5262342	12.29817528
0455c	348.3919923	5853.589471	33.76832909	18.90962466	18.25587544	165.3520153	112.9710591	13.05501835	94.75883854	11.40495049
0456a	394.8428312	6803.340039	37.63800718	25.89290171	20.40865024	201.7873051	137.3684196	16.16747714	109.8199443	12.18430226
0456b	359.6411389	6623.828253	25.68143516	24.34491186	20.69482085	197.4031948	130.7155299	14.79465443	109.5618479	12.78154517
0456c	383.4885589	7622.401111	38.35987292	26.43987708	22.01922035	207.4504847	140.7602522	13.73332294	109.6649897	13.84610225
0457a	363.5431304	5766.608428	26.08594862	17.71973476	18.3386292	174.2379701	116.610678	13.0085032	101.4543823	11.86087227
0457b	362.5704991	5918.609434	29.40283792	17.24471826	19.73709219	175.6331299	119.5868673	15.67376628	101.9477032	10.794751
0457c	368.058718	5633.641913	25.7024983	17.51729286	17.19176032	171.1445332	117.3102935	15.49820704	99.65259273	11.50024283

0458a	413.28184	6561.262541	33.03020697	21.78369393	19.05744197	189.7994687	129.6037564	13.41419891	107.7655309	11.86019343
0458b	327.5625553	7111.195342	40.15676209	23.26813625	18.93743248	193.8784295	134.6652118	15.43657981	108.4733419	11.9683639
0458c	390.1303592	6402.194264	33.62522975	20.90335449	19.5242819	183.6469995	128.8921749	17.60416182	104.8450114	12.0901503
0459a	427.8090867	7848.15881	39.15031013	21.9800135	18.92913576	184.0730982	135.717567	15.68882632	105.5752395	12.66189932
0459b	402.7492613	7519.142806	29.25907346	19.11243899	18.44934867	180.3836677	129.9570253	14.99237689	100.634548	11.7609081
0459c	398.8850094	7585.015905	26.53304905	20.32683931	19.46328604	176.8265337	128.5577557	13.91352278	103.0495561	11.76114634
0460a	340.2427308	6309.001189	32.76771509	20.34215033	21.10872079	187.2709554	127.4095752	13.64093293	107.5884454	12.98730694
0460b	370.4660318	6063.691234	24.50600852	22.61847088	19.6323514	180.6175264	121.9023738	13.9350222	104.076129	11.56190034
0460c	360.4287151	5762.725594	27.06336798	19.83487389	17.79496007	176.4720763	117.4960142	13.22433135	100.1591128	10.59536896
0461a	434.5747399	7253.039388	38.54259204	26.76064097	21.21861199	209.3141888	139.889133	14.96194005	114.8916895	12.74005749
0461b	348.543954	6521.298571	33.55469745	23.38570461	19.79668317	193.5713991	132.2847134	13.47372912	111.1164138	13.03361156
0461c	384.9745083	7099.554039	39.39479268	25.12671067	21.48397499	206.6947885	134.9090918	13.73214658	109.6488881	12.03912001
0464a	611.3419013	6984.880821	56.55111148	23.29686193	14.9639393	154.8536555	80.75663891	13.73803861	106.6425184	14.30285017
0464b	484.2307375	6848.586767	52.11430336	26.71223489	13.39106306	158.6290014	84.07926018	16.46037826	116.7189989	14.96801361
0464c	496.3574392	6885.36409	60.51384484	24.96869146	14.50537206	156.4593257	83.53292351	15.14886361	112.6444361	14.65909236
0468a	334.9008796	6358.165748	32.24859769	23.05516038	18.47097565	186.1336748	128.554691	14.75845879	106.0516759	11.81410181
0468b	367.6406126	6184.476946	28.84516088	24.14644922	20.12184825	186.5719843	128.1827817	13.8630133	104.8539384	11.8058864
0468c	371.4095613	6289.455974	30.91807045	20.79421362	20.76287202	182.8708087	127.8403067	15.14965548	105.0450315	11.49977854
0469a	382.3052974	6457.65799	28.0930578	22.28519739	19.13024242	183.8481003	130.1749889	16.4136625	105.8607754	12.22997887
0469b	339.648213	6412.505052	32.17895474	22.40891827	19.94004236	192.3741621	130.54622	13.16192337	105.9380477	12.71275553
0469c	396.2335679	6840.230632	34.27169969	23.92758428	23.27878216	200.5004779	136.8971394	15.38585779	112.5911268	14.27964878
0471a	476.0328921	7050.991839	37.53706537	26.54250556	21.1437306	196.512666	134.6845653	14.96527829	111.5524752	11.49375329
0471b	369.3824545	6995.025837	32.56902917	23.33715684	21.19920699	203.6297429	137.9356953	14.22447596	110.0193282	13.20813415
0471c	371.8382599	6758.320066	34.68153074	25.15044745	21.23742656	196.0043923	134.791575	15.85222613	112.2082018	12.95740754
0472a	402.4404136	7695.557072	53.42936067	28.58540389	24.8571932	219.0097812	146.880753	15.15856735	116.5739833	13.52719741
0472b	387.5586831	6673.398382	35.40547259	23.58365371	18.9103652	195.425453	132.2550455	15.08438415	108.6800175	13.06062342
0472c	384.8351299	6527.219267	30.09916536	26.27462185	18.05833745	194.6360219	132.4206764	13.51220226	109.8054461	13.63125158
0473a	315.4448944	5896.02719	26.45737926	19.16493423	16.67449646	167.9665478	114.3295018	12.9197338	99.75714891	10.67696303
0473b	331.2562113	5231.250408	18.52011599	18.95569361	15.15490768	156.1211286	107.7911874	12.04640042	91.76135513	11.91195054
0473c	323.5618028	6524.879577	33.05345161	20.96860558	17.94937571	174.5242053	117.1557673	14.35233309	101.6957047	10.96874095
0475a	396.9567779	7176.65058	37.95602862	26.80100933	19.66343878	207.455206	138.6506898	13.79048491	109.3965787	12.20052831

0475b	414.0296868	7144.127757	33.4826307	27.0555475	22.49964417	207.5453905	135.047445	12.81940122	109.9420923	12.3191333
0475c	409.2518424	7150.788619	42.64042702	29.40848636	19.45532565	201.7394789	137.4019396	15.00930399	110.1797246	13.89596073
0476a	398.0694029	7155.440927	39.3420895	23.55190664	22.827138	192.1972044	133.717093	15.64999834	108.3019367	12.60184843
0476b	388.3498143	7288.931468	44.03346175	24.93416099	23.47888275	197.4216093	131.7598671	15.05241265	107.7146684	12.065158
0476c	367.6036009	6274.809186	26.34492003	25.41881535	17.51926213	186.9813599	125.4879995	14.69014017	104.9110171	11.51422934
0480a	361.3840139	7025.979351	31.69377424	22.97238528	20.55889606	186.9810615	128.6492638	13.30733272	107.038755	12.13659193
0480b	351.2752267	6403.751014	24.79287519	22.11153987	18.9711047	177.3209553	122.7331862	14.22433036	103.8682079	11.92925691
0480c	413.0825207	7339.49044	40.7217029	24.32088758	17.51689702	196.2506897	137.8478105	15.00932014	108.5777127	12.58569815
0483a	334.9276498	5871.337415	36.26489469	22.79382181	17.96148365	175.0380679	122.6189701	13.28531002	101.2495628	11.9843619
0483b	301.1846437	6260.006657	34.16184142	22.10866011	18.1466089	181.0467931	122.4193812	12.91714791	105.3119131	11.66431863
0483c	411.4421589	6750.029827	33.29557628	23.88725296	22.24285441	195.8426751	131.9642704	13.71261556	108.6826938	12.62273076
0484a	348.6414652	6492.481915	172.2618879	23.58224764	17.17243395	193.4009717	130.5567778	13.69039827	104.6090436	13.23179715
0484b	373.596254	6889.105667	34.8882547	25.45007732	21.40275853	195.7394909	136.2922619	13.93112287	108.6880726	14.07835355
0484c	356.5949359	6779.000794	101.0637717	25.27178048	19.74484117	197.9591471	136.6447691	15.56319884	110.86876	11.78144461
0485a	315.8386873	5696.7409	24.35779873	19.88703071	18.34398058	171.3635519	116.2555101	14.60023238	98.81136899	10.56889401
0485b	330.805335	5687.401479	25.25688183	21.53462234	18.35332663	177.1934785	117.3194185	12.49261975	102.5605361	11.42862403
0485c	397.5684097	6720.134999	519.28114	25.82081352	20.796349	198.9610177	136.2695747	14.06897737	110.5005199	13.73681905
0487a	328.3644305	5715.776865	28.70836262	20.11404314	19.78395821	169.6694774	122.075848	13.9322117	100.293713	10.16541355
0487b	326.784168	5481.076248	24.68293423	18.42613255	18.24869974	169.4104018	110.9937083	13.09520824	95.46020866	10.21435403
0487c	382.9897418	5664.341467	25.72219673	17.23435164	17.37081322	168.8689528	115.0062966	15.3437257	101.2100373	11.60539548
0488a	312.983314	6081.934294	29.27681101	20.16876459	19.72592764	179.7298492	123.5994211	15.00527397	102.796716	11.36774592
0488b	409.3318538	5549.148762	35.81934003	20.88013502	15.81809822	167.0229957	114.4529374	13.82509603	97.67669095	11.83716996
0488c	396.1309945	6453.066388	42.32744026	23.19213967	20.02611753	182.0210282	128.0727277	14.1266984	102.6236398	11.11076142
0490a	340.2207907	6381.731074	25.68309567	25.77575284	20.36415732	189.6157778	128.4076891	14.04036606	104.5073096	11.78836689
0490b	397.314466	6922.392028	37.08891085	26.07062888	20.31449797	204.6789724	138.9882102	14.63674621	108.295419	12.13433437
0490c	344.6736625	6912.432157	36.60973648	26.21824639	22.07130754	205.2349781	138.1981548	12.81685193	109.4721731	13.88388635
0491a	368.4693556	6719.155023	374.2060398	26.26996544	23.57817118	193.0868548	131.0299314	11.46282498	105.4122783	13.25064165
0491b	502.8843535	6725.536112	273.5714989	25.82855374	20.12622854	188.0719539	131.6844314	13.29049464	105.0571401	12.87782273
0491c	406.7750217	7528.466999	55.57101257	27.69265933	23.30678716	208.9353021	145.6814621	16.79925847	111.9323319	13.72266391
0492a	448.7364487	6944.945061	39.92785552	28.0345023	20.84651313	209.4077558	141.2825201	15.05498748	114.0603382	13.11494326
0492b	355.2975385	6178.896146	27.51996576	21.16079822	19.74384651	189.8921099	130.7893612	14.84696268	108.7440877	11.95585374

0492c	368.3475017	6314.589788	51.54036192	22.69288271	17.92238806	185.6785562	128.7774735	14.75182437	105.908392	11.3542184
0493a	319.4286347	5843.151424	32.03017901	18.99110877	18.21272317	175.8202532	121.1741691	14.43080685	100.7713973	13.7040729
0493b	383.6950174	5887.499162	28.63866197	19.37815175	18.59663988	175.8625988	122.1688353	14.45924722	101.5313812	10.19107487
0493c	349.6667652	5671.671353	217.9180489	20.04711	15.96057685	172.0850522	112.2152254	13.64920276	101.5055899	10.46355059
0494a	310.5414759	5644.469222	26.96067897	18.01848913	20.17900969	173.2670243	115.9302625	13.37331955	99.2743132	11.1146272
0494b	347.2537857	5666.896174	24.81277166	17.70710097	19.10090839	173.7309177	118.3545716	13.46676144	102.1995947	11.81694839
0494c	341.571612	5695.227364	19.95571508	16.82367382	18.44164722	172.2821214	118.154789	13.51581559	99.95622097	11.48542847
0495a	326.2202503	5653.675094	22.42959086	18.46689402	20.23984667	167.4046316	115.7443742	13.30346786	96.78735707	11.37986161
0495b	337.6121113	5981.026073	24.40152978	18.60312551	18.65176983	171.5386756	122.5630226	15.53186541	101.0805855	11.88415136
0495c	353.4960252	5532.121729	22.85635329	17.54253705	18.62973863	163.8899249	113.3973089	14.47129275	97.40466021	10.39559352
0496a	405.243166	5756.523701	31.45407764	20.79479241	19.93742142	177.5608794	119.6029867	13.54542196	101.6809024	11.4705411
0496b	365.6001385	5848.751699	22.62568702	17.44719973	18.60189262	174.6642597	119.5745417	13.69001207	103.1685135	11.5598575
0496c	403.5403736	6429.732448	33.64808771	23.41126819	17.65184725	190.3718089	128.146777	12.60438761	107.4632963	13.14684038
0497a	362.5992795	5861.183668	28.84615068	20.58090448	18.85696219	182.8531737	120.757922	12.56753562	100.1322341	12.46089852
0497b	389.7437553	5728.765532	24.19949896	21.90630681	19.84236894	176.4005884	119.78281	13.55687481	102.1526292	11.29224602
0497c	389.2609109	7037.759841	40.15173238	25.43764052	19.25446805	206.1960278	137.6970186	13.63865406	110.7966251	13.98079264
0498a	318.8279829	5584.858414	28.10852151	18.68638895	16.80078115	173.0784145	115.0924618	13.84453904	96.34932146	10.35483523
0498b	273.1539139	5778.457377	31.02420279	16.71674516	17.56342586	171.8310015	117.5499986	13.55739801	98.71690346	11.00180697
0498c	362.5826933	5676.772566	29.7337741	17.82671248	19.09262334	172.7016699	115.4903605	13.59478105	98.71129213	11.260831
0499a	405.874314	6185.283977	31.70761354	18.99271849	18.56923678	181.1094721	124.7082567	12.90674868	103.9906056	12.24682028
0499b	390.4588084	5594.297907	30.75270832	15.95262473	19.86236779	164.6163358	113.9703443	12.52591875	99.03758663	11.21510764
0499c	309.2964009	5976.018348	76.38707172	21.09032696	17.84416659	172.1996725	119.6628479	13.5156778	101.138854	11.76431728
0500c	414.1157747	7496.889243	44.57347818	29.1057607	22.19145173	212.8671684	148.099488	15.2876384	114.696571	13.83816436
0501a	435.0894017	7078.524693	56.8515381	26.1991717	18.89255476	199.7539797	135.2588485	14.61613461	112.7037745	13.47646937
0501b	453.2523037	6975.399469	46.74514599	23.04349351	18.94500971	206.4957131	131.2890713	12.72577919	113.8813246	12.45140046
0502a	397.9936694	7169.658209	47.44077815	26.4222695	21.76481762	202.1270962	139.8653693	15.32237765	112.3491102	14.53023253
0502b	374.7914457	7204.182492	52.84131566	25.47464543	24.14050418	199.3163461	138.1903171	16.34018612	115.2311207	13.21818277
0502c	430.1918177	7083.401158	54.84850528	24.07162157	20.2860962	205.2874449	139.2946364	15.67194213	112.0358766	13.23990069
0503a	367.2165944	5674.374233	26.30659324	20.03339057	18.11573993	176.9874669	121.4923223	11.41071628	99.3472114	11.09688324
0503b	402.2257435	7070.702528	381.6336224	27.54840494	21.6967653	207.2019371	140.9181223	14.98778212	111.4041622	12.50793385
0503c	384.4372319	5884.898004	28.09996439	19.11882302	19.19849566	177.4888263	121.2730944	14.45373217	102.7491773	11.89319504

