# X-Ray Fluorescence Analysis of Obsidian Associated with Late Archaic Sites in Southwestern Idaho and Southeastern Oregon: Issues in Addressing Mobility

A Thesis

In Partial Fulfillment of the Requirements for the

Degree of Master of Arts

with a

Major in Anthropology

in the

College of Graduate Studies

University of Idaho

By

Chris A. Willson

December 2005

Major Professor

Dr. Robert Lee Sappington

# AUTHORIZATION TO SUBMIT

# THESIS

This thesis of Chris A. Willson submitted for the degree of Master of Arts with a major in Anthropology and titled "X-Ray Fluorescence Analysis of Obsidian Associated with Late Archaic Sites In Southwestern Idaho and Southeastern Oregon: Issues in Addressing Mobility," has been reviewed in final form. Permission, as indicated by the signatures and dates given below, is now granted to submit final copies to the College of Graduate Studies for approval.

Major Professor ______________________________ Date____________

Dr. Robert Lee Sappington

Committee Members ______________________________ Date____________

Dr. Laura Putsche

______________________________ Date____________

Dr. Peter Issacson

Department Administrator ______________________________ Date____________

Dr. Don Tyler, Chair

Discipline's College Dean ______________________________ Date____________

Joe Zeller, Dean

Final Approval and Acceptance by the College of Graduate Studies

______________________________ Date____________

Margrit von Braun, Dean

**Abstract**

Examination of data generated from X-ray Fluorescence (XRF) analysis has provided information relevant for exploring relationships between Late Archaic archaeological sites and the various obsidian sources located in southwest Idaho and southeast Oregon. Through Geographic Information Systems (GIS) software, sites and obsidian sources are examined using spatial analysis. This analysis includes the aspect and slope near source coordinates, relative and actual distances, cluster analysis of obsidian coordinates, and terrain analysis of riverine systems and hydrologic activities. This study examines potential patterns found in the region and addresses the issues raised in attempting to identify degrees of mobility using data generated through XRF analysis. Consequently, after critical examination of recent literature regarding hunter-gatherer mobility and through data retrieved during this study, it is determined that XRF analysis is not a sufficient technique for addressing hunter-gatherer mobility.

**Acknowledgements**

I am indebted to a number of individuals whose assistance has been invaluable during this project. My advisor and committee chair, Dr. Robert Lee Sappington at the University of Idaho, and my mentor, Dr. Mark G. Plew at Boise State University for seeing me through the process and keeping me focused. I would also like to thank Dr. Laura Putsche and Dr. Peter Issacson for serving on my committee, and my family for their patience.

This research was made possible in part by grants from the John Calhoun Smith Foundation, the Donald E. Crabtree Scholarship through the University of Idaho, and from the Northwest Research Obsidian Studies Laboratory in Corvallis, Oregon.

# Table of Contents

# List of Figures

# List of Tables

## CHAPTER ONE: INTRODUCTION

This thesis examines X-ray Fluorescence (XRF) data for 255 obsidian samples from 17 Late Archaic (ca. 1,500-250 B.P) sites located along the Middle Snake River in Idaho and in the Owyhee canyons in southeastern Oregon (Figure 1). The XRF analysis with the aid of Geographic Information System (GIS) software is used to examine the relationships between archaeological sites and obsidian sources.

Using GIS software, archaeological sites and obsidian sources are plotted, given coordinates, and then interpolated using spatial analysis. This analysis includes the aspect and slope near source coordinates, relative and actual distances through predefined buffer zones, cluster analysis of obsidian coordinates that examine the density of source points within a landscape and terrain analysis of riverine systems and hydrologic activities. This allows for a virtual examination of site to source corollaries that could not be accomplished under normal circumstances.

The focus of this study is to determine whether or not it is possible to identify degrees of mobility using XRF data. Consequently, a critical examination of recent literature regarding hunter-gatherer behavior and research suggests obsidian sourcing data can be used to discern mobility patterns (see Holmer 1997; Hughes 1996; Jones et al. 2003; Plager 2001). Although there is agreement among many archaeologists that Late Archaic hunter-gatherer groups were highly mobile and capable of moving great distances to obtain resources when necessary it is also agreed that many factors would have influenced this behavior.

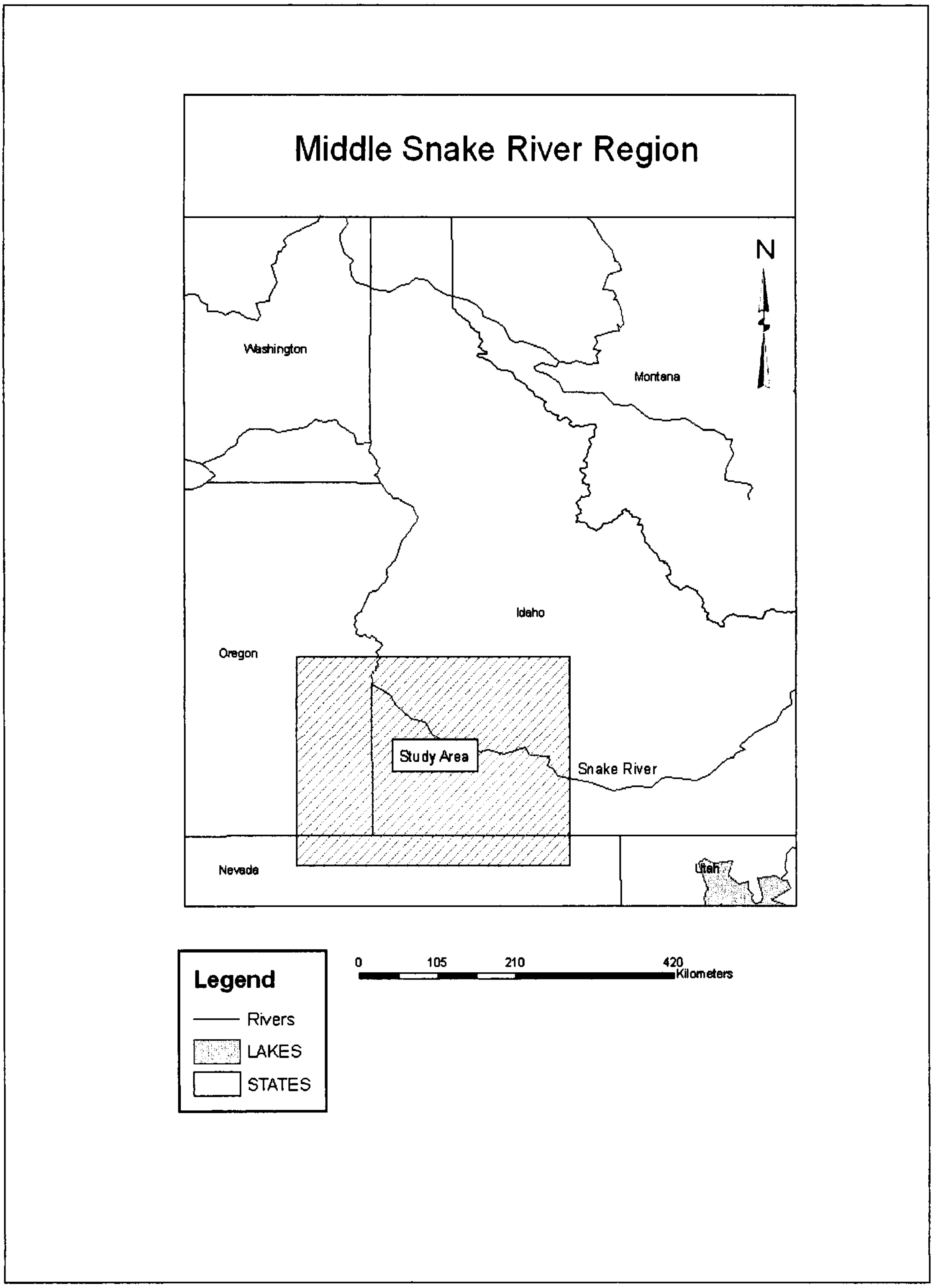



Figure 1. Regional map of the study area.

The archaeological record suggests that in addition to mobility, many behavioral adaptations such as settlement patterns and resource acquisition began to change markedly due to a number of reasons during the Late Archaic (Aikens 1984; Mehringer 1985:167-189). The means by which resources were ultimately obtained and the mechanisms for transporting these resources cannot be fully understood simply through identifying relationships of volcanic glass sources and archaeological site locations.

Kelly (1983b, 2001:37-38) suggests that it is likely that highly mobile groups move across a given landscape in relationship to resource availability and adapt to their environment by exploiting resources as they become available. Given this, environmental changes over time may have altered these behavioral patterns and can be seen in variations within the archaeological record relating to the acquisition of stone resources.

In addition to environmental changes, a variety of variables would have affected the decisions made by hunter-gatherers regarding mobility. This thesis will present alternatives to the conclusions made concerning mobility patterns in the region (see Jones et al. 2003). These alternative variables include natural movement of volcanic glass, trade, issues relating to resource value, recycling and re-use, and the limitations due to missing data and unknown variables.

Recent XRF studies attempt to address and discuss behaviors associated with mobility and aboriginal territories (Jones et al. 2003), and consequently infer human behavior exclusively based on the overall distribution of lithic materials (Holmes 1997; Plager 2001). However, these inferences are not entirely demonstrable. The issues in addressing questions such as the variation in behavior over time and more discrete behavioral adaptations such as resource value and decision-making strategies though XRF data analysis are many. Without the consideration of other behavioral variables it is inappropriate to directly infer patterns witnessed through XRF analysis to patterns of behavior.