0504a	313.1539585	6106.534114	30.39412523	20.3960696	20.28168325	176.3448073	122.0261218	12.3904701	101.8197826	11.17663494
0504b	401.7132682	6687.102126	34.27095231	23.85529261	20.59958641	190.3112684	124.9939115	15.74810389	107.5779134	13.21073623
0504c	464.3571878	7219.096578	46.13649279	24.44458297	19.2355488	198.103459	137.2068464	15.98239596	109.689972	12.83177309
0505a	356.4212975	6356.098918	26.13905236	20.36639103	20.12604077	189.92791	127.137637	13.36833788	106.5769628	12.63617535
0505b	400.9034151	6449.688928	29.97682455	24.90558983	18.03619782	195.7574159	130.6324416	14.1394061	107.2545715	13.68122377
0505c	352.1294564	6573.150694	39.6875192	23.37475872	20.10243881	194.7283345	130.2013483	14.92248173	107.3450056	13.06753199
0506a	424.3628943	5536.312428	35.2767994	19.49115029	12.42068773	135.083233	73.0054584	13.35391498	97.78938487	11.71866498
0506b	416.8670363	5578.933673	39.78415626	19.2611909	12.65219251	133.8052177	72.54396837	15.14511619	99.38364707	12.02044667
0506c	476.3673099	5578.725453	39.10806184	18.95318721	11.77929559	129.1125529	70.82169527	13.854405	98.77360765	11.67616017
0507a	374.0271574	6284.401914	25.61225193	22.11588654	18.00460071	184.7380746	129.8459961	13.26984106	105.9944794	12.4565625
0507b	361.2134887	6331.456967	27.82367265	20.74341203	20.94244544	191.069339	131.1670427	14.47434236	108.2904497	12.64371311
0507c	394.4716948	6309.532115	29.74581401	25.46273715	18.75835746	190.3615886	131.1706356	15.45560275	106.4178724	12.09232248
0508a	448.624102	6158.698747	38.9046632	23.17727424	12.73656482	146.6056853	79.3637678	13.38503087	106.3491259	13.37666706
0508b	494.5296599	5828.329668	36.28333278	22.44886035	11.10808929	139.7228749	71.90485721	14.85313651	104.8260703	13.37125017
0508c	502.242832	6186.534889	40.74028997	24.04897902	15.20870212	149.0515854	78.26984949	14.76094759	107.4070279	11.81235682
0509a	394.9051859	5942.744975	29.63458256	18.78655611	18.53419681	176.3745757	121.4572351	14.20635418	101.0890848	11.2916862
0509b	359.5751266	5706.677636	19.61344453	16.78994339	19.38006837	168.0124233	122.7798054	14.586442	99.90572977	10.81629772
0509c	393.5435063	5751.535811	25.56650423	14.97800765	19.6557448	172.6765105	117.7430047	14.02077616	100.0943918	11.13077786
0510a	367.3014782	5755.056493	30.98580917	19.73683229	18.84199224	174.827632	117.3165297	13.86477644	100.9386824	10.34451117
0510b	305.5506807	5925.05461	29.12393308	19.47504454	20.29248305	180.8655538	120.9384794	12.69336928	102.4985025	11.21205944
0510c	387.4459278	6204.797035	28.07328325	19.37536869	20.00542491	180.5017134	124.526863	14.54742867	104.1573553	12.17406077
0511a	385.6911949	6338.721176	193.8319871	19.41535327	19.6183328	183.4795753	126.4390986	13.936773	103.971369	11.98442694
0511b	416.8542079	7272.024922	564.463824	27.55920695	21.42539114	214.8971121	135.6950408	14.10777833	109.1918431	13.13916609
0511c	391.073783	7391.753848	550.9680262	25.69231922	20.91152338	207.9259277	138.8063881	14.58541268	109.162035	12.67210201
0512a	382.3950929	5510.465077	22.60986467	18.91168529	17.37260907	166.1852196	115.6511959	13.02128893	96.16380855	11.10248113
0512b	369.2190721	6346.458212	24.03622323	24.8469845	21.17793412	189.1909527	129.6373168	13.11939676	104.3822902	11.43950371
0512c	365.0517299	5403.481367	21.22836439	17.35147643	16.37440344	164.3667845	115.0369248	12.83660603	98.9607902	11.57627309
0513a	391.1616126	5903.640533	20.08241846	22.3710201	18.34214973	176.7569444	122.8052593	15.06911659	103.0447787	11.27191207
0513b	335.5704228	6135.161861	23.25096411	19.72099049	17.09133109	184.4554452	128.1798745	13.81531523	104.7688756	13.04870444
0513c	339.81823	5121.533451	23.82915745	18.54627838	17.46240185	159.032245	106.0755509	13.05711308	92.30333362	11.58276717
0514a	354.0933267	5979.810636	29.18238185	20.2080845	17.49230387	181.5883861	123.3885891	15.05506078	105.1851083	11.62521079

0514b	324.8408495	5758.871264	30.01290598	20.25229277	16.81548757	176.7525693	121.1555356	13.99593415	99.69606016	11.3857851
0514c	355.9929034	6280.529398	33.18419703	23.13746746	19.75249607	180.1899464	124.5900334	14.81094795	102.6776417	12.9685844
0515a	358.1703729	6054.977032	26.15012002	22.50573865	19.47268039	186.4432702	122.0735434	13.43209836	103.6075224	12.04850807
0515b	360.4910951	5789.626607	20.68786692	22.07421227	19.2262157	175.1270102	120.9383714	14.29534106	102.1442743	12.08732778
0515c	412.5988926	6600.522641	27.92507117	23.50441083	19.7887294	197.4604098	132.1614261	14.41010889	108.6792903	12.14644234
0516a	403.667988	6481.617044	30.9322082	23.06014446	19.44329041	194.1883241	131.6610992	17.37577715	109.5285432	12.20337201
0516b	390.8901192	6161.156863	24.29742228	24.83509572	22.47195642	187.8495512	131.1217537	14.65072583	106.9817451	12.02721732
0516c	365.5309493	6198.432615	34.01954438	24.34790026	20.31593006	184.5555288	130.0358486	12.64912404	107.1006368	11.73766125
0517a	360.6652787	6657.210463	30.96498084	27.23270786	18.87438215	198.5358839	136.5158588	15.55914805	111.0042388	13.24379381
0517b	383.515046	6216.254678	26.55636601	21.55054987	18.58968618	185.7321209	122.8122847	15.18949897	105.0507368	12.29667317
0517c	375.7354282	6173.917267	30.21666766	22.65705326	18.29407852	187.0947763	128.6117662	13.36204089	107.0101761	13.22641338
0518a	423.5436547	6828.466689	29.69505635	22.60645104	19.93231036	191.2958023	131.4131779	14.58290887	108.9866907	12.65178766
0518b	394.6707815	6605.537564	35.10115907	24.87795573	19.05410062	191.2472283	130.0742662	12.70898383	106.3353412	12.28380398
0518c	355.4517446	5729.635555	33.22212576	19.21935896	17.83951161	172.9280785	117.6773007	14.13832385	101.1581758	11.11257977
0519a	373.0918651	5995.035098	25.20321281	20.08522832	17.99669509	175.8442324	122.2720286	13.95063906	101.4490732	11.09250714
0519b	367.343119	5743.722406	23.54935237	18.2817265	18.13416529	176.8540557	120.1979027	13.2643566	99.84685153	11.39252321
0519c	406.8049372	6081.427239	32.23828382	21.41302184	19.80992849	180.7594252	124.4277232	13.75941602	101.9341111	11.81503347
0520a	370.0337505	6425.433074	27.721136	20.08586947	18.72788469	196.1786169	129.8585892	14.02814161	110.0086045	12.1800007
0520b	439.8777166	7184.603784	33.47599089	26.21147909	21.28115387	208.3717872	136.6766519	15.12039923	112.1243689	13.000834
0520c	375.0799743	6574.793126	91.73223088	24.57683234	18.75482721	192.5331734	128.0926629	14.51822542	108.6735099	12.44915558
0521a	268.5946033	5802.296809	25.64543987	17.8147736	19.35964455	170.325126	117.8354587	13.69460702	96.67390184	11.73434776
0521b	437.9399501	6169.385965	29.82998205	20.61832708	18.72227513	182.1849584	125.8860047	14.00965986	105.0102388	12.50607763
0521c	364.819696	5809.460677	31.1896175	23.48955878	17.03529083	174.4246038	120.320537	14.2292853	102.1751162	11.80241828
0522a	317.8267136	6315.703317	28.36091935	23.32545568	19.2515852	191.8686932	131.3509563	14.08003109	107.9013108	13.51440823
0522b	412.6568544	6648.977588	31.2727361	26.514762	20.59344753	199.7919695	137.3744036	15.1177774	112.2878016	12.92418937
0522c	385.6441094	6983.810201	29.17070214	26.97077785	21.43576617	206.2924459	138.4444473	16.26113366	111.9834508	13.32618266
0523a	336.355689	5674.481371	23.2930457	20.44028518	18.11055932	172.0016227	117.8917737	14.26936402	98.38486221	10.90474318
0523b	324.1896695	5656.572784	25.73793251	19.3447579	18.35473505	172.8564718	118.2282044	13.39327699	101.4230798	11.02795369
0523c	352.9625532	5712.251854	27.75676361	18.99832003	16.42968432	170.3030795	116.092053	12.89223528	97.77844679	10.33020229
0524a	347.0992771	5653.75574	25.29377804	18.07533527	18.18154696	165.6000229	114.4220819	13.38953428	97.9338368	11.69830116
0524b	300.3304068	5621.983336	22.14056198	17.51358334	17.48483153	165.0112113	112.8230828	12.8481817	98.38677241	11.13780165

0524c	329.2377419	5574.550193	25.83276691	16.71419645	17.74289391	165.8305184	114.7722495	13.38381439	97.25657879	10.78911303
0525a	331.3873501	5717.336278	32.27432545	19.99862619	17.0544879	174.6184234	116.0102118	14.01057365	99.96814861	11.15404974
0525b	344.7912884	5819.004284	28.86604834	20.04755261	19.89904195	174.6301293	117.1850227	14.4838343	99.59987641	10.71364083
0525c	356.7215517	6262.085618	27.63517543	21.69704962	20.39248944	185.2059376	126.3498633	13.18211448	102.6701056	11.72674125
0526a	438.8716966	6173.586487	49.00961044	22.97172464	12.97851827	144.5521844	78.74755174	14.97442086	104.474639	14.07780123
0526b	413.5700861	5567.170079	40.20077184	19.99006261	11.54833305	132.6166953	71.6613425	15.50334353	95.27262052	11.69789234
0526c	384.4410982	5550.986984	38.89875544	21.26662884	11.67596177	133.1473735	73.36651383	14.09176904	94.13293758	12.65799308
0527a	358.2194445	5677.394306	26.89421501	15.65583694	17.18656808	169.3222431	116.1867856	13.81297622	97.17837542	10.11305275
0527b	397.3302268	6343.603959	33.26559828	22.52929402	21.10605738	186.3340283	126.7293893	13.25970012	103.460459	12.29891178
0527c	337.9763218	6068.93033	30.52221633	18.06210637	17.90315661	179.0657545	121.2913699	15.2675878	100.688297	10.83577504
0528a	428.6975235	6656.900314	26.88288791	25.0122872	20.61797329	196.5649501	135.9455393	15.85297978	110.757045	13.10993453
0528b	392.4927386	6308.44115	23.40529855	24.17702554	22.44542985	192.7815089	127.6300805	15.21084677	109.3960305	12.63111986
0528c	339.0882828	5880.880003	26.00170782	20.71330294	17.84621451	175.0877704	119.2086715	14.44011452	103.4985923	10.66570091
0529a	343.5330709	6462.632235	29.17001569	23.26756859	18.81451738	196.4929201	135.5068855	14.08406074	109.7421725	12.116785
0529b	330.2316652	6080.723827	33.39192655	21.78763125	19.11665754	178.0160414	123.1048776	15.27221281	103.3931048	11.7746312
0529c	355.6515265	6192.375315	31.39003186	21.98877962	17.92034473	183.0065758	126.6290106	14.15063753	105.5559904	12.40930741
0530a	359.1941539	5939.142008	24.9827566	21.84384404	20.82943567	177.8254143	118.3250764	14.36376129	100.9329482	11.65480249
0530b	368.144472	5929.852432	24.20707927	21.97429845	18.6474298	172.8532004	120.619422	14.63030327	101.9437407	11.77848806
0530c	336.8335433	5972.685497	27.58051537	20.21068344	19.31193284	179.2470748	121.3945892	14.73436703	101.6482535	11.7919727
0540a	341.6431966	5662.904894	28.70223143	20.85319824	16.98097573	169.6206497	116.2653844	13.20298532	100.6474946	12.32747321
0540b	306.1937658	5678.296124	27.42660582	17.69771976	18.44638747	169.5024906	116.1199372	12.9887692	98.95606882	11.79571158
0540c	305.9796361	5648.049698	26.07260799	19.08801632	17.66022944	171.5789281	117.8688397	15.01573244	99.02200839	11.2100535
0541a	351.8521236	6250.71029	39.53289546	24.85658668	18.42415509	186.8341887	141.7308011	13.60262421	105.0620364	12.18367237
0541b	384.3937067	6121.073441	31.78551747	23.84770939	19.33737672	187.27317	136.8147695	13.66359116	105.222679	12.66282404
0541c	394.7133968	5787.796971	25.11057802	21.16283313	16.12312846	178.918789	122.3063807	14.38995009	102.3459858	10.70503639
0542a	346.3686229	5981.262773	26.16796524	21.15583391	18.77972919	182.9308071	127.1418831	13.70696801	103.0969713	11.52009186
0542b	306.7784522	5437.75808	27.19958563	17.05199454	17.80735253	166.9149889	113.9871147	14.17429631	98.95488743	10.70384916
0542c	338.0644863	5725.015933	24.26897219	20.51196655	18.06082471	172.3249943	118.5671026	14.704694	97.02184295	10.70730152
0543a	365.347846	5916.753679	23.90820243	19.82523186	21.52144336	178.8300603	123.5211166	13.49922825	103.9874922	11.66813615
0543b	320.1294436	5573.458377	22.67252097	19.88607684	18.44932564	172.6924839	117.5182808	13.49703501	100.1930248	10.76988662
0543c	334.3454858	5878.048104	30.65132948	23.24316766	16.61799221	174.2361295	120.5100285	13.4540706	100.6793489	12.006167

0544a	353.9976906	6194.37976	28.79265103	22.83401684	18.10660865	184.7282241	126.4846569	13.20235543	104.346357	12.34204829
0544b	328.692668	5498.349192	27.32498236	19.53773757	17.46182915	166.7573073	111.8079784	12.27217313	98.85684317	10.66645869
0544c	387.9447352	6193.950728	30.19292849	22.19080067	19.14584779	185.9811088	126.6541031	14.8492375	104.0651216	12.32511153
0545a	353.5742363	5859.801338	23.07043323	17.79095691	19.82568464	176.8532571	124.090316	14.76334147	99.01571465	12.51604853
0545b	326.5812097	5776.040146	24.07302629	21.13509117	17.87729546	175.5605026	118.3642251	12.49471833	101.1469767	10.93495586
0545c	355.6591446	5810.245766	25.26853152	19.84651406	17.66305626	172.7285207	119.6857926	13.56216946	99.74250114	11.3897245
0546a	314.574324	5543.40348	26.32978655	17.86913191	15.57652615	162.620109	111.9511133	14.52757933	97.20656797	11.86178473
0546b	382.4329362	5524.272592	20.0359902	17.89393951	16.24862613	164.0777739	112.8313255	11.90395148	94.17493567	10.77072118
0546c	367.0238201	5759.669683	20.46367923	19.16885128	16.49127564	170.2380625	114.7624545	15.15231271	95.23130055	10.76979349
0547a	367.9982863	6364.79022	33.20981431	17.71755944	20.34621848	178.8474207	124.7031902	13.93008426	103.4763647	12.1301354
0547b	353.0025131	5816.076592	22.84601482	19.90925932	17.30038464	174.7538192	119.8867354	15.5585158	103.2313316	11.47335201
0547c	342.4568111	5769.962944	19.16548658	19.16727186	18.66021868	174.811382	116.107441	12.13189345	99.21853313	10.51049673
0548a	368.4172941	6580.401911	42.61952708	20.70903207	18.09175835	187.5635687	124.0310101	15.66965026	103.6650761	12.84517014
0548b	337.1133215	5436.665358	28.85423219	16.98925986	16.75309841	165.6281682	111.0579533	13.76648061	95.30895151	10.57364353
0548c	381.0970672	6254.909949	31.85210073	21.67688922	18.6611002	185.1194296	125.9109728	13.95075195	102.6915192	11.80951836
0550a	345.1962649	6197.572954	27.30615316	19.51637294	19.11349092	179.4571355	126.6374796	14.56437317	102.614352	11.33276929
0550b	381.9650383	5957.766113	24.81572643	20.41106696	18.30244869	177.7021405	121.6680397	14.50352093	104.5355906	11.33994244
0550c	381.9939412	6767.000231	34.3412399	24.35249738	20.47778118	196.6589562	136.4372211	14.38557505	107.925076	12.39984191
0551a	437.9958917	6948.420634	34.71866197	28.7948634	21.74609862	202.2070994	140.2642172	15.20701973	110.5893217	13.8635136
0551b	374.078881	6405.348837	28.33996249	23.6330362	20.94576801	194.5817778	130.247172	12.8710231	108.4081997	11.62461731
0551c	382.5328961	6425.772177	27.6001718	24.6395964	18.43537308	192.6343521	134.5138643	15.48880096	108.7608013	12.30880626
0552a	416.7345007	6666.757525	27.30158511	24.66265107	21.02578046	195.2755986	131.2755977	14.93732746	110.6065688	13.0937217
0552b	391.271468	6701.097134	33.34783932	25.57417051	20.69744971	199.6669425	133.9499059	15.16860106	109.9508189	12.62067061
0552c	405.4924452	7059.702159	32.0443001	26.0647172	20.22841366	201.9946401	139.0300647	14.75679483	110.440802	12.95029983
0553a	367.4841202	5944.735805	24.73393772	19.88476988	18.42273933	181.0656734	117.7271776	12.86541611	101.7727172	11.96570064
0553b	401.4768027	5932.48895	28.8010551	21.29124251	18.30121448	178.0465979	125.0004397	14.85422506	101.5699564	12.08907112
0553c	314.2823941	5955.482356	451.9794017	20.80464272	18.18376882	180.1798158	120.6581016	13.38195919	102.1879591	12.40346227
0554a	373.4264072	6359.755067	26.33463739	22.67370463	21.12555416	189.2661531	129.7926204	14.72667358	105.3341774	12.98782836
0554b	350.3046729	5881.666546	27.11425751	19.66304765	16.90987628	179.8526998	121.5950497	14.44187082	101.1774907	10.74490848
0554c	367.7062438	5779.196465	25.42857988	20.58739063	19.6208343	176.3294865	117.2281468	14.56750477	101.4632743	11.55419038
0555a	409.9791958	6956.766461	34.4343167	27.05015149	21.52912771	201.4910489	137.5268614	16.75552426	107.2748622	13.08847077

0555b	371.1973635	6418.119347	29.75087734	22.9946787	20.56819919	191.6869944	130.1057121	14.89587795	108.2959363	12.41354028
0555c	369.921864	6168.821516	33.32334563	23.70601826	18.72699132	179.7413904	127.0481987	15.90098011	104.1822054	11.94629776
0556a	347.5852004	5753.438178	28.17714488	19.48772094	19.59353039	176.3284916	120.241698	13.94151633	99.64064967	12.10850898
0556b	322.9625262	5768.141999	28.86683128	18.84729304	17.71152283	173.7346711	120.1339168	13.50361046	101.9997444	11.53735921
0556c	436.7786529	5895.693666	27.72539775	19.47024758	19.93564441	179.0614289	121.7458366	14.42690762	102.20389	11.12215219
0558a	339.2385712	5874.481524	22.14614049	21.73626404	19.36667428	173.8630782	119.3016117	13.35112869	101.4290393	12.64860166
0558b	301.8377623	5698.473493	28.32427356	17.83041866	18.65276046	172.2895576	119.7189059	13.32399213	97.33611035	10.54892681
0558c	358.6863189	6193.138076	26.49885943	21.56380933	19.54251441	183.2209444	124.8174485	14.8191429	103.4177422	12.40908256
0559a	348.4061769	5787.918905	28.27380118	18.88177718	17.69919043	170.6406353	117.6443287	13.61227786	99.90334452	10.85759437
0559b	332.577841	5646.980467	23.81554587	17.45778801	17.72826703	174.753686	117.5131211	12.73628244	99.09329243	10.76248903
0559c	365.3556743	5798.599275	24.14616064	19.65133937	18.9323366	173.0382927	117.2226613	13.20018223	99.18422931	11.29596866
0560a	353.679294	5597.950786	32.85438203	21.88814904	16.68797483	165.4438336	112.1137551	13.17052275	97.8683472	10.66069082
0560b	301.6501781	5437.27597	28.03624161	24.20119642	15.94674206	166.6425284	114.635407	12.09802169	95.45952991	11.21898185
0560c	340.6231242	5165.566936	20.33288161	17.90514022	15.79647243	159.6800864	110.2549098	11.90536256	92.47323179	10.36371879
0561a	342.7685981	5717.037703	25.9960945	19.43012769	17.66187526	175.9721325	119.6826137	14.02184399	100.329713	10.81708669
0561b	315.102656	5758.075069	26.95754736	18.80019445	19.65387927	177.6692091	118.8709946	13.19130726	99.83258777	11.33061248
0561c	340.8140773	5894.267983	29.86752763	19.639639	18.83785348	175.0037173	119.6554831	12.32307512	101.2494839	10.40299448
0562a	414.3166278	5923.728886	27.69344508	21.12730431	19.33783826	178.6670583	124.6853219	14.15127046	102.7696317	11.79874912
0562b	342.102306	5725.325674	30.6084642	16.36517698	18.44844875	173.2556826	117.3642903	13.81903278	99.26930258	11.45250264
0562c	314.3044521	5878.780567	21.67325193	19.90790894	19.66482646	174.417193	122.0839623	15.11059547	98.90906767	11.01528365
0563a	358.4997168	5240.612992	31.22387412	13.99614186	17.34773351	149.7048006	101.3147274	11.95845207	88.8282868	11.09104642
0563b	416.2089106	5893.704258	28.68258124	20.43350897	17.29527507	173.3845289	118.7454133	14.58407229	101.9860244	10.78486453
0563c	394.5795158	5906.94276	29.94849372	18.4763404	18.03943854	174.1747514	117.45326	14.80698601	100.2666397	12.11331448
0564a	393.3793592	6192.597336	29.65452894	20.07877504	20.69598286	181.7066256	124.1653975	15.19225104	104.8724644	11.17193744
0564b	366.6412257	6230.241434	109.279303	21.0112645	19.09239351	185.6132355	124.6876997	15.19415298	104.4147929	12.00316623
0564c	386.8989935	6132.772143	26.36621852	18.79468586	18.90442084	177.6673961	121.8131329	14.70653236	100.2617898	10.70632358
0565a	372.2634851	5941.076733	33.87512947	19.98858564	19.959028	176.8642586	119.7140115	13.8436831	104.0491136	11.40686625
0565b	370.7192579	5878.735087	29.74155287	19.85650741	18.76230916	173.75335	118.3627376	14.38824748	98.45050046	11.24909337
0565c	342.5771795	5971.207034	27.07198501	18.5839229	18.87165236	172.947471	118.4744423	15.01474663	101.9180867	11.03990227
0566a	377.0296285	6407.545274	39.70812372	21.88910294	19.99962812	188.2734698	133.4902515	16.6893469	106.3230047	12.51137229
0566b	353.2194651	5978.687871	39.95113197	20.95841233	18.82377712	177.4586832	121.2151692	12.92394371	101.5459359	11.81685318