For example, hunting, butchering, and processing tasks often display varied levels of technological organization and development that were modified over time (Bradley 1987; Kelly 2001:73). These processes should be witnessed in the archeological record and considered as the starting point before any hypothesis is generated for discussion. This is problematic in recent studies (Jones et al. 2003; Plager 2001) because XRF results do not address these issues directly.

When attempting to address mobility based on XRF data, analysis is often tethered to site and source, creating a linear model while associations or relationships between the two are overlooked. This linear model fails to account for variables regarding specific tasks, time, return rates, fortuitous acquisition, and individual value of material, partly because these discrete behaviors cannot be fully evaluated. It is feasible that by creating a large detailed database through XRF analysis of obsidian, some patterns will emerge and can be adequately explored as supporting evidence for trade activities, resource acquisition, and mobility patterns. The data generated are evaluated using previous models as a means to explore mobility and to investigate whether XRF analysis is an appropriate technique for examining these behaviors.

This thesis is organized into eight chapters. This first chapter is comprised of three subsections: Chapter one is the introduction, an overview of XRF studies including the XRF process, and a methods section. Chapter two contains a discussion of the overall environmental context for the region. Chapter three provides the ethnographic description and chapter four presents the archeological descriptions for the region. Chapter five describes the sites selected for southwestern Idaho and the XRF results for each site. Chapter six is a description of southeastern Oregon sites and XRF results for the region. Chapter seven discusses previous literature regarding mobility and discusses issues in the models generated through XRF studies. Chapter eight is the conclusion.

## XRF Research

Until thirty years ago, lithic sourcing data were largely ignored. XRF analysis begins in earnest with Sappington's 1970s work and subsequent publications (1981a, 1981b, 1982, 1984). The fact that obsidian and other volcanic glasses contain unique geochemical signatures has allowed archaeologists to identify source locations. This technique has become widely utilized as a mechanism for hypothetically determining relationships between obsidian sources and artifactual evidence (Hanes 1988; Jones et al. 2003; Plager 2001). Interpretation of XRF data have led to hypotheses regarding how early hunter-gatherers obtained these materials and have been expanded to include behavioral adaptations such as mobility (Jones et al. 2003). Craig Skinner (2005), director of the Northwest Research Obsidian Studies Laboratory in Corvallis, Oregon, states that different classes of artifacts will tend to reflect different procurement behaviors and patterns. This suggests that In general, formed tools such as projectile points will tend to come from a wider variety of sources with higher source diversity than unformed, utilitarian artifacts or debitage.

Because of the pioneering work of Sappington (1981a, 1981b), Hanes (1988), and recent research by Skinner (2005), the ability to source lithic materials in the region has become widely accepted as an applicable and reliable method. In recent years it has become economically and logistically practical which has consequently increased the frequency of XRF analysis and has increased the breadth of data generated by the process.

The process by which results are obtained through XRF analysis involves both analytical and chemical aspects: X-rays shining on a sample excite the atoms of the sample, causing them to emit (fluoresce) characteristic radiation (x-rays). Each chemical element emits its unique set of x-ray "lines." Analysis of the spectrum of the emitted radiation provides the elements that are present (based on the occurrence of characteristic x-ray lines) and the concentrations of those elements.

Depending on the current configuration of the spectrometer (for information see Skinner 2005), one can use XRF to analyze most of the elements on the periodic table, from boron (atomic number 5) to uranium (atomic number 92). The Northwest Research Obsidian Studies Laboratory spectrometer is currently configured for the analysis of samples for eleven different trace element concentrations (Ti, Mn, $Fe_2O_3^T$, Zn, Ga, Rb, Sr, Y, Zr, Nb, and Ba) and such analysis is completed using a Spectrace 5000 energy dispersive X-ray fluorescence spectrometer. The system is equipped with a Si(Li) detector with a resolution of 155 eV FHWM for 5.9 keV X-rays (at 1000 counts per second) in an area 30 $mm^2$. Signals from the spectrometer are amplified and filtered by a time variant pulse processor and sent to a 100 MHZ Wilkinson type analog-to-digital converter. The X-ray tube employed is a

Bremsstrahlung type with a rhodium target and 5 mil Be window. The tube is driven by a 50 kV 1 mA high voltage power supply, providing a voltage range of 4 to 50 kV (Skinner 2005).

After receiving the results, analyzed specimens that have trace elements matching a known source are organized into a data table. Known sources have been given names such as Timber Butte, Owyhee, and Sinker Canyon. These names are generally associated with a geographic area. This data table is the primary source of analysis for the archaeologist because any variations in trace elements are reflected here.

Skinner (2005) suggests that "more samples equals greater source diversity" and states that "greater numbers of analyzed artifacts tend to yield larger numbers of different individual sources." This is the case in most regions, especially in areas where there is little source variation. This does not seem to be the case in southern Idaho and in southeastern Oregon. Data suggest that three sources, Timber Butte, Owyhee, and Brown's Bench occur most frequently in the material record, and that the degree of variation within the samples is high.

**Methods**

With the assistance of the University of Idaho's John Calhoun Smith grant, the Northwest Research Obsidian Studies Laboratory grant, and the Boise State University Archaeological Research Facility, sixty-two obsidian samples from eleven Late Archaic sites located in the Snake River region and in the Owyhee canyonlands of southeastern Oregon were submitted for X-Ray Fluorescence analysis. The experimental process utilized geochemical data to examine known parent sources of lithic material and any relationships to

Late Archaic stone artifacts recovered from archaeological sites. Given that experimental studies are often difficult, developing a set of guidelines proved most practical in choosing archaeological sites and samples for study.

Using GIS software, this project geographically represents the relationships between obsidian sources and archaeological sites located along the Snake River Region southwestern Idaho and southeastern Oregon. This study of obsidian site/source correlations through XRF analysis allows for the discussion of site locations, site type, mean and actual distances to obsidian source coordinates, source descriptions, and regional landscape variations.

The Late Archaic period (ca. 1,500 to 250 B.P.) on the Snake River Plain is analogically defined by three distinct technological innovations and events (Butler 1978; Gould 1990; Plew 1986a, 2000), these are the presence of pottery, the presence of Rose Spring and Desert Side-Notched points, and the presence of Euro-American items such as glass beads, copper, and brass. The decision to use Late Archaic sites in this study was made due to the availability of artifacts and the greater geographic distribution of sites in the region.

Of the eleven sites selected for this study, all met at least two of the three criteria. The samples for this study were selected solely on the availability of artifacts that maintained Late Archaic (ca. 1,500 to 250 B.P.) attributes and were adequate for XRF analysis (see section on XRF process).

Although this case study provided 93% (58/62) usable results, an initial strategy was developed to minimize error. Since XRF analysis often yields 40-50% of samples inconclusive, five to ten samples were selected from each of the 11 sites. By considering a broader geographic area and controlling for temporal component by selecting formal artifacts instead of debitage, which are insufficient as temporal indicators, results are expected to provide a broader picture of the lithic use for the region during this period in time.

To best control the time components, samples were chosen from sites with known provenience, associated features such as house structures and similar features, and proximity to relative and actual dating, and/or culturally distinct, typologically identifiable artifacts. Preexisting XRF data is included in this study, bringing the total sites to 17 with 255 samples included in the analysis and discussion. In most cases, the three aforementioned attributes used to analogically define the Late Archaic were not used to include or exclude preexisting data sets. All data were included and analyzed.

# CHAPTER TWO: ENVIRONMENTAL CONTEXT

Humans may not appear to qualify as sensitive biotic indicators (Mehringer 1985:167-168), but the array of cultural materials testifies to adaptation to environmental diversity over time. This is crucial in developing appropriate archaeological analogies regarding the use of resources, cultural adaptations, and the acclimatization of prehistoric people of the Snake River Plain and its surrounding regions, since the larger environmental context cannot be viewed as homogeneous.

The areas in and around the region are comprised of several geological features that result in immense variation in the landforms, climate, and floral and faunal distributions (Plew 2000:11) which would have had a profound impact on the cognitive decisions and distribution of people living in the area. Recent literature has demonstrated that these environmental variations are not always considered in the descriptions of archaeological diversity and prehistoric behavior (Jones et al. 2003). In fact, it has become commonplace to include sections regarding the environment in all archaeological descriptions and survey reports, with little regard for analogical discussion of the potential impact on the overall interpretations.

Considering modern environmental and paleoenvironmental complexity and the multiplicity of change over time is imperative in developing constructive analogies about the use of natural resources. Furthermore, these considerations are crucial in identifying any departure from what is reasonably expected in the archaeological record. This is especially critical when examining more complicated hunter and gatherer behaviors such as mobility patterns, subsistence, settlement patterns, and unique technological adaptations made for successful existence on the prehistoric Snake River Plain.

XRF studies should not only append and support the archaeological record, but also provide invaluable data in the discussion of the formation of the geologic landscape. Volcanic activities, especially in the Snake River region, are central in any discussion of the changes that have occurred over time and the mechanisms by which materials move and change (Sheets et al. 1979:4-6). These macro- and micro-environmental changes are expected to influence human adaptations to the environmental conditions (Kelly 2001: 23-24; Mehringer 1985:167-168) and thus, such variables are included in this study.

Archaeologists are often faced with challenges while attempting to interpret the behaviors of prehistoric people. Evidence is often latent, and disturbance from farming, public land use, vandalism, looting, and increasing land development, further complicates the process. Environmental changes can sometimes be extreme and occur rapidly, as in the case of the Bonneville flood. More often, they are subtle and impact the area in ways not readily visible through conventional archaeological investigations.