0566c	364.9013912	5967.652126	27.31009054	19.64098405	19.07394369	182.0297366	122.256573	14.86108161	102.4052274	10.60980736
0567a	292.8030836	5106.923793	29.00058252	14.61401035	15.99389327	152.4495508	102.0236445	13.19580397	89.22650217	9.687534366
0567b	329.5564061	5343.673705	26.28606012	18.34923637	16.6843863	153.3944915	103.0166604	13.25053519	92.85637609	11.52521669
0567c	317.5044512	5940.518399	39.45272585	17.94390086	16.58133374	167.3564679	116.9392099	14.37663003	97.87520488	11.27531084
0568a	334.6016614	5772.290648	26.41557166	20.88321279	18.44813307	175.2656798	118.0538461	13.99811645	99.98055698	11.42719404
0568b	364.7416958	5939.013782	27.94883332	18.25642612	18.18966615	179.4830378	119.1556649	13.13151852	103.1113373	10.74047863
0570a	438.1047163	7429.630415	364.2530344	28.71706097	21.43551149	212.4219936	145.8215481	15.86138068	115.6798921	14.2036382
0570b	361.5871721	6234.18322	856.8861605	26.14458585	19.69960093	192.985582	129.3342089	13.17603088	107.0979371	13.02292873
0570c	415.949573	7076.993753	36.59362614	28.46060436	20.84168813	208.5311376	140.2990448	14.84173522	112.9656895	13.32158401
0571a	467.1377623	6662.682807	35.89535453	22.83074001	20.58022197	197.2452388	133.5662006	12.88427097	106.7383311	11.32188507
0571b	379.3409447	6453.964284	220.1563866	24.21069258	19.32818972	186.8976344	131.4827458	15.33808298	105.8844209	12.94390665
0571c	411.0974517	7294.569392	50.14556237	26.71611716	20.83266351	213.2667465	139.5039778	15.50439379	115.3684864	12.8637916
0573a	387.6280927	5958.110417	29.36064198	17.58708402	19.42677958	176.34564	120.1259927	14.71183105	99.63386327	10.70620595
0573b	335.7098094	5368.108847	23.30861268	17.62691581	17.10222408	160.2147668	110.8171238	13.39501152	95.85686963	10.8189264
0573c	355.4934829	5906.618451	25.47340418	20.2780158	17.02574715	171.1564027	123.2359319	15.37265407	101.5818425	11.11731552
0574a	361.661134	5609.786171	24.04218652	18.69501329	17.16580253	168.9478066	113.9896036	11.78735242	99.32786131	11.01597535
0574b	341.4649893	5425.097004	24.11744244	17.64549293	17.60535431	161.0903961	112.114726	12.91639839	96.87945924	10.65575511
0574c	371.8104086	5880.619127	32.59655234	18.76458015	18.10623189	178.9023309	119.294498	12.64810626	100.9501181	12.24402867
0575a	412.960835	6525.22238	66.74129855	27.33063742	21.45598348	196.618221	129.0991086	13.57641949	107.3978038	12.57927819
0575b	361.2607108	6229.478084	81.66034171	21.07108851	20.3621455	191.2381493	130.2344586	13.80456571	103.5947282	12.13691533
0575c	441.6673643	7204.540137	31.76919189	28.08340386	23.82904077	214.2166515	140.3291075	14.70283991	112.1381342	14.24361629
0576a	344.7230419	6594.327932	35.60909348	24.32436906	18.21950465	193.4580515	128.8170993	14.15339455	107.8913573	12.18426681
0576b	306.6261193	5550.455775	187.5208204	19.60776512	17.56112677	170.7154502	117.0535086	14.21397335	98.15779999	10.89411111
0576c	357.0690751	6325.596887	29.70551598	21.5911198	19.81681438	187.9835107	127.4233048	13.85340509	105.9281721	11.78466623
0577a	346.8515787	5897.659365	33.76719388	20.90454467	16.97065115	174.3239721	120.850547	13.31818875	100.9336029	11.9397393
0577b	373.903402	7118.827232	42.96317602	26.97143284	20.9279426	197.9331619	136.2451823	16.52652628	108.7790043	14.33206442
0577c	467.3271731	7043.67056	43.21014766	22.82929932	19.94881593	201.5600129	132.8867632	15.27271388	110.4875695	12.71871481
0579a	440.6957557	6556.937851	41.8656803	24.51450853	21.10690421	195.1620372	127.9130052	15.54949074	110.3440374	13.15438837
0579b	388.6673836	6538.740472	729.6248367	24.5346755	20.84359909	186.1804257	129.4364299	14.61089376	105.6028388	12.84367855
0579c	367.3436998	6508.378495	28.14289682	25.43322774	18.02249632	196.6849344	129.3224419	13.25384448	105.4648339	13.27584287
0580a	368.3132292	5835.895088	25.65377169	17.00207691	17.74806297	169.921294	114.0655493	13.88933261	99.72336178	10.07472957

0580b	346.9399923	5667.495256	30.66153114	19.00946391	17.49843243	166.9056776	111.336065	14.45838626	95.67874608	10.54067356
0580c	366.7984485	6063.672824	29.59139935	16.66090099	20.49236302	176.9789732	118.2737608	13.78199112	99.16531478	12.36210584
0581a	350.2283312	5780.26639	24.8948869	15.23532132	20.07307843	169.8343684	120.1284611	14.1761841	99.46866588	11.33039175
0581b	349.377644	5881.677527	27.74998037	18.06271687	18.08074095	180.2678899	120.9519881	12.316952	102.9517432	11.48826658
0581c	393.9538114	6212.06536	36.88898686	22.32275537	18.6466733	184.3516041	126.5434049	14.95813532	107.1528982	13.00668026
0582a	337.9838056	5707.585051	27.15094669	18.63246721	19.17430474	168.8435867	113.4786493	12.65094516	100.8380772	10.67482404
0582b	308.3297896	5607.103392	28.88044951	17.05255783	17.39425928	164.7461278	111.0670576	13.27363216	96.4413097	10.21437622
0582c	350.4073158	5301.231006	25.6680033	16.44651676	15.34224695	158.6707268	108.6498495	12.48499971	93.14454799	10.49595351
0583a	343.2198971	5738.214651	24.33776628	20.72614218	15.86637794	171.6837585	116.9818064	13.40176164	96.14254414	10.37250115
0583b	345.0558752	6257.710782	26.53602192	20.30037416	21.06187954	185.368045	124.638669	13.42307736	103.449312	13.04002282
0583c	362.3687491	5434.675684	25.4612225	17.34026499	16.22019432	158.8555937	108.8660032	13.36372597	94.89645237	10.7336005
0584a	283.5342103	5753.056062	29.47982914	18.1725356	19.42558982	173.5486958	117.3747651	14.39519318	99.36267758	11.09917095
0584b	334.0173655	5216.987154	27.46784424	18.40031278	14.57295519	155.6526742	106.5159304	13.19325795	93.37882562	11.58403928
0584c	328.0696738	5448.843345	28.67446755	15.63937558	15.56592311	161.6068587	110.6447136	11.6209675	92.68968395	11.14697724
0585a	343.0465913	5691.460567	27.53249318	19.82413116	16.4648593	165.3401893	112.6228389	13.54930131	95.92687178	10.65109478
0585b	323.3991341	5619.60224	25.72356632	18.60229252	15.05339764	166.7216366	110.6535788	13.83313929	97.6484143	10.84687529
0585c	355.037504	5905.947813	30.37408794	17.86018224	17.94554556	170.4590534	115.9399904	13.4470463	96.99824589	10.64258059
0586a	393.5167442	5934.702456	24.19752946	21.4200739	17.56379937	175.2864743	120.6209923	14.5648614	97.73524964	10.8557035
0586b	376.5116605	6020.977738	30.66843318	18.84597559	17.92903781	170.4537749	119.8296093	13.54344276	101.1124491	11.03822692
0586c	356.5925613	5948.43296	34.57750004	20.16589437	20.7583352	178.2234284	119.3048592	14.65818101	100.9523957	10.88173043
0587a	427.7940701	6371.937321	30.97848154	21.994937	20.31762306	188.6776402	126.2763851	13.21175113	103.5011132	12.28049648
0587b	345.2136472	5955.149005	26.07379137	18.53712544	19.70288763	181.350487	119.2686527	14.66905525	101.158513	11.5911281
0587c	317.0745768	5750.5419	26.03180269	16.80289314	17.18064239	174.3958307	117.7429632	12.33678487	98.25214686	11.6608772
0588a	323.3805233	6097.084412	22.94978374	22.84100812	19.67140073	182.5526066	124.2021467	14.49197956	105.4462185	12.73658455
0588b	341.7851219	6335.670634	32.05843006	23.1776493	18.82661429	188.8973658	129.3654098	14.67091419	106.3970601	12.1491328
0588c	297.498741	6452.950604	24.54732567	25.37077351	22.72522729	194.7827903	130.3572704	15.69785977	108.1686984	12.77135296
0590a	424.8321017	7497.001526	39.26555186	27.32395789	26.92979954	216.6336864	146.8930234	14.41815957	115.7241288	12.99067252
0590b	442.393871	7100.96683	33.45704421	27.67199324	22.14395767	209.7657202	142.3316189	13.48637739	112.8789137	12.70588761
0590c	375.8131631	6458.838291	29.86690739	24.54477869	19.5929038	196.1860979	130.7654219	13.40026275	111.583568	13.16059814
0591a	490.5081392	7183.336018	38.42087529	23.35837402	21.98196601	196.5781065	136.9744988	15.12554171	107.9424554	12.54953138
0591b	403.7061101	6714.952906	34.59045024	22.72341634	20.69043511	193.8764702	127.0706029	14.61995178	105.7525215	12.73799416

0591c	430.5468242	7216.011369	451.2544691	25.03574764	18.81704754	200.3305911	141.0910562	15.87476587	113.1739196	13.61059504
0593a	381.95031	6310.040113	40.11157726	22.43758479	19.83622532	185.113862	124.8349502	14.05646135	106.5209255	11.06393138
0593b	339.5555381	5907.1426	34.17798677	20.24257288	19.29316008	175.0580078	118.7129052	14.31651409	100.6668361	11.00897715
0593c	299.3861777	6040.905798	27.85226168	19.89214953	20.34355652	175.5570003	124.2705984	13.28975025	100.4649008	11.86988899
0598a	298.641937	6366.133368	28.25145294	23.22795552	20.91125183	191.0846213	129.9917839	15.82854203	109.6049762	11.94534802
0598b	328.2726149	6481.713945	22.49376038	26.71741028	21.88468378	199.909884	134.5011943	13.74412715	109.1765331	11.57271928
0598c	360.1708382	6141.024087	21.76947972	21.39440577	19.54475367	185.305357	127.4606665	14.47312509	106.1580458	11.77363251
0599a	464.4404437	7290.945531	59.33761679	24.94746059	23.0935894	205.2950145	143.2873764	11.93594125	110.9877519	12.16650024
0599b	388.8364218	8342.076086	58.93062693	25.36760709	23.74785662	212.4542457	149.5599287	15.40468493	114.8526793	12.75456892
0599c	404.6574816	6170.60779	32.89811127	25.23384367	19.56010653	184.9442713	124.0378429	13.86784175	106.1788512	12.21223278
0600a	362.0233719	5903.965296	28.097694	21.1131489	16.75851985	176.741625	120.0656319	14.61426764	100.7851042	11.47509993
0600b	304.9248333	5839.876106	29.72128516	19.92517826	16.55579665	172.9347168	119.6956911	13.85742787	100.016735	11.80593629
0600c	337.6872736	5904.965162	35.3079704	21.80750773	19.55378181	174.4199921	116.8202801	13.9815434	100.8966315	9.984109144
0602a	353.9047983	6126.428757	33.4834885	23.56743136	18.38836171	186.908817	125.4146228	14.69796832	106.1883778	12.88162233
0602b	393.7128936	6639.038877	37.62447185	24.16537416	16.46191056	171.1039586	119.5696631	15.62797925	104.0446054	11.84433558
0602c	368.0231662	6687.559127	41.13236957	24.26092591	17.14492807	176.6541968	119.4505747	12.99478417	100.9430149	12.46468128
0603a	398.0263595	6916.343621	32.78788198	25.9769235	21.86015261	200.1284835	138.5053344	14.74658112	110.9971898	12.93481935
0603b	356.0021838	6361.628121	23.53470304	23.10164776	20.21004587	190.7138236	132.1598901	13.33313966	107.812004	12.71003802
0603c	355.5063898	6505.581009	22.2982145	25.96349028	19.13618383	196.8145179	135.0094582	14.19559877	108.6824353	12.5211796
0604a	360.2220175	5818.846625	219.5322614	21.31422498	17.90929705	173.3268323	117.1784769	10.66048686	102.2978965	12.22987906
0604b	365.7036975	6387.737315	83.81276258	25.98128573	17.85651661	185.6004949	127.6371713	13.25133407	104.9656652	13.41271158
0604c	363.0912578	6314.42989	76.19771701	24.95481111	18.00491806	185.0163705	126.0661339	13.51135044	105.8857725	11.65974664
0608a	394.7186746	5745.556031	28.95031393	20.34749316	18.34725721	170.8420551	117.0605047	14.06172886	102.6937297	10.77184958
0608b	342.3106572	5344.205153	24.09760141	17.33355453	16.65662824	161.6190108	112.0344681	13.64879824	94.79457393	10.7794413
0608c	311.5226934	5813.485904	22.66668758	20.29144397	17.81604776	172.9888549	119.4294401	13.62983766	100.8460119	11.21838788
0609a	364.2728632	6270.715744	27.14267341	22.1192222	20.64875265	187.8773593	123.609913	13.47286832	103.8374849	11.44639776
0609b	350.3231794	6172.632419	27.42053411	23.17677825	20.46057159	185.8352145	128.6841366	15.74974445	103.7712638	11.81747674
0609c	400.2985648	6722.850954	31.86418118	27.50361495	19.47098692	194.8888254	134.0176648	14.7126889	108.281958	12.60701402
0610a	438.3055964	5337.610487	42.27215738	18.7128482	11.733969	124.2613875	65.16403387	12.12386477	92.87513575	9.88944438
0610b	461.6269179	5319.028369	43.80575508	18.79043818	11.99984563	127.1538493	66.46744311	12.79664049	91.44625823	11.80705085
0610c	443.2382384	5430.504534	34.61951192	18.2487303	12.54046242	129.6481116	69.24405777	12.19447864	99.19646469	11.62329642

0612a	368.7144188	6571.841509	49.36896	25.77433492	19.15847427	190.4459922	132.4571312	14.5033778	111.3833742	12.98483366
0612b	352.0506073	6378.137897	31.80834736	24.44975416	19.75152677	191.2035054	127.8202779	12.90362373	105.4917918	12.70063067
0612c	396.7500607	6278.079821	32.6772396	23.49462646	21.07326315	186.4269146	127.0611114	14.47882516	103.8909907	12.49167821
0615a	377.2293159	6218.756822	37.24462574	22.51540566	19.61916584	183.924417	120.8470563	13.59361106	99.57608799	12.61521141
0615b	390.5312564	6267.001166	33.85730891	28.15170048	17.39985578	183.0509381	128.6309733	14.27669872	102.6743029	12.71429342
0615c	407.1234812	6710.120582	36.81287973	22.47091355	20.72941062	181.2462485	130.2286171	11.492652	99.57080149	12.10994132
0617a	335.0721375	5674.144948	29.15629192	18.60776488	17.20862787	166.541242	118.1203584	13.13672463	97.27432162	12.05976927
0617b	313.5685189	5629.230073	30.56852953	19.45356952	17.67817933	172.2755998	116.4350131	12.64485877	97.66877232	10.83301006
0617c	292.7961193	5679.629081	30.70747408	17.09975496	18.19508731	167.4507193	115.4214395	14.06732249	97.36782555	11.48943733
0618a	317.597548	5389.332393	28.1048222	17.40789579	16.19863162	163.2538119	109.1876022	10.99903139	93.95856434	10.69842271
0618b	348.4180426	5837.817983	23.35466768	20.35855624	16.65492849	173.2659291	117.89905	12.39431933	98.74112558	12.20560464
0618c	337.2543503	5427.061009	56.65534419	17.02578258	14.83980935	162.9929944	112.0350827	13.4082752	96.3101929	11.29120443
0619a	468.1882539	6309.954992	34.24175873	19.23675424	17.9414521	166.4276356	141.6160808	18.08875149	120.343533	14.02945112
0619b	426.1617052	6207.227412	32.02359438	19.24914193	15.18330743	164.1822156	136.5466611	17.41597651	121.7160224	14.12748862
0619c	503.534446	6675.9742	60.29955412	22.77100092	18.9066987	173.7370743	150.4383378	18.16239008	124.5493757	14.22106251
0620a	385.9116229	7183.03961	27.43866171	27.68851683	21.58472029	215.3658468	149.9225857	16.51433572	115.6747006	14.46265186
0620b	395.2785743	6734.872868	30.15034108	23.6979307	21.79618353	200.6476228	138.3307534	14.40015595	109.2722262	13.25085766
0620c	347.5499849	6812.565421	112.4801249	28.30118001	23.56338557	206.1698863	139.1329483	14.25261092	110.5461516	13.07403266
0621a	390.7341114	6477.238536	29.63859149	26.4062748	20.49768635	200.186146	136.520454	13.15544648	109.8213605	13.61669641
0621b	334.6353159	6601.382085	26.52404124	26.16374158	20.37861062	201.0587604	136.8622118	15.23796675	110.2439803	12.39403084
0621c	384.3479771	6920.576705	37.26731689	30.20931097	21.30061209	211.8045585	144.000325	13.20297475	113.8485476	15.29858037
0622a	402.7468432	6371.229152	29.13377934	21.44016608	19.36188424	188.7030406	129.169355	14.259648	107.6239281	12.50353282
0622b	317.8562521	5966.303941	25.57577424	21.8752158	17.43075469	176.5668705	119.9881411	13.70797276	101.8296759	10.68216897
0622c	359.9040687	6652.528264	44.8604134	24.74214287	17.98373859	200.3664433	134.0423793	11.24988524	109.8493789	13.61586063
0623a	362.3756291	5457.387785	34.27531931	19.20330118	16.45670335	164.9908875	112.7800166	12.34840755	93.51813871	10.24294378
0623b	341.6809708	5582.857158	32.01120147	18.48618684	18.72874674	167.7300958	113.7068727	12.11130355	94.45741795	10.43785545
0623c	327.5999042	6520.956742	32.90989342	20.77987757	17.21093886	174.1866302	121.0652725	13.41439296	102.1065298	11.00432561
0624a	449.9425779	5638.475615	40.8327673	17.91003845	12.48819261	136.1714045	74.03125815	14.46651341	99.07176034	10.8639621
0624b	450.768264	5809.459066	42.30159379	19.0492801	13.11614979	136.3344121	73.16476068	12.84482944	101.3247203	12.76890542
0624c	427.7056169	5970.84538	39.42252829	23.49429762	11.54745391	140.5588501	77.56161198	14.24697042	101.5278822	12.72635561
0625a	333.8382264	6484.776579	29.72506665	25.87944533	20.5130412	190.5664193	135.4472172	16.96255158	109.7598188	12.90645661

0625b	408.3670718	6603.316357	27.15111949	24.77412323	20.63565226	202.4868235	136.853984	15.85845085	110.2056406	12.68031311
0625c	347.0844233	6303.862985	26.72249299	22.66194002	18.65018029	191.6628668	129.8526228	14.70002598	104.4109512	12.0359602
0626a	383.0852012	6281.522475	29.4678294	24.25639757	20.28684547	189.3893058	129.9459732	14.5437224	107.336006	13.08470551
0626b	377.0107688	6038.286841	100.8795706	22.63287571	19.31140053	185.611188	124.153652	13.2838071	104.9487834	11.66972455
0626c	369.7433194	6460.565152	28.53697242	22.75487063	21.23678708	189.3457397	127.8635493	14.23104516	107.5348907	12.98512006
0627a	401.4780958	6440.311772	35.68054697	23.4875288	22.81993298	190.0177922	130.3368724	13.86962127	106.6900527	11.91759532
0627b	350.5445138	5832.591286	395.651882	19.89659521	17.73065124	173.4674449	119.9344577	14.17122968	101.9115921	11.01319288
0627c	370.6265972	6341.016992	29.97812425	18.83596528	19.18380198	177.6663951	123.8532268	14.60281174	103.5710583	11.48036709
0629a	291.3210752	5811.649039	26.3989088	19.23035315	16.56008181	170.9746166	115.4249896	13.88855094	101.5034269	10.26544592
0629b	338.2329216	6373.235548	32.48539541	22.60822744	19.56573042	183.9574627	128.3269433	14.7789175	105.6952107	12.94843285
0629c	414.7863787	6348.81274	32.63699942	23.83519319	15.645143	185.0044188	130.9733752	14.61477131	105.4081173	12.35941142
0630a	370.1050647	5919.113692	931.3837359	22.72275755	19.02281897	179.58043	121.1348957	13.4203558	99.99727415	12.22275705
0630b	374.8148491	6105.988612	940.5279076	23.27033833	19.38537558	175.9898589	118.8023896	14.13615277	103.5439852	10.82228639
0630c	307.4110004	5142.855118	32.44144242	16.24636356	17.65238467	157.6726993	106.5557282	12.31375768	89.84308857	9.619959567
0632a	561.5711966	6636.028516	56.34979886	25.92718453	13.24529913	154.4682899	84.60164957	15.7949397	116.2599785	14.10965485
0632b	523.6504362	6599.080228	1093.807981	28.20107025	14.90922991	158.3128083	83.7506207	16.69425022	113.0751439	14.26622871
0633a	415.9230862	7131.534488	49.89335958	23.56158067	20.14469899	204.7247235	138.8219797	15.1809491	111.1575908	12.8960796
0633b	449.1457699	7211.154091	34.92196172	24.83960077	24.77302002	196.5620403	139.2790907	17.39397514	112.1098377	11.35052737
0633c	423.9098133	7146.756364	46.10118647	24.72952721	26.29099514	200.6601365	135.1997314	13.34419808	111.9282046	12.98530033
0634a	266.4324997	5596.510696	23.65730097	17.8401935	18.5107273	164.8497503	109.7232223	12.05102237	95.58946244	10.63684677
0634b	391.2845308	5477.499544	23.17024237	16.17105178	17.76566873	167.1179485	112.7650593	13.15143108	96.33095837	10.63600954
0634c	318.7766888	5810.549381	31.51911704	17.95516879	17.62416649	170.9908483	116.2864546	11.9966216	99.99801418	10.91024175
0635a	435.1287134	5350.585792	34.53337506	15.5845606	10.4517865	123.9322209	68.48577456	14.32880272	92.36219559	11.12873559
0635b	420.8941492	5156.50705	33.45109988	17.78921791	11.84179914	121.7927373	66.03161931	14.10536458	91.22390618	10.46044993
0635c	471.0924165	5556.722707	37.00101875	17.14299124	10.0597652	128.9628871	69.79150667	14.38898157	94.47255343	10.87679848
0636a	343.2475671	5921.943957	23.28592987	20.8344174	18.61503384	169.2965105	118.0656814	12.70374031	97.88120598	11.76315131
0636b	286.5996313	5529.88715	25.29666927	20.2540905	16.22200137	161.6121319	109.9505436	13.58098217	93.35836909	10.94647548
0636c	304.7149147	5486.311374	28.26747244	16.60821839	15.61679443	162.7894513	110.2172447	13.19398708	94.82678502	10.51697619
0637a	318.6640049	5788.740508	28.11449834	21.93050161	18.26449878	170.4437971	119.7224757	14.51224128	98.45971812	11.34034526
0637b	366.6345911	5628.505187	22.46959946	19.48669557	16.45129294	171.7579856	117.0311713	13.64265325	96.67344311	10.84474291
0637c	358.4405587	6121.814654	26.67851014	19.78848953	18.693894	174.6167588	117.5735117	12.80939248	101.213484	10.75140406

0638a	315.4361779	5471.513411	43.67498284	19.45236369	17.87349417	167.4218696	114.3271979	12.18258704	95.40170919	10.88975319
0638b	314.858119	5639.144595	26.28985719	16.55801772	18.63012195	167.7458997	116.3335849	13.90451717	97.23246814	11.31317788
0638c	381.1770258	5814.133866	30.93972901	19.31321059	18.59449715	174.6128363	116.7941615	12.57587384	100.922329	10.99666084
0639a	464.8977007	7050.20683	35.8926346	26.67916625	21.54751336	206.4881104	138.4096756	15.50042035	111.5837058	14.19868312
0639b	401.7713116	6767.529984	33.95385594	27.5360383	19.43207286	192.0353902	132.4359581	13.46985523	109.7356853	13.80717408
0639c	440.2443807	7496.659191	83.7120677	28.291413	21.6479164	209.3589531	142.4793989	15.07068115	113.2932824	14.13729187

APPENDIX II

ATTRIBUTE RESULTS

	Count
A (A4-B4)	14 (2.23%)
A (A5)	1 (0.16%)
A (B4)	4 (0.64%)
A (C9)	3 (0.48%)
A (D9)	2 (0.32%)
B (A4-B4)	6 (0.95%)
B (A5)	4 (0.64%)
B (A6)	3 (0.48%)
B (A8-B8-B9)	1 (0.16%)
B (B4)	5 (0.80%)
B (C6)	8 (1.27%)
B (C9)	1 (0.16%)
B (D7-D8)	15 (2.39%)
B (D9)	1 (0.16%)
B (E10)	2 (0.32%)
C (A5)	29 (4.62%)
C (A6)	43 (6.87%)
C (B4)	10 (1.59%)
C (B5-B6)	1 (0.16%)
C (C6)	2 (0.32%)
C (C9)	4 (0.64%)
C (D7-D8)	3 (0.48%)
C (NA)	2 (0.32%)
D (A5)	11 (1.75%)
D (A6)	11 (1.75%)
D (A8-B8-B9)	2 (0.32%)
D (B4)	8 (1.27%)
D (B5-B6)	20 (3.18%)
D (C5)	11 (1.75%)
D (C6)	74 (11.78%)
D (D7-D8)	1 (0.16%)
D (D9)	16 (2.55%)
D (NA)	4 (0.64%)
E (A5)	10 (1.59%)
E (B4)	17 (2.70%)
E (B5-B6)	9 (1.43%)
E (C5)	6 (0.95%)
E (C6)	7 (1.16%)
E (C9)	1 (0.16%)
E (D9)	102 (16.24%)
F (E10)	13 (2.07%)
G (B4)	5 (0.80%)
G (C6)	4 (0.64%)
H (B4)	13 (2.07%)

J (B4)	2 (0.32%)
J (E10)	7 (1.16%)
K (B4)	2 (0.32%)
M (B4)	3 (0.48%)
N (B4)	3 (0.48%)
P (B4)	8 (1.27%)
S (A5)	4 (0.64%)
S (C6)	40 (6.37%)
N/A (A5)	21 (3.34%)
N/A (A6)	5 (0.80%)
N/A (B5-B6)	6 (0.95%)
N/A (C6)	1 (0.16%)
N/A (C9)	2 (0.32%)
N/A (F)	10 (1.60%)
N/A (N/A)	5 (0.80%)
TOTAL	628 (100%)

Appendix 2.1. Obsidian count by *capa*. (Sub-sector in parentheses.)

	Sector I	***Sector II***	***Sector III***	***Total***
Biface	0 (0%)	13 (2.07%)	9 (1.43%)	22 (3.50%)
Core	0 (0%)	1 (0.16%)	0 (0%)	1 (0.16%)
Flake	11 (1.75%)	237 (37.73%)	113 (17.99%)	361 (57.48%)
Fragment	8 (.80%)	154 (24.52%)	56 (8.92%)	218 (34.71%)
Nodule	0 (0%)	1 (0.16%)	0 (0%)	1 (0.16%)
Point	0 (0%)	13 (2.07%)	11 (1.75%)	24 (3.82%)
Uniface	1 (0.16%)	0 (0%)	0 (0%)	1 (0.16%)
Total	20 (3.18%)	419 (66.72%)	189 (30.09%)	628 (100%)

Appendix 2.2. Artifact count by type and sector.

	Sector I	***Sector II***	***Sector III***	***Total***
Biface	0 (0%)	13 (59.10%)	9 (40.90%)	22 (100%)
Core	0 (0%)	1 (100%)	0 (0%)	1 (100%)
Flake	11 (3.04%)	237 (65.65%)	113 (31.31%)	361 (100%)
Fragment	8 (3.69%)	154 (70.63%)	56 (25.68%)	218 (100%)
Nodule	0 (0%)	1 (100%)	0 (0%)	1 (100%)
Point	0 (0%)	13 (54.16%)	11 (45.84%)	24 (100%)
Uniface	1 (100%)	0 (0%)	0 (0%)	1 (100%)

Appendix 2.3. Artifact types as a proportion of artifact type assemblage, across sectors.