Considering the variables that may have impacted the decisions of people living in a region is imperative in addressing the reality of prehistoric behavior. It is not appropriate to base interpretations on modern climates and contemporary resource availability. Additionally, it is not appropriate to infer behavior solely on ethnographic accounts of resource use and mobility patterns since the multiplicity of changes over time are not entirely understood. The question then, becomes a matter of extrapolating data in a way that combines quantitative data with careful analogy and inference.

The area of the Middle Snake River in southwestern Idaho and the Owyhee Canyon in southeastern Oregon is a diverse landscape primarily formed from volcanic eruptions and persistent alluvial and aeolian-driven agencies (Plew 2000:03). Within these larger geologic contexts are smaller ecological niches and zones (Malde 1965:255), all of which have changed dramatically over time, most notably during the past 10,000 years (Mehringer 1985:167-168). It appears that environmental transformations in this area occurred gradually in some regions and relatively rapidly in others. Such changes would have impacted the availability of selected staple resources, as well as mean temperature, yearly rainfall, and snow accumulations.

Generally, the region is characterized by unique geological features. The landscape began to form nearly 12 million years ago with eruptions of rhyolites and basalts, forming the mountains and expansive lava fields existing today (Hackett and Bonnichsen 1995:37-38). Pluvial lake sediments and pillowed basalts suggest that large Pleistocene lakes formed across the entire basin (Plew 2003:11). The largest of these Tertiary lakes was Lake Idaho, expanding into the western and central plains and reaching a maximum of 1,158.25 meters above sea level. As the lake drained nearly one million years ago, the Snake River was formed from the headwaters of the Salmon which had previously emptied into the lake (Thornbury 1965). Many smaller rivers that drained into the lake were left perched about the lake floor (Plew 2000:13). As these large catch basins drained downward, they formed the canyons of the Bruneau and Owyhee in southwest Idaho and southeastern Oregon (Hackett and Bonnichsen 1995:38).

These events laid the foundation for a diverse ecological system that can be currently witnessed as a dynamic landscape. Within this larger environmental context and dispersed within the various regional zones are smaller, more specific and consequently more sensitive ecological niches (Kuchler 1964). Minor changes in temperature and precipitation either sustain or eliminate the fragile biome (Kelly 1996; Mehringer 1985:167-168) thus resulting in a distinct and marked change in the ecosystem.

During the warming period of the late Pleistocene (ca. 15,000-12,000 B.P.) the Ice age alpine glaciers receded gradually northward, draining into the Great Basin (Barnosky et al 1987:289). The result was the formation of Lake Bonneville. A glacial moraine formed on the northern edge of the lake and as warming continued, the lake filled to capacity until it burst catastrophically nearly 14,500-12,500 B.P. (Figure 2). The result was devastating to riverine biomes since the canyons of the Snake River were ripped apart and millions of tons of debris were carried in a total flood volume believed to be nearly 380 cubic miles (Malde 1965).

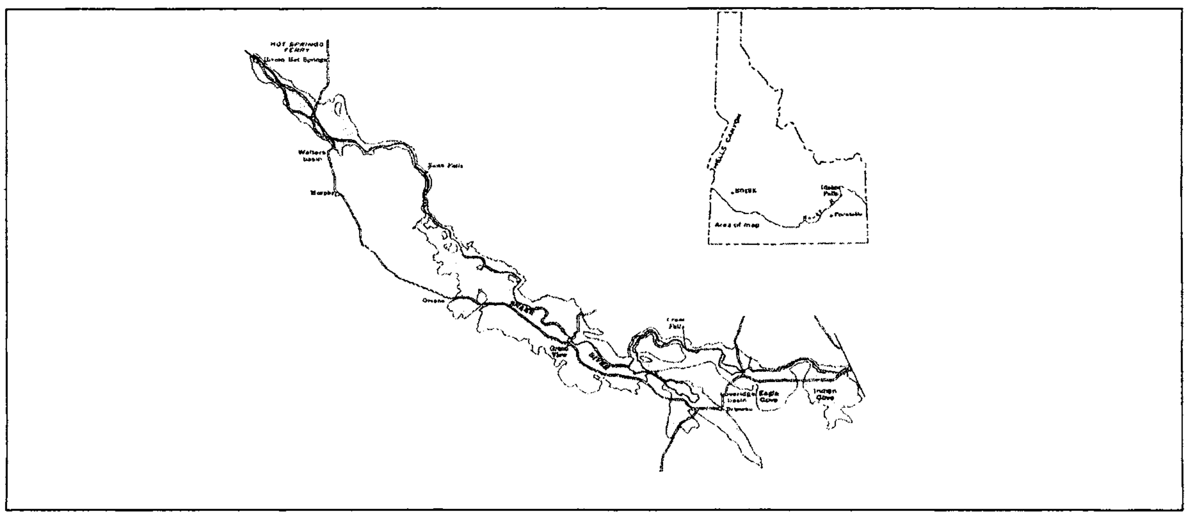


Figure 2. Bonneville flood path adapted from figures in 1965 U.S. Geological Survey Professional Paper 596, by H. E. Malde.

The Snake River Plain is a section of the High Lava Plain Subprovince of the Intermontane Province as defined by Freeman, Forrester and Lupher (1945) and is characterized as an arc curving 560 kilometers east to west and 110 kilometers north to south across southern Idaho (Malde 1965:255) (Figure 3).

In total, the area encompasses approximately 61,000 square kilometers (Freeman et al. 1945:71). Ninety percent of the Snake River Plain section is covered with Quaternary basalts (Thornbury 1965). Malde (1965:255) contends that the "Quaternary features of the Snake River Plain express the latest stages of tectonic and depositional events that began in late Tertiary times." Owing to the recent nature of the Snake River basalts, many areas are characterized by minimal soil cover suitable for sustaining vegetation (Thornbury 1965:459).

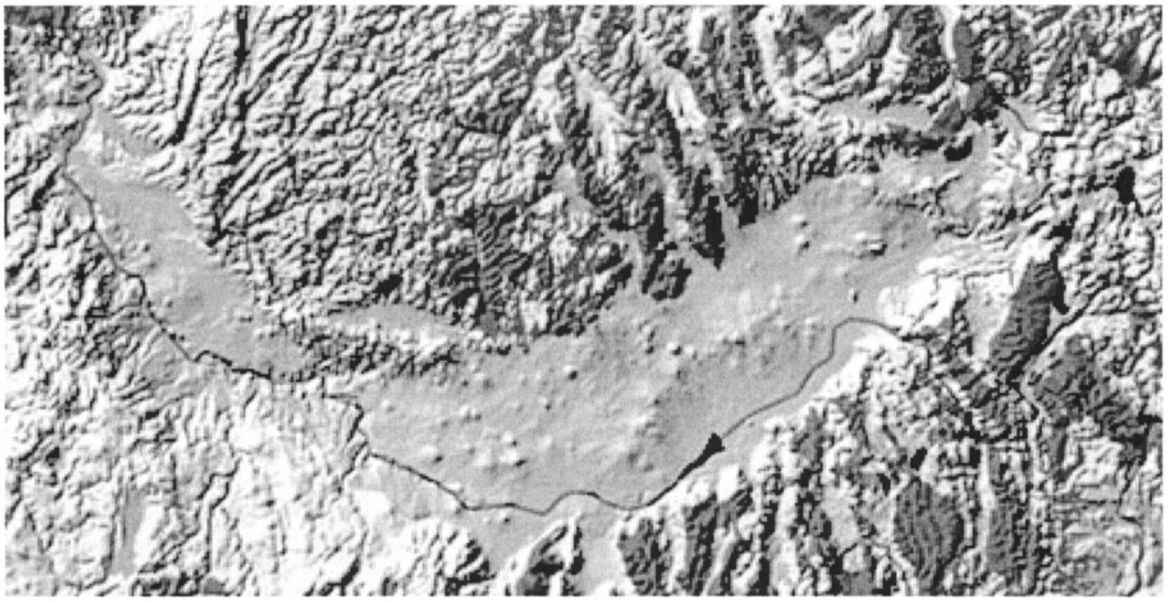


Figure 3. Arc as described by Malde 1965:255
Source: http://nationalatlas.gov/articles/geology/features/snakeriver.html.

The Middle Snake River area is characterized as having five major geological episodes, including the Glenns Ferry Formation, Tuana Gravels, Bruneau Formation, Eastern Snake River Plain lava flows, and Melon Gravels (Malde 1965:258-261). The Glenns Ferry Formation contains extensive but poorly consolidated clastic material including detrital sedimentary rocks of shale, siltstone, and sandstone, in minor basalt flows, little precipitated material, and few ash beds (Malde 1965:258). The Tuana Gravels document some canyon cutting and are associated with pebble and cobble gravel combined with sand and silt, whereas the Bruneau Formation is associated with broad valley erosion and consists of clays, diatomites, and beach gravels mixed with basalts. The youngest of these basalts is dated at 1.4 million years (see Malde 1965:260). Additionally, the Block Mesa Gravels comprise a deposit of locally derived sand and gravels approximately 8 meters thick (Malde 1965:259). This formation is associated with partial canyon entrenchment and is capped with a hard calcium carbonate often referred to as "caliche" (Malde 1965:260). Malde (1965) further describes a series of minor episodes involving pebble/gravel outwash and basalt flows associated with canyon/terrace cutting also characterizing the late Pleistocene. Around 14,500-12,500 B.P., melon gravels or rounded boulders and cobbles of local basalts were deposited by the outflow of Pleistocene Lake Bonneville during the Bonneville flood.

An absence of major tributaries flowing into the Snake River contributes to the permeability of the area's lavas (Thornbury 1965:460). The largest and best known group of springs, aptly referred to as Thousand Springs, occurs on the north side of the Snake River between Twin Falls and Bliss, Idaho. The discharge of Thousand Springs is estimated at

40,000 gallons per second (USGS 2005), discharging from alcoves or box canyons, characteristic of the area.

Sediments in this region suggest a succession of alluvial and aeolian materials (Bentley 1981). These consist primarily of silts and sands intermixed with small gravels and underlain by more extensive gravel deposits. Large melon gravels are commonly exposed within the study area as are localized sand dunes.

Vegetation cover currently includes a variety of species adapted to southern Idaho's arid soils (see Soil Conservation Service 1973). Predominant among the species associated with these aridisols are varieties of sagebrush (*Artemisia*), particularly the large sagebrush (*Artemisia tridentata*). Perennial grasses are common, as are varieties of willow (*Salix*) and cottonwood (*Populus*), which border the Snake River and its tributary streams. Other species, including non-native groups, are commonly found as well. These consist of greasewood (*Sarcobatus vermiculatus*), cheat-grass (*Taeniatherum caput-medusae*), Russian olive (*Elaeagnus angustifolia*), and poison ivy (*Toxicodendron radicans*).

Conifers emerge at elevations over 1000 meters at the border of the sage steppe desert. Short grasses and shadscale (*Atriplex confertifolia*) predominate at lower elevations. Varieties of trees and shrubs can be found within the smaller river canyons and near natural springs (Barnosky 1987:299; Henry 1984).

The history of the vegetational fluctuations is primarily based on the well-preserved fossilized dung of now-extinct ground sloth (*Nothrotheriops shastensis*) and pollen samples recovered from dry caves along the southern Snake River province (Mehringer 1985:180-81). These locations contained plant species still occurring in the region along with evidence that indicated significant vegetational changes from 40,000 to 11,000 years ago (Mehringer 1985:167-189).

Among these were woodland trees, including bristle cone conifers (*Pinus aristata*) and white fir (*Abies concolor*), and various highland shrubs which indicate a wetter and cooler desert environment. Only within the past 7,000 to 4,000 years has the region resembled the modern day steppe sage environment. Higher elevations (914 -1,235 meters) were dominated by subarctic alpine conditions (Wells 1983:Table 3) and extended as far south as the Bonneville lakeshore.

Associated with the floral community is a diverse animal population typical of the Northern Great Basin Biotic Complex (Davis 1939:32-34). Species common to the area include mule deer (*Odocoileus hemionus*), bobcat (*Lynx rufus*), yellow bellied marmot (*Marmota flaviventris*), muskrat (*Ondatra zibethicus*), badger (*Taxidea taxus*), coyote (*Canis latrans*), weasel (*Mustela erminea*), mink (*Mustela vison*), and otter (*Lutra canadensis*). Smaller mammals include desert black-tailed jack rabbit (*Lepus californicus deserticola*), Nevada wood rat (*Neotoma lepiola nevadensis*), Townsend pocket gopher (*Thomomys townsendii*), Great Basin chipmunk (*Eutomias minimus scrutator*), Nevada mantled ground squirrel (*Spermophilus lateralis*), Snake River Valley raccoon (*Procyon lotor excelus*), little spotted skunk (*Spilogale gracilis saxatilis*), and the Nevada long-eared desert fox (*Vulpes macrotis nevadensis*) (see Larrison 1967). Mammals found outside the canyon proper include pronghorn antelope (*Antilocapra americana*) and in the early historic period, modern bison (*Bison bison*). Reptiles and numerous species of birds abound (Larrison 1967). Avifauna which reside on a seasonal basis include game birds, waterfowl, and raptors.

Aquatic resources also thrive within the area. Common species include mollusks, varieties of trout, whitefish, squawfish, and sturgeon. Of these, the more important aboriginal resources included chinook salmon (*Oncorhryncus tshawytscha*), steelhead trout (*Salmo gairdnerii*), pikeminnow (*Ptychocheilus oregonensis*), bridgelip sucker (*Catostomus columbianus*), and sturgeon (*Acipenser transmontanus*).

**Archaeological Data Regarding Environmental Change**

Considering these environmental changes to the region is imperative in creating sufficient analogies regarding possible behavioral changes in hunter-gather populations. For example, it is thought that prior to the introduction of cattle, the area was characterized by much higher densities of understory grasses (Yenson 1982). Evidence that these environments have changed over time is also demonstrated by Henry's (1984) investigations at Murphey Rock shelter and Mehringer's (1985) North American pollen studies. Henry argues for a sequence beginning with the appearance of "grass-like" vegetation approximately 10,300 years ago, which he believes supported the megafauna believed common throughout the region during that time period.

Henry (1984) describes a period from 9,990 B.P. to 6,250 B.P. which marks the emergence of the shadschale (*Atriplex confertifolia*) steppe community, and suggests a somewhat warmer and drier climate. Henry's (1984) third brief period between 6,350 B.P. and 5,900 B.P. is characterized by a turn to relatively cooler, moister conditions (also see Butler 1969; Mehringer 1985). It appears that between 5,900 B.P. and 3,500 B.P., sagebrush becomes an important element of the community with a greater diversity of species emerging in the archaeological record. These episodic changes were affected by varied micro-environmental conditions, insinuate patterns which undoubtedly would have affected the mobility behaviors of native populations.

During the Late Archaic, the environment mirrored modern day conditions (Mehringer 1985). Pollen studies to the south support a fairly contiguous environment for 1000-2000 years which further supports data analysis from the Wasden site and Nahas cave site.

Based on events at Wilson Butte Cave (Gruhn 1961a), the Wasden site and Swan Lake (Butler 1978), and a small rock shelter in Southwest Idaho (Henry 1985), it is suggested that a series of climatic ecological periods were apparent. Fluctuations in the climate from about 15,000 years ago and persisting to 10,300 B.P. suggest the conditions were relatively cold to cool-moist with alpine glaciations and more extensive conifer forests in the north (Barnosky et al. 1987). By 13,000 B.P to 8,000 B.P. the Altithermal, a warming trend, commenced (Figure 4) and is characterized by glacial melt and higher water run-offs. From 11,400 to 8,400 B.P., the warming trend affected the retreat of the conifers and allowed for the expansion of sage and grasses (Barnosky et al 1987; Plew 2000).

Pollen samples taken form nearby pluvial lake deposits show an increased density of conifers by 7,200 B.P. (Mehringer 1985:167), but as the warming trend reached its optimum, a retreat of these species to the higher elevations and moister climates occurred. After a minor cooling at about 3,800 B.P., often referred to as the younger Dryas or “Little Ice Age,” conditions stabilized and approximated more modern environmental conditions (Figure 4).

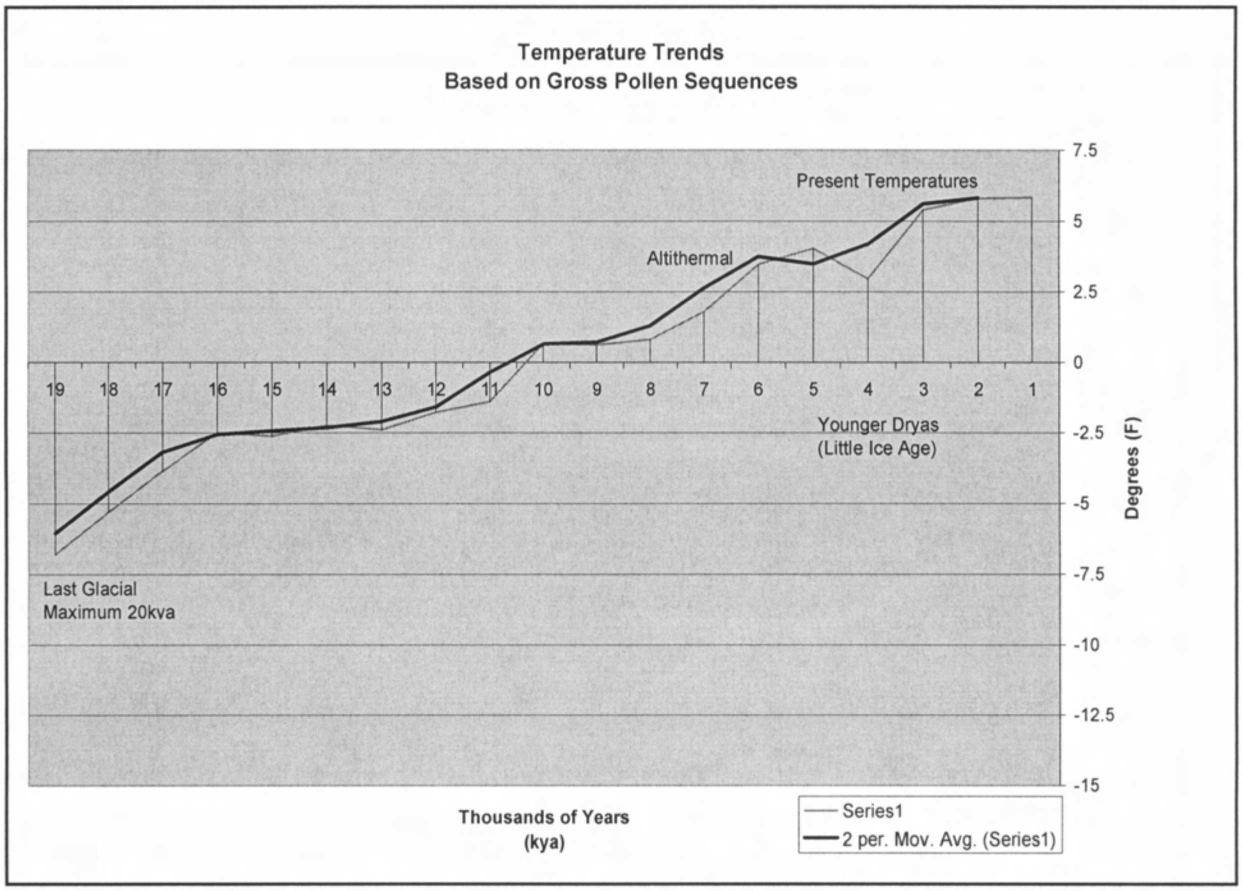



Figure 4. Temperature fluctuations during the late Quaternary period, adapted from Mehringer 1985.