	Biface	*Core*	*Flake*	*Frag*	*Nodule*	*Point*	*Uniface*	*Total*
A4-B4	0 (0%)	0 (0%)	11 (1.7%)	8 (1.27%)	0 (0%)	0 (0%)	1 (0.16%)	20 (3.18%)
A5	1 (0.16%)	0 (0%)	29 (4.61%)	46 (7.32%)	0 (0%)	4 (0.64%)	0 (0%)	80 (12.74%)
A6	2 (0.32%)	0 (0%)	34 (5.41%)	24 (3.82%)	0 (0%)	2 (0.32%)	0 (0%)	62 (9.87%)
B4	0 (0%)	0 (0%)	54 (8.60%)	21 (3.34%)	1 (0.16%)	4 (0.64%)	0 (0%)	80 (12.74%)
B5-B6	1 (0.16%)	0 (0%)	16 (2.55%)	18 (2.87%)	0 (0%)	1 (0.16%)	0 (0%)	36 (5.73%)
C5	2 (0.32%)	0 (0%)	8 (1.27%)	7 (1.11%)	0 (0%)	0 (0%)	0 (0%)	17 (2.71%)
C6	7 (1.11%)	1 (0.16%)	91 (14.49%)	35 (5.57%)	0 (0%)	2 (0.32%)	0 (0%)	136 (21.66%)
A8-B8-B9	0 (0%)	0 (0%)	2 (0.32%)	1 (0.16%)	0 (0%)	0 (0%)	0 (0%)	3 (0.48%)
C9	0 (0%)	0 (0%)	5 (0.80%)	6 (0.95%)	0 (0%)	0 (0%)	0 (0%)	11 (1.7%)
D7-D8	1 (0.16%)	0 (0%)	16 (2.55%)	2 (0.32%)	0 (0%)	0 (0%)	0 (0%)	19 (3.03%)
D9	8 (1.27%)	0 (0%)	68 (10.83%)	37 (5.89%)	0 (0%)	8 (1.27%)	0 (0%)	121 (19.27%)
E10	0 (0%)	0 (0%)	14 (4.27%)	8 (1.27%)	0 (0%)	0 (0%)	0 (0%)	22 (3.50%)
N/A	0 (0%)	0 (0%)	13 (2.07%)	5 (0.80%)	0 (0%)	3 (0.48%)	0 (0%)	21 (3.34%)
Total	22 (3.5%)	1 (0.16%)	361 (57.48%)	218 (34.71%)	1 (0.16%)	24 (3.82%)	1 (0.16%)	628 (100%)

Appendix 2.4. Artifact count by type and sub-sector.

	Biface	***Core***	***Flake***	***Fragment***	***Nodule***	***Point***	***Uniface***
A4-B4	0 (0%)	0 (0%)	11 (3.05%)	8 (3.67%)	0 (0%)	0 (0%)	1 (100%)
A5	1 (4.55%)	0 (0%)	29 (8.03%)	46 (21.10%)	0 (0%)	4 (16.67%)	0 (0%)
A6	2 (9.09%)	0 (0%)	34 (9.42%)	24 (11.01%)	0 (0%)	2 (8.33%)	0 (0%)
B4	0 (0%)	0 (0%)	54 (14.96%)	21 (9.63%)	1 (100%)	4 (16.67%)	0 (0%)
B5-B6	1 (4.55%)	0 (0%)	16 (4.43%)	18 (8.26%)	0 (0%)	1 (4.17%)	0 (0%)
C5	2 (9.09%)	0 (0%)	8 (2.22%)	7 (3.21%)	0 (0%)	0 (0%)	0 (0%)
C6	7 (31.82%)	1 (100%)	91 (25.21%)	35 (16.06%)	0 (0%)	2 (8.33%)	0 (0%)
A8-D8-A9	0 (0%)	0 (0%)	2 (0.55%)	1 (0.46%)	0 (0%)	0 (0%)	0 (0%)
C9	0 (0%)	0 (0%)	5 (1.38%)	6 (2.75%)	0 (0%)	0 (0%)	0 (0%)
D7-D8	1 (4.55%)	0 (0%)	16 (4.43%)	2 (0.92%)	0 (0%)	0 (0%)	0 (0%)
D9	8 (36.36%)	0 (0%)	68 (18.84%)	37 (16.97%)	0 (0%)	8 (33.33%)	0 (0%)
E10	0 (0%)	0 (0%)	14 (3.88%)	8 (3.67%)	0 (0%)	0 (0%)	0 (0%)
N/A	0 (0%)	0 (0%)	13 (3.60%)	5 (2.29%)	0 (0%)	3 (12.5%)	0 (0%)
Total	22 (100%)	1 (100%)	361 (100%)	218 (100%)	1 (100%)	24 (100%)	1 (100%)

Appendix 2.5. Artifact types as a proportion of artifact type assemblage, across sub-sectors.

	Temporal Phase	***Biface***	***Core***	***Flake***	***Frag***	***Nodule***	***Point***	***Uniface***
A (C9)	Wari B	0 (0%)	0 (0%)	2 (0.76%)	1 (0.72%)	0 (0%)	0 (0%)	0 (0%)
A (D9)	Wari B	0 (0%)	0 (0%)	1 (0.38%)	0 (0%)	0 (0%)	1 (7.14%)	0 (0%)
B (A6)	Wari B	0 (0%)	0 (0%)	1 (0.38%)	2 (1.45%)	0 (0%)	0 (0%)	0 (0%)
B (A8-B8-A9)	Wari A, Wari B	0 (0%)	0 (0%)	0 (0%)	1 (0.72%)	0 (0%)	0 (0%)	0 (0%)
B (C9)	Huarpa, Wari A	0 (0%)	0 (0%)	1 (0.38%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
B (D7-D8)	Huarpa, Wari A, Wari B	1 (5.88%)	0 (0%)	12 (4.58%)	2 (1.45%)	0 (0%)	0 (0%)	0 (0%)
B (D9)	Huarpa, Wari A	0 (0%)	0 (0%)	1 (0.38%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

C (A6)	Wari A, Wari B	1 (5.88%)	0 (0%)	26 (9.92%)	14 (10.14%)	0 (0%)	2 (14.29%)	0 (0%)
C (B4)	Huarpa, Wari A	0 (0%)	0 (0%)	7 (2.67%)	3 (2.17%)	0 (0%)	0 (0%)	0 (0%)
C (B5-B6)	Huarpa, Wari A	0 (0%)	0 (0%)	0 (0%)	1 (0.72%)	0 (0%)	0 (0%)	0 (0%)
C (C9)	Huarpa, Wari A	0 (0%)	0 (0%)	1 (0.38%)	3 (2.17%)	0 (0%)	0 (0%)	0 (0%)
C (D7-D8)	Huarpa, Wari A	0 (0%)	0 (0%)	3 (1.15%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
D (A5)	Wari A, Wari B	0 (0%)	0 (0%)	5 (1.91%)	6 (4.35%)	0 (0%)	0 (0%)	0 (0%)
D (A6)	Huarpa, Wari A	1 (5.88%)	0 (0%)	6 (2.29%)	4 (2.90%)	0 (0%)	0 (0%)	0 (0%)
D (A8-B8-B9)	Wari A	0 (0%)	0 (0%)	2 (0.76%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
D (B4)	Huarpa	0 (0%)	0 (0%)	4 (1.53%)	4 (2.90%)	0 (0%)	0 (0%)	0 (0%)
D (B5-B6)	Huarpa	0 (0%)	0 (0%)	10 (3.82%)	10 (7.25%)	0 (0%)	0 (0%)	0 (0%)
D (C5)	Huarpa	1 (5.88%)	0 (0%)	4 (1.53%)	6 (4.35%)	0 (0%)	0 (0%)	0 (0%)
D (C6)	Huarpa, Wari A	2 (11.76%)	1 (100%)	48 (18.32%)	22 (15.94%)	0 (0%)	1 (7.14%)	0 (0%)
D (D7-D8)	Huarpa	0 (0%)	0 (0%)	1 (0.38%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
D (D9)	Huarpa, Wari A	2 (11.76%)	0 (0%)	3 (1.15%)	9 (6.52%)	0 (0%)	2 (14.29%)	0 (0%)
E (A5)	Huarpa, Wari A	0 (0%)	0 (0%)	4 (1.53%)	6 (4.35%)	0 (0%)	0 (0%)	0 (0%)
E (B4)	Huarpa	0 (0%)	0 (0%)	12 (4.58%)	3 (2.17%)	1 (100%)	1 (7.14%)	0 (0%)
E (B5-B6)	Huarpa	1 (5.88%)	0 (0%)	3 (1.15%)	5 (3.62%)	0 (0%)	0 (0%)	0 (0%)
E (C5)	Huarpa	1 (5.88%)	0 (0%)	4 (1.53%)	1 (0.72%)	0 (0%)	0 (0%)	0 (0%)
E (C6)	Huarpa, Wari A	1 (5.88%)	0 (0%)	6 (2.29%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
E (C9)	Huarpa	0 (0%)	0 (0%)	1 (0.38%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
E (D9)	Huarpa	6 (35.29%)	0 (0%)	63 (24.05%)	28 (20.29%)	0 (0%)	5 (35.71%)	0 (0%)
G (B4)	Huarpa	0 (0%)	0 (0%)	4 (1.53%)	1 (0.72%)	0 (0%)	0 (0%)	0 (0%)
G (C6)	Huarpa	0 (0%)	0 (0%)	3 (1.15%)	1 (0.72%)	0 (0%)	0 (0%)	0 (0%)
H (B4)	Huarpa	0 (0%)	0 (0%)	9 (3.44%)	3 (2.17%)	0 (0%)	1 (7.14%)	0 (0%)
J (B4)	Huarpa	0 (0%)	0 (0%)	2 (0.76%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

K (B4)	Huarpa	0 (0%)	0 (0%)	1 (0.38%)	1 (0.72%)	0 (0%)	0 (0%)	0 (0%)
M (B4)	Huarpa	0 (0%)	0 (0%)	3 (1.15%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
N (B4)	Huarpa	0 (0%)	0 (0%)	3 (1.15%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
P (B4)	Huarpa	0 (0%)	0 (0%)	6 (2.29%)	1 (0.72%)	0 (0%)	1 (7.14%)	0 (0%)
TOTAL		17 (100%)	1 (100%)	262 (100%)	138 (100%)	1 (100%)	14 (100%)	0 (100 %)

Appendix 2.6. Artifact types by *capa* and temporal context. Proportional representation of artifact types within artifact type assemblage.

	Biface	***Core***	***Flake***	***Fragment***	***Nodule***	***Point***	***Count***
Huarpa	9 (2.08%)	0 (0%)	133 (30.72%)	64 (14.78%)	1 (0.23%)	8 (1.85%)	215 (49.65%)
Huarpa, Wari A	6 (1.39%)	1 (0.23%)	80 (18.48%)	48 (11.09%)	0 (0%)	3 (0.69%)	138 (31.87%)
Wari A	0 (0%)	0 (0%)	2 (0.46%)	0 (0%)	0 (0%)	0 (0%)	2 (0.46%)
Wari A, Wari B	1 (0.23%)	0 (0%)	31 (7.16%)	21 (4.85%)	0 (0%)	2 (0.46%)	55 (12.70%)
Wari B	0 (0%)	0 (0%)	4 (0.92%)	3 (0.69%)	0 (0%)	1 (0.23%)	8 (1.84%)
Huarpa, Wari A, Wari B	1 (0.23%)	0 (0%)	12 (2.77%)	2 (0.46%)	0 (0%)	0 (0%)	15 (3.46%)
Total	17 (3.92%)	1 (0.23%)	262 (60.51%)	138 (31.87%)	1 (0.23%)	14 (3.23%)	433 (100%)

Appendix 2.7. Artifact type by temporal context.

	Unretouched Flake	***Retouched Flake***	***Unretouched Fragment***	***Retouched Fragment***	***Count***
Huarpa	128 (29.56%)	5 (1.15%)	43 (0.24%)	21 (4.85%)	197 (45.50%)
Huarpa, Wari A	77 (17.78%)	3 (0.69%)	36 (8.31%)	12 (2.77%)	128 (29.56%)
Wari A	2 (0.46%)	0 (0%)	0 (0%)	0 (0%)	2 (0.46%)
Wari A, Wari B	30 (6.93%)	1 (0.23%)	12 (2.77%)	9 (2.08%)	52 (12.10%)
Wari B	4 (0.92%)	0 (0%)	3 (0.69%)	0 (0%)	7 (1.62%)
Huarpa, Wari A, Wari B	12 (2.77%)	0 (0%)	2 (0.46%)	0 (0%)	14 (3.23%)
Total	253 (58.43%)	9 (2.08%)	96 (22.17%)	42 (9.70%)	400 (92.37%)

Appendix 2.8. Retouched and unretouched flakes and fragments by temporal context. (Chi-square for flakes: value=0.702, df=5, p<0.983).(Chi-square for fragments: value=4.559, df=4, p<0.336).

	Sector I	*Sector II*	*Sector III*	*Total*
< 6.35mm	2 (0.55%)	0 (0%)	0 (0%)	2 (0.55%)
6.35–12.7mm	1 (0.28%)	10 (2.77%)	2 (0.55%)	13 (3.60%)
12.7–25.4mm	5 (1.39%)	132 (36.57%)	60 (16.62%)	197 (54.57%)
> 25.4mm	3 (0.83%)	95 (26.32%)	51 (14.13%)	149 (41.26%)
Total	11 (3.05%)	237 (65.65%)	113 (31.30%)	361 (100%)

Appendix 2.9. Flake size-grade by sector.

	Sector I	*Sector II*	*Sector III*	*Total*
< 6.35mm	2 (100%)	0 (0%)	0 (0%)	2 (100%)
6.35–12.7mm	1 (7.70%)	10 (76.92%)	2 (15.38%)	13 (100%)
12.7–25.4mm	5 (2.53%)	132 (67.01%)	60 (30.46%)	197 (100%)
> 25.4mm	3 (2.01%)	95 (63.76%)	51 (34.23%)	149 (100%)

Appendix 2.10. Flake size-grade by as a proportion of size-grade assemblage.

	< 6.35mm	**6.35–12.7mm**	**12.7–25.4mm**	**> 25.4mm**	**Total**
A4-B4	2 (0.55%)	1 (0.28%)	5 (1.39%)	3 (0.83%)	11 (3.05%)
A5	0 (0%)	0 (0%)	20 (5.54%)	9 (2.49%)	29 (8.03%)
A6	0 (0%)	0 (0%)	24 (6.65%)	10 (2.77%)	34 (9.42%)
B4	0 (0%)	8 (2.22%)	28 (7.76%)	18 (4.99%)	54 (14.96%)
B5-B6	0 (0%)	0 (0%)	7 (1.94%)	9 (2.49%)	16 (4.43%)
C5	0 (0%)	0 (0%)	2 (0.55%)	6 (1.66%)	8 (2.22%)
C6	0 (0%)	2 (0.55%)	48 (13.30%)	41 (11.36%)	91 (25.21%)
A8-B8-A9	0 (0%)	0 (0%)	2 (0.55%)	0 (0%)	2 (0.55%)
C9	0 (0%)	0 (0%)	2 (0.55%)	3 (0.83%)	5 (1.39%)
D7-D8	0 (0%)	0 (0%)	10 (2.77%)	6 (1.66%)	16 (4.43%)
D9	0 (0%)	0 (0%)	31 (8.59%)	37 (10.25%)	68 (18.84%)
E10	0 (0%)	2 (0.55%)	11 (3.05%)	1 (0.28%)	14 (3.88%)
N/A	0 (0%)	0 (0%)	7 (1.94%)	6 (1.66%)	13 (3.60%)
Total	2 (0.55%)	13 (3.60%)	197 (54.57%)	149 (41.27%)	361 (100%)

Appendix 2.11. Flake size-grade by sub-sector.