These environmental changes and fluctuations can be examined and interpolated into archaeological studies in a variety of ways. Assemblages of now extinct megafauna and terrestrial mammals coupled with variations in stone tools and lithic source materials, suggest either a dependence or adaptation to the sub-arctic, alpine environment at the beginning of the early Holocene ca. 10,000-8,000 years ago.

# CHAPTER THREE: ARCHAEOLOGICAL OVERVIEW

The earliest evidence of prehistoric occupation in Idaho is from Wilson Butte Cave, located near Eden, Idaho (Gruhn 1961a; Plew 2000). Excavations documented very simple tools in association with camel and horse bones dating to as early as 10,500 years ago. This sheltered site is unique in that the deposits produced evidence for continuous occupations over roughly 10,000 years (Gruhn 1961a). Wilson Butte Cave contained six cultural assemblages associated with six geological strata (Plew 2000), and three of the zones were of Paleoindian (pre-Holocene) age. The later deposits contained the remains of extinct species of camel and horse, which suggests a slightly cooler moister period about 15,000 to 6,500 years ago. Analysis of lithic source materials in Stratum C (Bailey 1992) implies that materials were obtained within 120 km of Wilson Butte Cave, which may indicate a high degree of mobility. However, this distance appears to fall well within the pattern that is evidenced in previous XRF studies for the region and is confirmed by this 2005 study.

Baker Cave, located within the Wapai lava flow near Minadoka, Idaho, contained an important Archaic archaeological component in shallow aeolian (wind) deposits (Plew, Pavesic, and Davis 1987). The site at Baker Cave appeared to be intact and contained a significant archaeological assemblage. The remains of seventeen bison (*Bison bison*) and a collection of stone tools suggested that the site might have been used for butchering and processing. This also indicates that grasslands similar to those of the northern plains region predominated in the region.

The prehistory of the Owyhee Upland-Malheur area of southeastern Oregon parallels the general chronology of southwestern Idaho and northern Nevada. The chronology and culture history as with those of Idaho and Nevada are based upon controlled excavations of deeply stratified caves and rockshelters.

Bedwell (1973) reported a radiocarbon date of 13,200 B.P. for charcoal, making this the earliest occupation of the Owyhee Upland-Malheur area. Though the integrity of the date and its associations has been challenged (see Haynes 1971 in Plew 2004), it remains the earliest date for human use of the area.

The most notable Paleo-Indian discovery was made at the Dietz site in the central portion of southeastern Oregon (Fagan 1988; Willig 1988). Dietz contained 61 fluted projectiles and fragments along with manufacturing tools and though no radiocarbon dates exist, the site is thought to date to about 11,500 years ago. The Folsom horizon is known from a number of isolated finds at such localities as Coyote Flat (Butler 1970) and the Alvord Desert (Pettigrew 1984).

The site at Nahas Cave, located in the Owyhee uplands south of Grandview, Idaho, provided evidence for a tentative chronology and settlement model in the region (Plew 1981, 1986b). Several stone artifacts, including groundstone, in association with a large assemblage of charred animal bone suggest a seasonal hunting camp. Radiocarbon dates confirm that the site was occupied at intervals from 5,900 B.P. to 250 B.P. The material remains, including the presence of modern faunal groups coupled with the radiocarbon dates are relatively consistent with Butler and Henry's climatic-ecological stages.

Excavations at Milner Rockshelter in southern Idaho provided rich evidence of past human occupations (Yohe 2002). The greatest intensity of use appears to have been within the last 2,000 years, but a 5,300 B.P. date and the presence of a typologically distinct Haskett Point, considered to be pre-Archaic, suggests much earlier occupations (Yohe 2002). Analysis indicates that lithic materials were brought to the area from as far as 90 km and locally available materials seem to be primarily associated with expedient use.

Recent excavations at Little Owl Cave in southeastern Oregon recovered a tule-reed bag that was radiocarbon dated to 2,500 B.P (Plew et al. 2003). Bull Creek (Plew and Willson 2004), a rockshelter in southeastern Oregon, provided artifactual evidence of an Early to Middle Archaic occupations (9,000-5,000 B.P.) with evidence of Late Archaic use of the region as seen through Desert Side-Notched points. Excavations conducted in the late 1960s by Butler and reported by Plew et al. (2004) at Antelope Overhang provided evidence for multiple occupations over a long period of time. This was supported by several typologically distinct points and perishable items that provided radiocarbon dates ranging from 9,000 to 1,500 years B.P.

Many Late Archaic sites (ca. 1,500 to 250 B.P.) have been recorded along the Snake River region in southwestern Idaho. Excavated sites along the Snake River near Melba, Idaho, have presented radiocarbon dates of 1,500 to 450 B.P. (Plew et al. 2004). Primary activities seemed to have been short-term occupation with little evidence of defined features. Faunal assemblages included an adolescent and adult deer, various small mammals, and anadromous fish.

In general, the Late Archaic period is characterized by changes in the material cultural most notably the adoption of the bow and arrow (Plew 1986b, 2000:79) and the introduction of pottery. The emergence of Desert Side-Notched and Rosegate points became more common during this period beginning about 1000 years ago, and may represent the widespread replacement of the atlatl and a shift towards hunting smaller mammals.

Aboriginal populations expanded during this period and several settlement and subsistence strategies were established. It appears from the archaeological record that a greater focus by some groups may have been on a single resource (Gould and Plew 1988). Along the Snake River there appears to be a greater emphasis on fishing. Excavations at Three Island Crossing (Gould and Plew 1988) recovered 19,000 fish remains associated with a structure and storage pits.

Population appears to have increased during this time and the settlement patterns were more sedentary. Based on Steward's (1938) observations, there was roughly one inhabitant for every 20 miles$^2$. Based on these calculations, within the 7000 miles$^2$ of Owyhee County, the largest county in Idaho, one would have seen a total population density of about 350 people.

The Snake River area is characterized by an ecological diversity that has changed over time and would have provided a broad spectrum of resources for aboriginal use. A number of the animal and plant species noted above are known ethnographically to have contributed to the native diet (see Steward 1938). Among these are elk, deer, and rabbits, as well as anadromous and non-anadromous fish, all of which would have been available in varying abundance at varying elevations during the different seasons (Figure 5).

Among the varieties of plants located in the region, Steward (1938) documented the use of Great Basin wild rye, shadscale, Indian ricegrass, and various roots and berries for subsistence. Willow and sagebrush were often used for utilitarian purposes (King 1996) such as basketry, arrow shafts, and shelters.

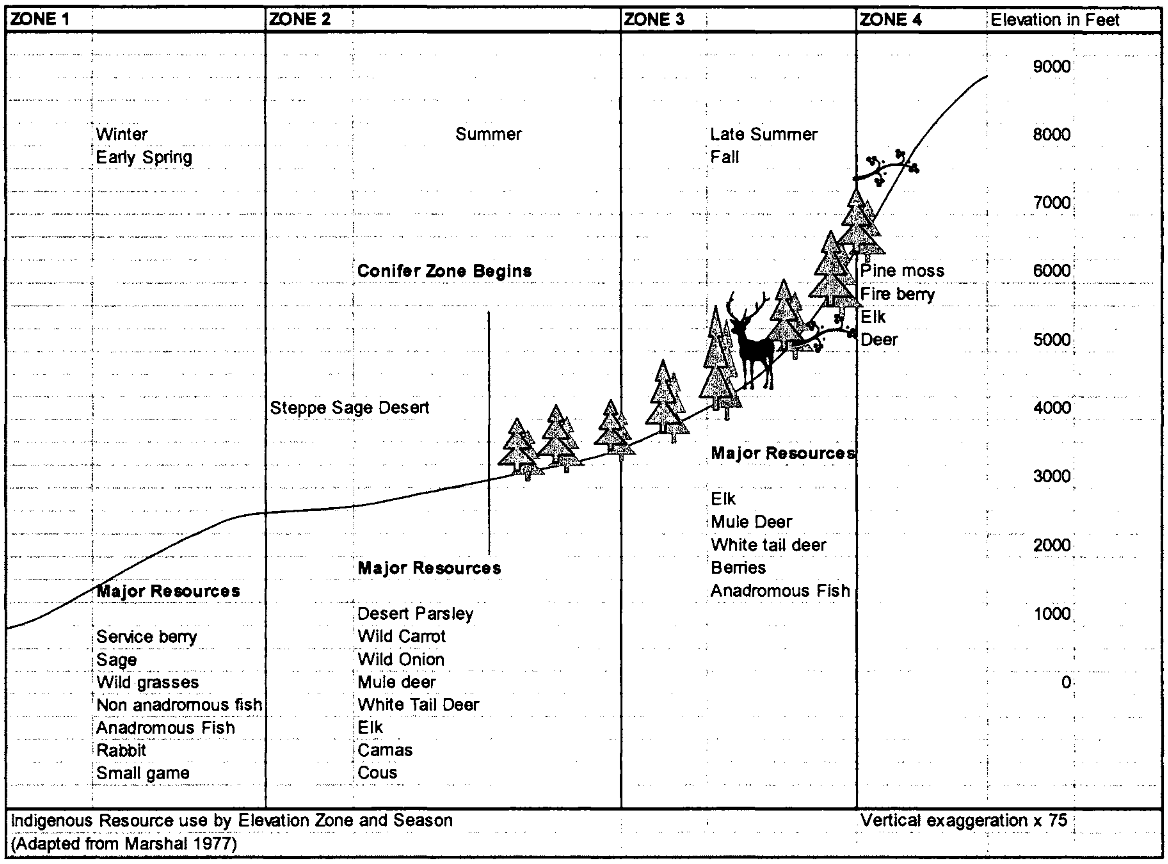



Figure 5. Aboriginal resource use by zone adapted from Marshall 1977.

Use of the area can be separated into elevational zones, each with varied temperature, precipitation, habitats, and ecological niches. These zones would have been utilized seasonally, influencing the behavior patterns of the inhabitants to the region. Based on the ethnographic record, environmental data, and the archaeological record, most mobility patterns would have dictated by the acquisition of these resources and would have varied seasonally over time.

# CHAPTER FOUR: ETHNOGRAPHIC DESCRIPTION

The historic inhabitants of southern Idaho, the Northern Shoshone and Northern Paiute's primary difference is linguistic, (Murphy and Murphy 1986:284) and not technologically or economically defined. There is no ethnographic documentation regarding the use and manufacture of stone tools; hence, the acquisition of obsidian resources is also not clearly documented. However, in order to completely examine all potential drivers for behavioral adaptations, ethnographic work regarding the inhabitants of the region is useful in developing reasonable and informed archaeological analogies for discussion of prehistoric behavior.

Economic lifeways and socio-political organization were similar for the Shoshone--including the Boise, Bruneau, and Weiser subgroups--and the Northern Paiute, and both occupied southwestern Idaho at the time of historic contact (Murphy and Murphy 1960, 1986; Steward 1938; Walker 1978). The Northern Paiute comprised the Payette, Weiser, and Bannock subgroups, with the latter defining a group of mounted hunters who moved eastward to the Fort Hall area during the eighteenth century (Liljeblad 1957:81).

Murphy and Murphy (1960) provide a relatively detailed view of the socio-political organization and economy of Middle Snake River groups. Following Steward (1938), they suggest that the Snake River Shoshone resemble the Western Shoshone of Nevada in social, political, and economic characteristics more than other Idaho groups, noting few horses, no bison hunting activities, and virtually no warfare (Murphy and Murphy 1960:321).

As described by Murphy and Murphy (1960), there were no band chiefs, and winter villages lacked headmen. Generally, the socio-cultural pattern was a rather loose organization in which individuals occasionally were chosen to coordinate specific tasks, such as being "fishing directors" (Steward 1938:168-169).

The principal settlement pattern is one of small aggregates of nuclear families camping together and performing subsistence-related activities as a group, but the composition of a cluster was highly fluid in that allegiances shifted as families moved to pursue different resources (Steward 1970:129-130). Also, a somewhat larger but substantially less common unit was documented, one which consisted of multi-cluster aggregates marking "temporary allegiances for a few corporate activities, such as hunting, or other associations where local resources could support unusual numbers of people" (Steward 1970:130). Although such corporate organizations are known, they certainly were the exception. When looking at the Shoshone of Nevada and those living along the Snake River, Steward (1938:239) is quite clear that "the household was very nearly a self-sufficient economic unit and as such an independent social and political unit."

The common settlement type noted along the course of the Middle Snake River was that of highly dispersed, small winter residences (Murphy and Murphy 1960:322). The area was occupied during that time of year because of a perceived good supply of both wood and shelter. The splitting of residence groups into smaller winter camps of two or three lodges is important in that the same people did not camp together at the same sites each winter (Liljeblad 1957:36; Murphy and Murphy 1960:322). This corroborates Steward's (1938:169) observation that the "true political unit was the village, a small and probably unstable group."

In this context the term "village" as it is now used in specific relation to rank societies implies some greater socio-political complexity than was, in fact, the case among Snake River groups (Liljeblad 1957:35-36).

The major subsistence pursuits of Middle Snake River groups were fishing and camas collecting (Plew 2000). Three major anadromous fish runs during the spring, summer, and fall provided an important food source; two of these were Chinook salmon (*Oncorhynchus tschawytscha*), while the other was comprised of Steelhead trout (*Salmo gairdnerii*).

Ethnographic accounts suggest that southeastern Oregon was inhabited by Uto-Aztecan speaking Northern Paiute groups (Stewart 1938). In general Northern Paiute groups are thought to have consisted of independent family units that remained quite mobile while employing hunting, gathering, and fishing strategies (Fowler and Liljeblad 1986; Steward 1938; Steward and Wheeler-Voegelin 1974). Regardless, it is clear that local groups were loosely integrated and moved frequently on a seasonal basis (Plew et al. 2004). The diversity of the Owyhee terrain and the resource base suggests the likelihood of multiple and overlapping subsistence strategies by local Paiute peoples.

# CHAPTER FIVE: SITE DESCRIPTIONS AND XRF RESULTS FOR SOUTHWESTERN IDAHO

Using GIS software, the sites selected for this study were placed within a digital (30 meter hillshade) elevation model with a z factor of 10. The following figures are the result of this process and have been produced for analytical study with a range of error of 1-2 kilometers. The obsidian source locations were entered based on decimal degree coordinates provided by Craig Skinner at the Northwest Research Obsidian Studies laboratory and represent locations of known and measured points in the landscape, but the totality of the range of obsidian materials that have not yet been identified.

The following figures (Figures 6, 7, and 8) will be referred to for all general discussion in this section with additional figures that illustrate unique landforms and/or potential patterns. The following descriptions of the archaeological sites selected for this study are listed from west to east moving along the Snake River and its surrounding areas. The Oregon locations are listed in the following section and discussed separately.

Of 62 samples submitted for analysis, 58 were returned with positive geochemical source identification. This 93% return rate is very high and increased the potential for analysis greatly. The four undetermined items have been documented to be from the general region but fall within the "unknown" category. This is notable, since the variation of known obsidian locations (i.e. Brown's Bench) leads one to believe that much of the variation returned from the analysis may, in fact, originate from variation in the geochemical signature within a known source. Thus, due to unknown trace elements for the region, many unknown sources may in fact be associated with known sources and simply reflect variation in the geochemical signature.