	< 6.35mm	**6.35–12.7mm**	**12.7–25.4mm**	**> 25.4mm**
A4-B4	2 (100%)	1 (7.69%)	5 (2.54%)	3 (2.01%)
A5	0 (0%)	0 (0%)	20 (10.15%)	9 (6.04%)
A6	0 (0%)	0 (0%)	24 (12.18%)	10 (6.71%)
B4	0 (0%)	8 (61.54%)	28 (14.21%)	18 (12.08%)
B5-B6	0 (0%)	0 (0%)	7 (3.55%)	9 (6.04%)
C5	0 (0%)	0 (0%)	2 (1.02%)	6 (4.03%)
C6	0 (0%)	2 (15.38%)	48 (24.37%)	41 (27.52%)
A8-B8-A9	0 (0%)	0 (0%)	2 (1.02%)	0 (0%)
C9	0 (0%)	0 (0%)	2 (1.02%)	3 (2.01%)
D7-D8	0 (0%)	0 (0%)	10 (5.08%)	6 (4.03%)
D9	0 (0%)	0 (0%)	31 (15.74%)	37 (24.83%)
E10	0 (0%)	2 (15.38%)	11 (5.58%)	10 (6.71%)
N/A	0 (0%)	0 (0%)	7 (3.55%)	6 (4.03%)
Total	2 (100%)	13 (100%)	197 (100%)	149 (100%)

Appendix 2.12. Flake size-grade by as a percentage of size-grade assemblage.

	< 6.35mm	***6.35–12.7mm***	***12.7–25.4mm***	***> 25.4mm***	***Total***
Huarpa	0 (0%)	7 (2.67%)	63 (24.05%)	63 (24.05%)	133 (50.76%)
Huarpa, Wari A	0 (0%)	3 (1.15%)	42 (16.03%)	35 (13.36%)	80 (30.53%)
Wari A	0 (0%)	0 (0%)	2 (0.76%)	0 (0%)	2 (0.76%)
Wari A, Wari B	0 (0%)	0 (0%)	22 (8.40%)	9 (3.44%)	31 (11.83%)
Wari B	0 (0%)	0 (0%)	2 (0.76%)	2 (0.76%)	4 (1.52%)
Huarpa, Wari A, Wari B	0 (0%)	0 (0%)	8 (3.05%)	4 (1.52%)	12 (4.58%)
Total	0 (0%)	10 (3.82%)	139 (53.05%)	113 (43.13%)	262 (100%)

Appendix 2.13. Flake size-grade by time period.

	< 6.35mm	***6.35–12.7mm***	***12.7–25.4mm***	***> 25.4mm***
Huarpa	0 (0%)	7 (70%)	63 (45.32%)	63 (55.75%)
Huarpa, Wari A	0 (0%)	3 (30%)	42 (30.22%)	35 (30.97%)
Wari A	0 (0%)	0 (0%)	2 (1.44%)	0 (0%)
Wari A, Wari B	0 (0%)	0 (0%)	22 (15.83%)	9 (7.96%)
Wari B	0 (0%)	0 (0%)	2 (1.44%)	2 (1.77%)
Huarpa, Wari A, Wari B	0 (0%)	0 (0%)	8 (5.76%)	4 (3.54%)
Total	0 (0%)	10 (100%)	139 (100%)	113 (100%)

Appendix 2.14. Flake size-grade by time period, percentage of size-grade assemblage.

	0% Cortex	*1–49% Cortex*	*50–99% Cortex*	*100% Cortex*	*Total*
12.7–25.4mm	5 (41.67%)	0 (0%)	0 (0%)	0 (0%)	5 (41.67%)
> 25.4mm	4 (33.33%)	3 (25%)	0 (0%)	0 (0%)	7 (58.33%)
Total	9 (75%)	3 (25%)	0 (0%)	0 (0%)	12 (100%)

Appendix 2.15. Cortex present on flake artifacts with edge retouching. (Chi-square: value=0.310; df=2; p<0.857).

	0% Cortex	*1–49% Cortex*	*50–99% Cortex*	*100% Cortex*	*Total*
Sector I	5 (1.40%)	5 (1.40%)	1 (0.28%)	0 (0%)	11 (3.07%)
Sector II	188 (52.52%)	39 (10.89%)	7 (1.96%)	0 (0%)	234 (65.36%)
Sector III	84 (23.46%)	29 (8.10%)	0 (0%)	0 (0%)	113 (31.56%)
Total	277 (77.37%)	73 (20.39%)	8 (2.23%)	0 (0%)	358 (100%)

Appendix 2.16. Cortex present on flakes by Sector.

	0% Cortex	*1-49% Cortex*	*50-99% Cortex*	*100% Cortex*	*Total*
A4-B4	5 (1.40%)	5 (1.40%)	1 (0.30%)	0 (0%)	11 (3.07%)
A5	18 (5.03%)	8 (2.23%)	3 (0.84%)	0 (0%)	29 (8.10%)
A6	26 (7.26%)	8 (2.23%)	0 (0%)	0 (0%)	34 (9.50%)
B4	44 (84.62%)	6 (1.68%)	0 (0%)	0 (0%)	52 (14.53%)
B5-B6	11 (3.07%)	5 (1.40%)	0 (0%)	0 (0%)	16 (4.47%)
C5	6 (1.68%)	2 (0.56%)	0 (0%)	0 (0%)	8 (2.23%)
C6	79 (22.07%)	10 (2.79%)	2 (0.56%)	0 (0%)	91 (25.42%)
A8-B8-A9	1 (0.30%)	1 (0.30%)	0 (0%)	0 (0%)	2 (0.56%)
C9	4 (1.12%)	1 (0.30%)	0 (0%)	0 (0%)	5 (1.40%)
D7-D8	15 (4.19%)	1 (0.30%)	0 (0%)	0 (0%)	16 (4.47%)
D9	47 (13.13%)	21 (5.87%)	0 (0%)	0 (0%)	68 (18.99%)
E10	12 (3.35%)	2 (0.56%)	0 (0%)	0 (0%)	14 (3.91%)
N/A	9 (2.51%)	3 (0.84%)	0 (0%)	0 (0%)	12 (3.35%)
Total	277 (77.37%)	73 (20.39%)	8 (2.23%)	0 (0%)	358 (100%)

Appendix 2.17. Flake cortex by sub-sector.

	0% Cortex	*1-49% Cortex*	*50-99% Cortex*	*100% Cortex*	*Total*
Huarpa	103 (39.62%)	27 (10.38%)	1 (0.38%)	0 (0%)	131 (50.38%)
Huarpa, Wari A	65 (25%)	11 (4.23%)	4 (1.54%)	0 (0%)	80 (30.77%)
Wari A	1 (0.38%)	1 (0.38%)	0 (0%)	0 (0%)	2 (0.77%)
Wari A, Wari B	21 (8.08%)	9 (3.46%)	1 (0.38%)	0 (0%)	31 (11.92%)
Wari B	3 (1.15%)	1 (0.38%)	0 (0%)	0 (0%)	4 (1.54%)
Huarpa, Wari A, Wari B	11 (4.23%)	1 (0.38%)	0 (0%)	0 (0%)	12 (4.62%)
Total	204 (78.46%)	50 (19.23%)	6 (2.31%)	0 (0%)	260 (100%)

Appendix 2.18. Flake cortex by time period.

	0% Cortex	***1–49% Cortex***	***50–99% Cortex***	***100% Cortex***	***Total***
Count	195 (90.70%)	18 (8.37%)	2 (0.93%)	0 (0%)	215 (100%)

Appendix 2.19. Cortex present on fragment artifacts.

	0% Cortex	***1–49% Cortex***	***50–99% Cortex***	***100% Cortex***	***Total***
Count	60 (93.75%)	4 (6.25%)	0 (0%)	0 (0%)	64 (100%)

Appendix 2.20. Cortex present on retouched fragment artifacts.

	Feathered	***Hinged, Stepped, Overshot***	***Total***
Sector I	4 (11.17%)	7 (1.96%)	11 (3.07%)
Sector II	126 (35.20%)	108 (30.17%)	234 (65.36%)
Sector III	63 (17.60%)	50 (13.97%)	113 (31.56%)
Total	193 (53.91%)	165 (46.09%)	358 (100%)

Appendix 2.21. Flake termination on flakes by Sector.

	Feathered	***Hinged, Stepped, Overshot***	***Total***
A4-B4	4 (1.12%)	7 (1.96%)	11 (3.07%)
A5	15 (4.19%)	11 (3.07%)	26 (7.26%)
A6	18 (5.03%)	16 (4.47%)	34 (9.50%)
B4	30 (8.38%)	24 (6.70%)	54 (15.08%)
B5-B6	7 (1.96%)	9 (2.51%)	16 (4.47%)
C5	6 (1.68%)	2 (0.56%)	8 (2.23%)
C6	45 (12.57%)	46 (12.85%)	91 (25.42%)
A8-B8-A9	1 (0.28%)	1 (0.28%)	2 (0.56%)
C9	2 (0.56%)	3 (0.84%)	5 (1.40%)
D7-D8	11 (3.07%)	5 (1.40%)	16 (4.47%)
D9	35 (9.78%)	33 (9.22%)	68 (18.99%)
E10	8 (2.23%)	6 (1.68%)	14 (3.91%)
N/A	11 (3.07%)	3 (0.84%)	13 (3.63%)
Total	193 (53.91%)	165 (46.09%)	358 (100%)

Appendix 2.22. Flake termination by sub-sector.

	Feathered	*Hinged, Stepped, Overshot*	*Total*
Huarpa	76 (29.01%)	57 (21.76%)	133 (50.76%)
Huarpa, Wari A	40 (15.27%)	40 (15.27%)	80 (30.53%)
Wari A	1 (0.38%)	1 (0.38%)	2 (0.76%)
Wari A, Wari B	13 (4.96%)	18 (6.87%)	31 (11.83%)
Wari B	2 (0.76%)	2 (0.76%)	4 (1.53%)
Huarpa, Wari A, Wari B	7 (2.67%)	5 (1.91%)	12 (4.58%)
Total	139 (53.05%)	123 (46.95%)	262 (100%)

Appendix 2.23. Flake termination by time period.

	Flat	*Complex*	*Cortical*	*Total*
Sector I	7 (2.36%)	2 (0.67%)	1 (0.34%)	10 (3.37%)
Sector II	63 (21.21%)	113 (38.05%)	20 (6.73%)	196 (65.99%)
Sector III	40 (13.47%)	39 (13.13%)	12 (4.04%)	91 (30.64%)
Total	110 (37.04%)	154 (51.85%)	33 (11.11%)	297 (100%)

Appendix 2.24. Flake termination on flakes by Sector.

	Flat	*Complex*	*Cortical*	*Total*
A4-B4	7 (2.36%)	2 (0.67%)	1 (0.34%)	10 (3.37%)
A5	6 (2.02%)	12 (4.04%)	4 (1.35%)	22 (7.41%)
A6	9 (3.03%)	13 (4.38%)	4 (1.35%)	26 (8.75%)
B4	5 (1.69%)	30 (10.10%)	6 (2.02%)	41 (13.80%)
B5-B6	5 (1.69%)	7 (2.36%)	4 (1.35%)	16 (5.39%)
C5	4 (1.35%)	2 (0.67%)	2 (0.67%)	8 (2.69%)
C6	32 (10.77%)	47 (15.82%)	0 (0%)	79 (26.60%)
A8-B8-A9	1 (0.34%)	1 (0.34%)	0 (0%)	2 (0.67%)
C9	2 (0.67%)	2 (0.67%)	2 (0.67%)	6 (2.02%)
D7-D8	3 (1.01%)	8 (2.69%)	8 (2.69%)	19 (6.40%)
D9	27 (9.09%)	19 (6.40%)	19 (6.40%)	65 (21.89%)
E10	3 (1.01%)	8 (2.69%)	8 (2.69%)	19 (6.40%)
N/A	6 (2.02%)	3 (1.01%)	3 (1.01%)	12 (4.04%)
Total	110 (37.04%)	154 (51.85%)	33 (11.11%)	297 (100%)

Appendix 2.25. Flake termination by sub-sector.

	Flat	*Complex*	*Cortical*	*Total*
Huarpa	37 (16.97%)	55 (25.23%)	17 (7.80%)	109 (50%)
Huarpa, Wari A	31 (14.22%)	35 (16.06%)	3 (1.38%)	69 (31.65%)
Wari A	1 (0.46%)	1 (0.46%)	0 (0%)	2 (0.92%)
Wari A, Wari B	6 (2.75%)	13 (5.96%)	6 (2.75%)	25 (11.47%)
Wari B	2 (0.92%)	1 (0.46%)	1 (0.46%)	4 (1.83%)
Huarpa, Wari A, Wari B	1 (0.46%)	6 (2.75%)	2 (0.92%)	9 (4.13%)
Total	78 (35.78%)	111 (50.92%)	29 (13.30%)	218 (100%)

Appendix 2.26. Flake termination by time period.

	0 Flake Scars	***1 Flake Scar***	***2-5 Flake Scars***	***> 5 Flake Scars***	***Total***
Sector I	7 (1.96%)	2 (0.56%)	2 (0.56%)	0 (0%)	11 (3.07%)
Sector II	65 (18.16%)	62 (17.32%)	57 (15.92%)	50 (13.97%)	234 (65.36%)
Sector III	31 (8.66%)	34 (9.50%)	24 (6.70%)	24 (6.70%)	113 (31.56%)
Total	103 (28.77%)	98 (27.37%)	83 (23.18%)	74 (20.67%)	358 (100%)

Appendix 2.27. Flake termination on flakes by Sector.