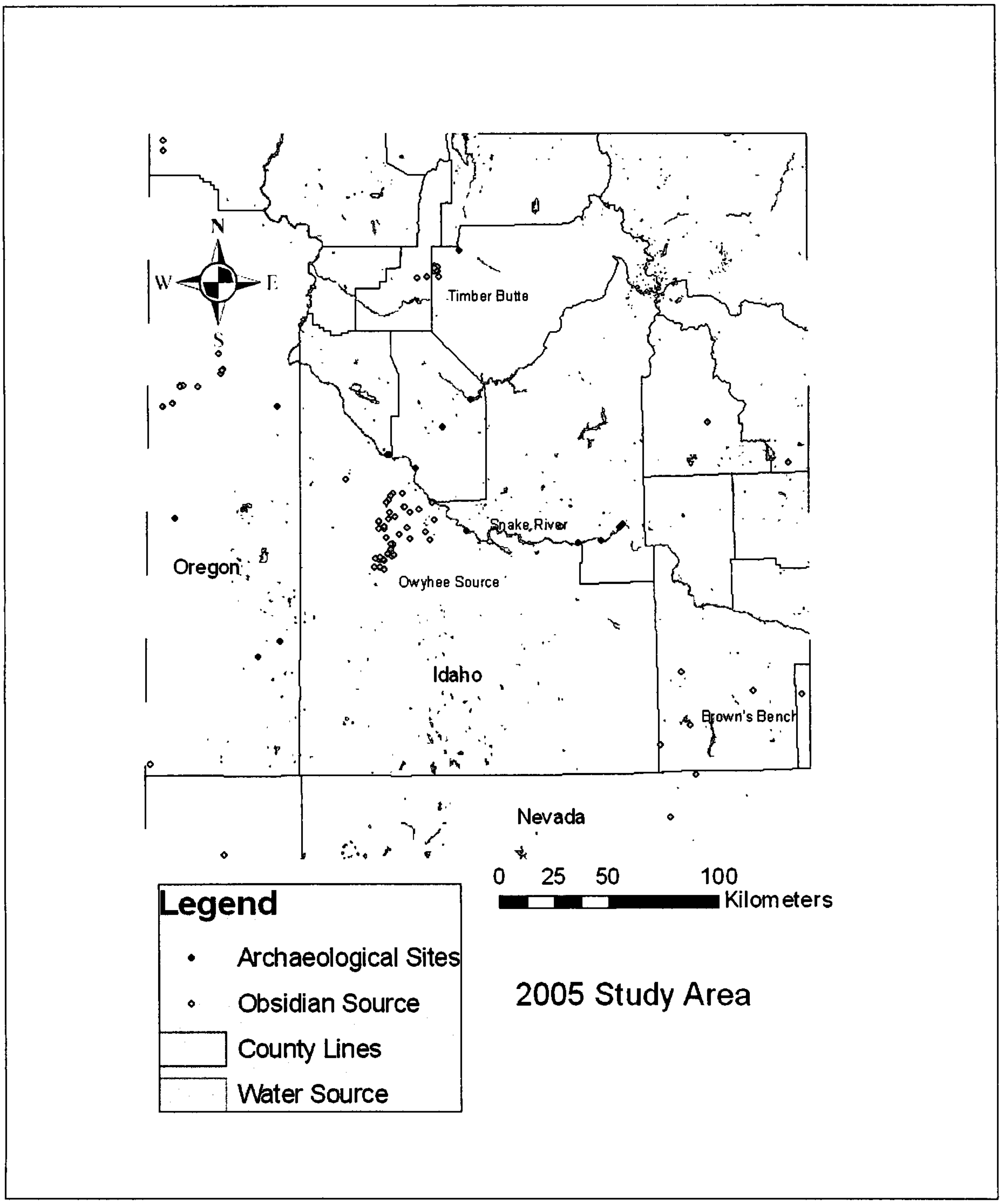
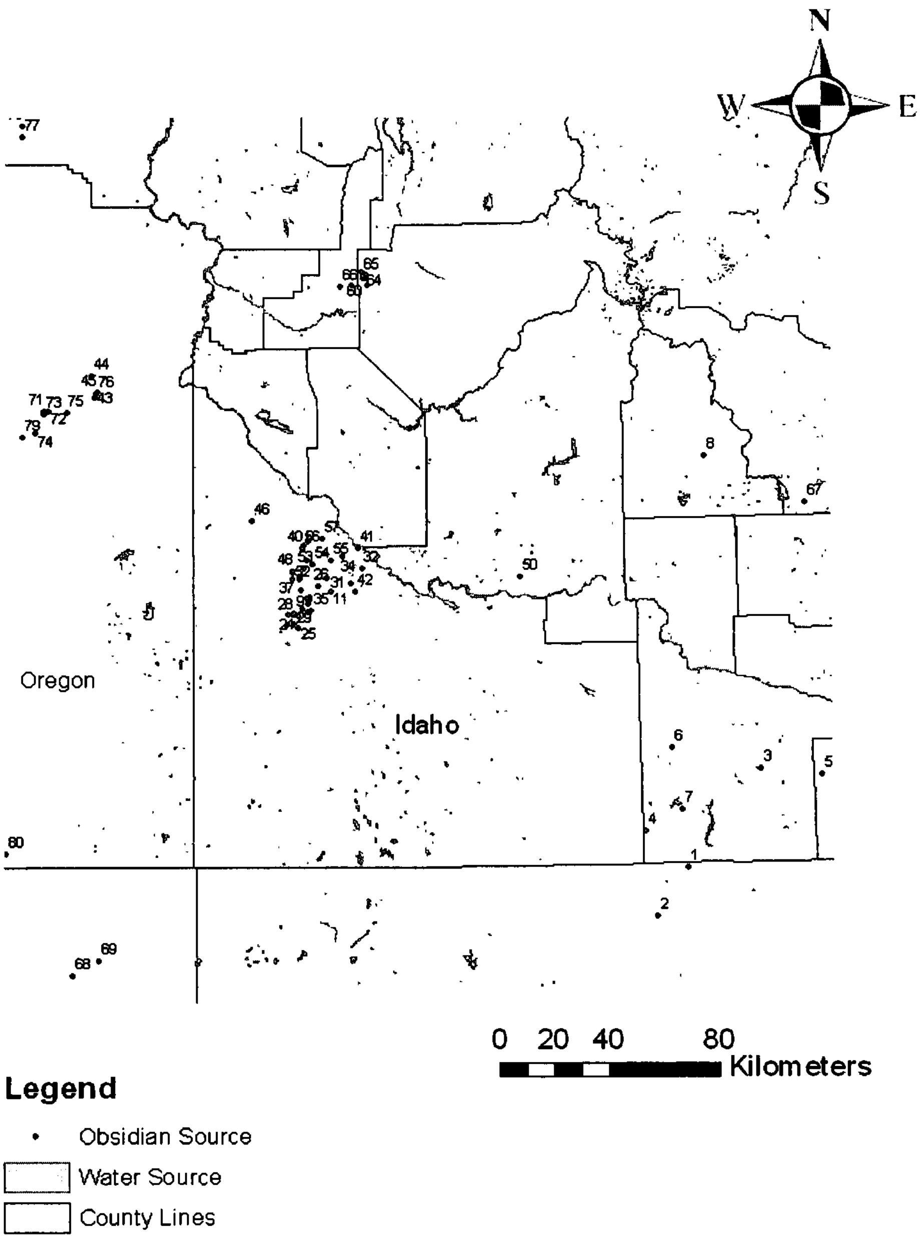



Figure 6. 2005 study area.




1-7= Brown's Bench, 8= Cannonball Mtn., 9-45=Owyhee, 46=Reynolds, 47-57=Sinker Canyon, 58-66=Timber Butte, 67= Wedge Butte, 68-69= Paradise Valley, 78=Indian Creek Buttes, 79= Skull Springs, 80= White Horse

Figure 7. Identified obsidian sources in southwest Idaho and southeastern Oregon.

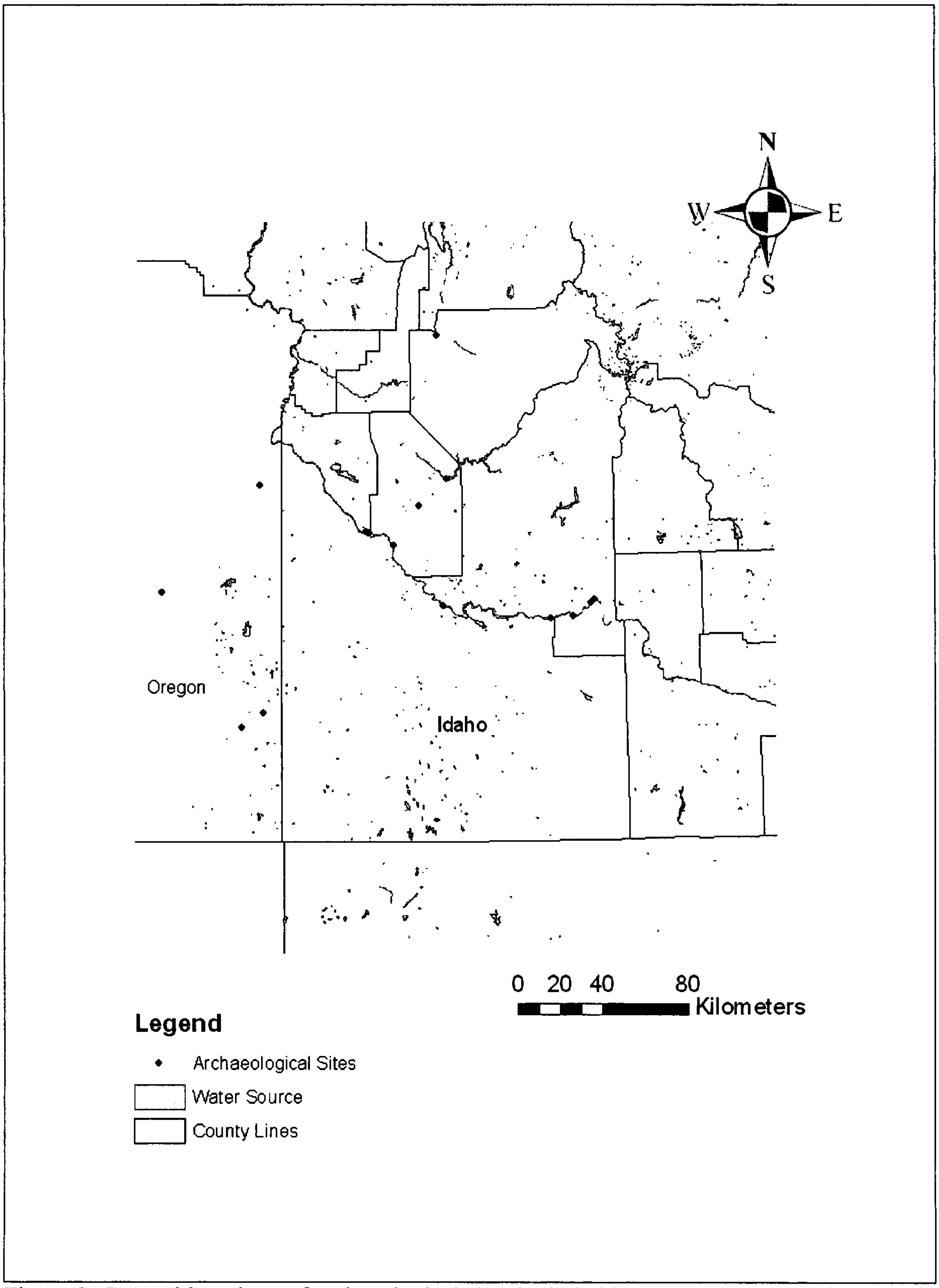



Figure 8. General locations of archaeological sites included in 2005 study.