	0 Flake Scars	***1 Flake Scar***	***2-5 Flake Scars***	***> 5 Flake Scars***	***Total***
A4-B4	7 (1.96%)	2 (0.56%)	2 (0.56%)	0 (0%)	11 (3.07%)
A5	8 (2.23%)	13 (3.63%)	5 (1.40%)	3 (0.84%)	29 (8.10%)
A6	14 (3.91%)	10 (2.79%)	6 (1.68%)	4 (1.12%)	34 (9.50%)
B4	8 (2.23%)	11 (3.07%)	19 (5.31%)	14 (3.91%)	52 (14.53%)
B5-B6	3 (0.84%)	2 (0.56%)	3 (0.84%)	8 (2.23%)	16 (4.47%)
C5	5 (1.40%)	3 (0.84%)	0 (0%)	0 (0%)	8 (2.23%)
C6	26 (7.26%)	21 (5.87%)	24 (6.70%)	20 (5.59%)	91 (25.42%)
A8-B8-A9	1 (0.30%)	1 (0.30%)	0 (0%)	0 (0%)	2 (0.56%)
C9	3 (0.84%)	2 (0.56%)	0 (0%)	0 (0%)	0 (0%)
D7-D8	5 (1.40%)	2 (0.56%)	6 (1.68%)	3 (0.84%)	16 (4.47%)
D9	16 (4.47%)	23 (6.42%)	9 (2.51%)	20 (5.59%)	68 (18.99%)
E10	1 (0.30%)	5 (1.40%)	8 (2.23%)	0 (0%)	14 (3.91%)
N/A	6 (1.68%)	3 (0.84%)	1 (0.30%)	2 (0.56%)	12 (3.35%)
Total	103 (28.77%)	98 (27.37%)	83 (23.18%)	74 (20.67%)	358 (100%)

Appendix 2.28. Flake termination by sub-sector.

	0 Flake Scars	***1 Flake Scar***	***2-5 Flake Scars***	***> 5 Flake Scars***	***Total***
Huarpa	29 (11.15%)	38 (14.62%)	28 (10.77%)	36 (13.85%)	131 (50.38%)
Huarpa, Wari A	27 (10.38%)	15 (5.77%)	21 (8.08%)	17 (6.54%)	80 (30.77%)
Wari A	1 (0.38%)	1 (0.38%)	0 (0%)	0 (0%)	2 (0.77%)
Wari A, Wari B	14 (5.38%)	9 (3.46%)	4 (1.54%)	4 (1.54%)	31 (11.92%)
Wari B	2 (0.77%)	2 (0.77%)	0 (0%)	0 (0%)	4 (1.54%)
Huarpa, Wari A, Wari B	5 (1.92%)	1 (0.38%)	5 (1.92%)	1 (0.38%)	12 (4.62%)
Total	78 (30%)	66 (25.38%)	58 (22.31%)	58 (22.31%)	260 (100%)

Appendix 2.29. Flake termination by time period.

APPENDIX III

PXRF RESULTS

	Sector I	*Sector II*	*Sector II*	*Total*
Alca	0 (0%)	10 (58.82%)	7 (41.18%)	17 (100%)
Puzolana	0 (0%)	1 (100%)	0 (0%)	1 (100%)
Quispisisa	16 (3.30%)	320 (65.98%)	149 (30.72%)	485 (100%)
N/A	0 (0%)	2 (66.67%)	1 (33.33%)	3 (100%)

Appendix 4.1. Obsidian source-type by sector, percentage is of source-type assemblage.

Sub-sector	*Alca*	*Puzolana*	*Quispisisa*	*N/A*
A4-B4	0 (0%)	0 (0%)	16 (3.29%)	0 (0%)
A5	3 (17.65%)	0 (0%)	55 (11.34%)	0 (0%)
A6	0 (0%)	0 (0%)	44 (9.07%)	1 (33.33%)
A-B8-D9	0 (0%)	0 (0%)	3 (0.62%)	0 (0%)
B4	1 (5.88%)	1 (100%)	65 (13.40%)	0 (0%)
B5-B6	0 (0%)	0 (0%)	29 (5.98%)	0 (0%)
C5	1 (5.88%)	0 (0%)	11 (2.27%)	0 (0%)
C6	4 (23.53%)	0 (0%)	112 (23.09%)	1 (33.33%)
C9	0 (0%)	0 (0%)	10 (2.06%)	0 (0%)
D7-D8	1 (5.88%)	0 (0%)	15 (3.09%)	0 (0%)
D9	6 (35.29%)	0 (0%)	95 (19.59%)	1 (33.33%)
E10	0 (0%)	0 (0%)	15 (3.09%)	0 (0%)
N/A	1 (5.88%)	0 (0%)	15 (3.09%)	0 (0%)
Total	17 (100%)	1 (100%)	485 (100%)	3 (100%)

Appendix 4.2. Obsidian source-type by sub-sector, percentage is by source-type.

	Alca	*Puzolana*	*Quispisisa*
A (A4-B4)	0 (0%)	0 (0%)	13 (2.57%)
A (A5)	0 (0%)	0 (0%)	1 (0.20%)
A (B4)	0 (0%)	0 (0%)	4 (0.79%)
A (C9)	0 (0%)	0 (0%)	2 (0.40%)
A (D9)	1 (0.20%)	0 (0%)	1 (0.20%)
B (A4-B4)	0 (0%)	0 (0%)	3 (0.59%)
B (A5)	1 (0.20%)	0 (0%)	3 (0.59%)
B (A6)	0 (0%)	0 (0%)	1 (0.20%)
B (A8-B8-B9)	0 (0%)	0 (0%)	1 (0.20%)
B (B4)	0 (0%)	0 (0%)	4 (0.79%)
B (C6)	0 (0%)	0 (0%)	7 (1.38%)
B (C9)	0 (0%)	0 (0%)	1 (0.20%)
B (D7-D8)	0 (0%)	0 (0%)	13 (2.57%)
B (D9)	0 (0%)	0 (0%)	1 (0.20%)
B (E10)	0 (0%)	0 (0%)	2 (0.40%)

C (A5)	2 (0.40%)	0 (0%)	21 (4.15%)
C (A6)	0 (0%)	0 (0%)	31 (6.13%)
C (B4)	0 (0%)	0 (0%)	9 (1.78%)
C (B5-B6)	0 (0%)	0 (0%)	1 (0.20%)
C (C6)	0 (0%)	0 (0%)	2 (0.40%)
C (C9)	0 (0%)	0 (0%)	4 (0.79%)
C (D7-D8)	1 (0.20%)	0 (0%)	1 (0.20%)
C (NA)	0 (0%)	0 (0%)	2 (0.40%)
D (A5)	0 (0%)	0 (0%)	8 (1.58%)
D (A6)	0 (0%)	0 (0%)	9 (1.78%)
D (A8-B8-B9)	0 (0%)	0 (0%)	2 (0.40%)
D (B4)	0 (0%)	0 (0%)	5 (0.99%)
D (B5-B6)	0 (0%)	0 (0%)	17 (3.36%)
D (C5)	1 (0.20%)	0 (0%)	7 (1.38%)
D (C6)	2 (0.40%)	0 (0%)	64 (12.65%)
D (D7-D8)	0 (0%)	0 (0%)	1 (0.20%)
D (D9)	3 (0.59%)	0 (0%)	11 (2.17%)
D (NA)	0 (0%)	0 (0%)	3 (0.59%)
E (A5)	0 (0%)	0 (0%)	7 (1.38%)
E (B4)	1 (0.20%)	1 (0.20%)	14 (2.77%)
E (B5-B6)	0 (0%)	0 (0%)	7 (1.38%)
E (C5)	0 (0%)	0 (0%)	4 (0.79%)
E (C6)	0 (0%)	0 (0%)	3 (0.59%)
E (C9)	0 (0%)	0 (0%)	1 (0.20%)
E (D9)	2 (0.40%)	0 (0%)	82 (16.21%)
F (E10)	0 (0%)	0 (0%)	8 (1.58%)
G (B4)	0 (0%)	0 (0%)	4 (0.79%)
G (C6)	0 (0%)	0 (0%)	3 (0.59%)
H (B4)	0 (0%)	0 (0%)	10 (1.98%)
J (B4)	0 (0%)	0 (0%)	2 (0.40%)
J (E10)	0 (0%)	0 (0%)	5 (0.99%)
K (B4)	0 (0%)	0 (0%)	2 (0.40%)
M (B4)	0 (0%)	0 (0%)	3 (0.59%)
N (B4)	0 (0%)	0 (0%)	3 (0.59%)
P (B4)	0 (0%)	0 (0%)	5 (0.99%)
S (A5)	0 (0%)	0 (0%)	3 (0.59%)
S (C6)	2 (0.40%)	0 (0%)	32 (6.32%)
N/A (A5)	0 (0%)	0 (0%)	12 (2.37%)
N/A (A6)	0 (0%)	0 (0%)	3 (0.59%)
N/A (B5-B6)	0 (0%)	0 (0%)	4 (0.79%)
N/A (C6)	0 (0%)	0 (0%)	1 (0.20%)
N/A (C9)	0 (0%)	0 (0%)	2 (0.40%)
N/A (F)	0 (0%)	0 (0%)	0 (0%)
N/A (N/A)	1 (0.20%)	0 (0%)	2 (0.40%)
TOTAL	17 (3.36%)	1 (0.20%)	485 (95.85%)

Appendix 4.3. Obsidian count by *capa* and source-type (Sub-sector in parentheses.)

	Alca	*Puzolana*	*Quispisisa*	*N/A*
Huarpa	4 (36.36%)	1 (100%)	170 (50%)	1 (50%)
Huarpa, Wari A	6 (54.54%)	0 (0%)	111 (32.65%)	1 (50%)
Huarpa, Wari A, Wari B	0 (0%)	0 (0%)	13 (3.82%)	0 (0%)
Wari A	0 (0%)	0 (0%)	2 (0.59%)	0 (0%)
Wari B	1 (9.09%)	0 (0%)	4 (1.18%)	0 (0%)
Wari A, Wari B	0 (0%)	0 (0%)	40 (11.76%)	0 (0%)
Total	11 (100%)	1 (100%)	340 (100%)	2 (100%)

Appendix 4.4. Obsidian source-type by time period, percentage by source-type assemblage.

	Alca	*Puzolana*	*Quispisisa*	*N/A*
Biface	0 (0%)	0 (0%)	22 (4.54%)	0 (0%)
Core	0 (0%)	0 (0%)	1 (0.21%)	0 (0%)
Flake	8 (47.06%)	0 (0%)	255 (52.58%)	1 (33.33%)
Fragment	7 (41.18%)	0 (0%)	186 (38.35%)	1 (33.33%)
Nodule	0 (0%)	1 (100%)	0 (0%)	0 (0%)
Point	2 (11.76%)	0 (0%)	20 (4.12%)	1 (33.33%)
Uniface	0 (0%)	0 (0%)	1 (0.21%)	0 (0%)
Total	17 (100%)	1 (100%)	485 (95.85%)	3 (100%)

Appendix 4.5. Obsidian source-type by artifact type, percentage is by source-type.

	Alca	*Puzolana*	*Quispisisa*	*N/A*	*Total*
6.35–12.7mm	0 (0%)	0 (0%)	2 (100%)	0 (0%)	2 (100%)
12.7–25.4mm	2 (1.61%)	0 (0%)	122 (98.39%)	0 (0%)	124 (100%)
>25.4mm	6 (4.35%)	0 (0%)	131 (94.93%)	1 (0.73%)	138 (100%)

Appendix 4.6. Obsidian source-type by flake size-grade, percentage by flake size-grade assemblage.

	Alca	*Puzolana*	*Quispisisa*	*N/A*	*Total*
0% Cortex	0 (0%)	1 (100%)	0 (0%)	0 (0%)	1 (100%)
1–49% Cortex	0 (0%)	0 (0%)	7 (100%)	0 (0%)	7 (100%)
50–99% Cortex	0 (0%)	0 (0%)	78 (100%)	0 (0%)	78 (100%)
100% Cortex	15 (4%)	0 (0%)	358 (95.47%)	2 (0.53%)	375 (100%)

Appendix 4.7. Obsidian source-type by cortex.

	Alca	*Puzolana*	*Quispisisa*	*N/A*	*Total*
Feathered	7 (5.22%)	0 (0%)	126 (94.03%)	1 (0.75%)	134 (100%)
Hinged, Stepped, Overshot	1 (0.79%)	0 (0%)	125 (99.21%)	0 (0%)	126 (100%)

Appendix 4.8. Obsidian source-type by flake termination, percentage is of termination assemblage.

	Alca	*Puzolana*	*Quispisisa*	*N/A*	*Total*
Flat	0 (0%)	0 (0%)	80 (100%)	0 (0%)	80 (100%)
Complex	6 (5.41%)	0 (0%)	104 (93.69%)	1 (0.90%)	111 (100%)
Cortical	0 (0%)	0 (0%)	30 (100%)	0 (0%)	30 (100%)

Appendix 4.9. Obsidian source-type by striking platform, percentage is of platform assemblage.

	Alca	*Puzolana*	*Quispisisa*	*N/A*	*Total*
0 Flake Scars	1 (0.91%)	1 (0.91%)	107 (97.27%)	1 (0.91%)	110 (100%)
1 Flake Scar	2 (2.33%)	0 (0%)	83 (96.51%)	1 (1.16%)	86 (100%)
2-5 Flake Scars	2 (2.13%)	0 (0%)	92 (97.87%)	0 (0%)	94 (100%)
> 5 Flake Scars	10 (5.85%)	0 (0%)	161 (94.15%)	0 (0%)	171 (100%)

Appendix 4.10. Obsidian source-type by flake scar, percentage is assemblage of flake scar.