**10-CN-1**

The site at 10-CN-1 (Sayer et al. 1997) is located just west of Celebration Park near Melba, Idaho. Characterized by three to five stratigraphic horizons, cultural materials were located within approximately two meters of deposition consisting of both alluvial and aeolian sediments. Although the site produced minimal evidence of archaeological features, concentrations of charcoal and variable densities of lithic, bone, shell, and thermally altered rock are highly varied. The recovery of Late Archaic points, such as Desert Side-Notched and Rose Spring, along with a glass trade bead, suggest a temporal time frame consistent with the Late Archaic (ca. 1,500 years to 250 years B.P.).

The five samples selected for analysis returned data for the Owyhee and Timber Butte obsidian source locations. Timber Butte is located roughly 85 km north of the site, and the Owyhee source resides 30-35 km to the southeast. However, both of these sources exist in a fairly mountainous region with slope variations from 0-85 degrees. The landscape is marked by ridges and valleys and in the case of the Owyhee source covers an area of 1280 $km^2$.

These XRF studies are the first ones to be prepared for this site and no preexisting data were available. The sites listed below, 10-CN-5 and 10-CN-6, are within one 1 km of the 10-CN-1. Combined, these three sites provided 34 samples for analysis including lithic debris and formal artifacts. Further information regarding the overall locations of obsidian sources will be combined in the discussion of these sites since it is impossible to separate them by any discrete determinant.

**10-CN-5**

10-CN-5 (Huter et al. 2000) is located within the Celebration Park recreation area approximately four miles south of Melba, Idaho. The site covers an estimated 7200 $meters^2$ with an average depth of 80 cm. Testing of the site produced several sherds of Shoshone Grayware pottery as well as Desert Side-Notched and Rose Spring projectile points, suggesting a Late Archaic component.

Initial XRF analysis indicated obsidian materials were geochemically similar to those at the Owyhee and Coyote Wells source locations ranging from 35-85 km from the site respectfully. For this study, five typologically Late Archaic artifacts were sent for analysis and results were returned for the Timber Butte, Owyhee, Indian Creek Buttes, and Sourdough Mountain sources. This range of locations is interesting since two are in Oregon although not outside of the known range for Late Archaic groups living in the region. However, the locations are commensurate with the Owyhee group (see Figure 7) and cannot be inferred as behavioral indicators.

**10-CN-6**

10-CN-6 (Plew et al. 2004), located less than 200 meters west of site 10-CN-5, is also situated within the Celebration Park recreation area near Melba, Idaho. Although these two sites are near each other, it is not believed that they are spatially connected and no evidence exists to adequately define them as temporally separate. Both sites fall generally within the Middle to Late Archaic Period and demonstrate similar settlement patterns and subsistence strategies. A radiocarbon date taken of a feature located in the 2004 excavations provided a date of 620 B.P. (Plew et al. 2004). This date and the presence of artifactual materials fit to the Late Archaic temporal scheme.

Previous XRF data from 10-CN-6 also documented geochemically distinct materials from the Owyhee and Timber Butte sources, but also included materials from the Coyote Wells source in Oregon. Coyote Wells is located on the northwestern extent of the Owyhee Mountains chain roughly 85 km from the 10-CN-6.

Of the ten artifacts sent for analysis in 2005, nine returned results varying from Timber Butte, Owyhee, and Sinker Canyon, and the slightly northeastern sources, Venator and Coyote Wells. Notable is that the Sinker Canyon, Venator, and Coyote Wells sources are part of a sweeping lava flow that extends southeast to northwest and each has are varied by minor geochemical differences (Table 1).

***Northwest Research Obsidian Studies Laboratory***

Table A-1. Results of XRF Studies: Several Sites in Canyon, Ada, Elmore, and Malheur Counties, Idaho and Oregon

| Site | Specimen No. | Catalog No. | | Trace Element Concentrations Zn | Pb | Rb | Sr | Y | Zr | Nb | Ti | Mn | Ba | $Fe_2O_3^T$ | Ratios Fe:Mn | Fe:Ti | Geochemical Source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10-CN-1 | 1 | A71 | | 55 | 32 | 230 | 35 | 31 | 124 | 13 | NM | NM | NM | NM | 56.7 | 51.7 | Owyhee * |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-CN-1 | 2 | A105 | | 43 | 29 | 185 | 22 | 43 | 58 | 33 | NM | NM | NM | NM | 7.4 | 61.9 | Timber Butte * |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-CN-1 | 3 | A122 | | 39 | 24 | 220 | 30 | 30 | 106 | 9 | NM | NM | NM | NM | 55.7 | 73.9 | Owyhee * |
| | | | ± | 12 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-CN-1 | 4 | A137 | | 57 | 31 | 178 | 26 | 43 | 61 | 34 | NM | NM | NM | NM | 9.3 | 48.1 | Timber Butte * |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-CN-1 | 5 | A138 | | 111 | 23 | 126 | 31 | 65 | 440 | 31 | NM | NM | NM | NM | 31.9 | 47.3 | Coyote Wells * |
| | | | ± | 12 | 6 | 5 | 9 | 3 | 11 | 2 | NM | NM | NM | NM | | | |
| 10-CN-5 | 6 | A5 | | 65 | 25 | 182 | 32 | 51 | 163 | 30 | NM | NM | 147 | NM | 28.0 | 72.1 | Indian Creek Buttes * |
| | | | ± | 10 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | 32 | NM | | | |
| 10-CN-5 | 8 | A34 | | 64 | 31 | 181 | 21 | 38 | 58 | 34 | NM | NM | NM | NM | 7.3 | 50.6 | Timber Butte * |
| | | | ± | 10 | 4 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-CN-5 | 9 | A50 | | 51 | 26 | 239 | 35 | 30 | 111 | 10 | 593 | 346 | 163 | 0.98 | 24.7 | 55.6 | Owyhee |
| | | | ± | 9 | 4 | 5 | 9 | 3 | 10 | 2 | 89 | 28 | 32 | 0.11 | | | |
| 10-CN-5 | 10 | A59 | | 36 | 19 | 134 | 35 | 37 | 207 | 21 | NM | NM | 425 | NM | 46.2 | 40.4 | Sourdough Mountain * |
| | | | ± | 11 | 5 | 4 | 9 | 3 | 10 | 2 | NM | NM | 32 | NM | | | |
| 10-CN-6 | 12 | A34 | | 31 | 20 | 222 | 32 | 25 | 109 | 8 | NM | NM | NM | NM | 72.0 | 67.9 | Owyhee * |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-CN-6 | 13 | A35 | | 59 | 30 | 188 | 23 | 44 | 59 | 33 | NM | NM | NM | NM | 7.1 | 65.1 | Timber Butte * |
| | | | ± | 10 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-CN-6 | 14 | A46 | | 74 | 20 | 114 | 25 | 61 | 428 | 34 | NM | NM | NM | NM | 34.1 | 50.1 | Coyote Wells * |
| | | | ± | 10 | 5 | 4 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-CN-6 | 15 | A48 | | 38 | 31 | 238 | 41 | 30 | 117 | 8 | NM | NM | NM | NM | 61.3 | 46.5 | Owyhee * |
| | | | ± | 10 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-CN-6 | 16 | A57 | | 41 | 19 | 101 | 154 | 26 | 95 | 14 | NM | NM | 891 | NM | 17.8 | 81.6 | Venator * |
| | | | ± | 10 | 5 | 4 | 9 | 3 | 10 | 2 | NM | NM | 33 | NM | | | |
| 10-CN-6 | 17 | A60 | | 36 | 31 | 251 | 34 | 27 | 115 | 9 | 436 | 168 | 137 | 0.89 | 47.3 | 68.0 | Owyhee |
| | | | ± | 10 | 4 | 5 | 9 | 3 | 10 | 1 | 88 | 27 | 32 | 0.11 | | | |
| 10-CN-6 | 18 | A78 | | 50 | 27 | 226 | 35 | 31 | 107 | 13 | 514 | 160 | 135 | 0.93 | 51.6 | 60.5 | Owyhee |
| | | | ± | 10 | 4 | 5 | 9 | 3 | 10 | 1 | 88 | 27 | 32 | 0.11 | | | |

All trace element values reported in parts per million; ± = analytical uncertainty estimate (in ppm). Iron content reported as weight percent oxide.
NA = Not available; ND = Not detected; NM = Not measured.; * = Small sample.

A - 1

Table 1. Trace element concentrations for obsidian samples at 10-CN-1, 10-CN-5, and 10-CN-6.

Although it appears that the people who frequented this site acquired materials from a range of obsidian sources, the average distance to any of these locations is less than 68 km, fitting nicely with Holmer's (1997) model of resource acquisition and distance. Data suggests a limited range for the acquisition of obsidian resources but does not suggest a pattern of mobility or trade due to unknown variables and the range of geographic and geologic diversity (Figure 9). This is further complicated by the overall site diversity. Based on excavations at this site it appears to have been frequented several times over many thousands of years and likely by many different groups.

**10-BO-1**

Site 10-BO-1 (Plew et al. 1984) is located along the Payette River drainage near Zimmer Creek in Boise County, Idaho. Of the obsidian materials recovered, 120 specimens were sent to the University of Idaho for XRF and hydration analysis (Sappington 1984). Interestingly, 95-98% of the materials analyzed were from the Timber Butte source. Of further note, hydration dates range from 2343 B.P. to 5635 B.P. Although this is not a Late Archaic site, it is significant that in almost 2000 years, the obsidian resource did not change.

Based on the current coordinates provided by the Northwest Research Obsidian Studies Laboratory (2005), Timber Butte is located no more than 12-20 km from the site, and it is expected that materials would be utilized frequently from the source location.

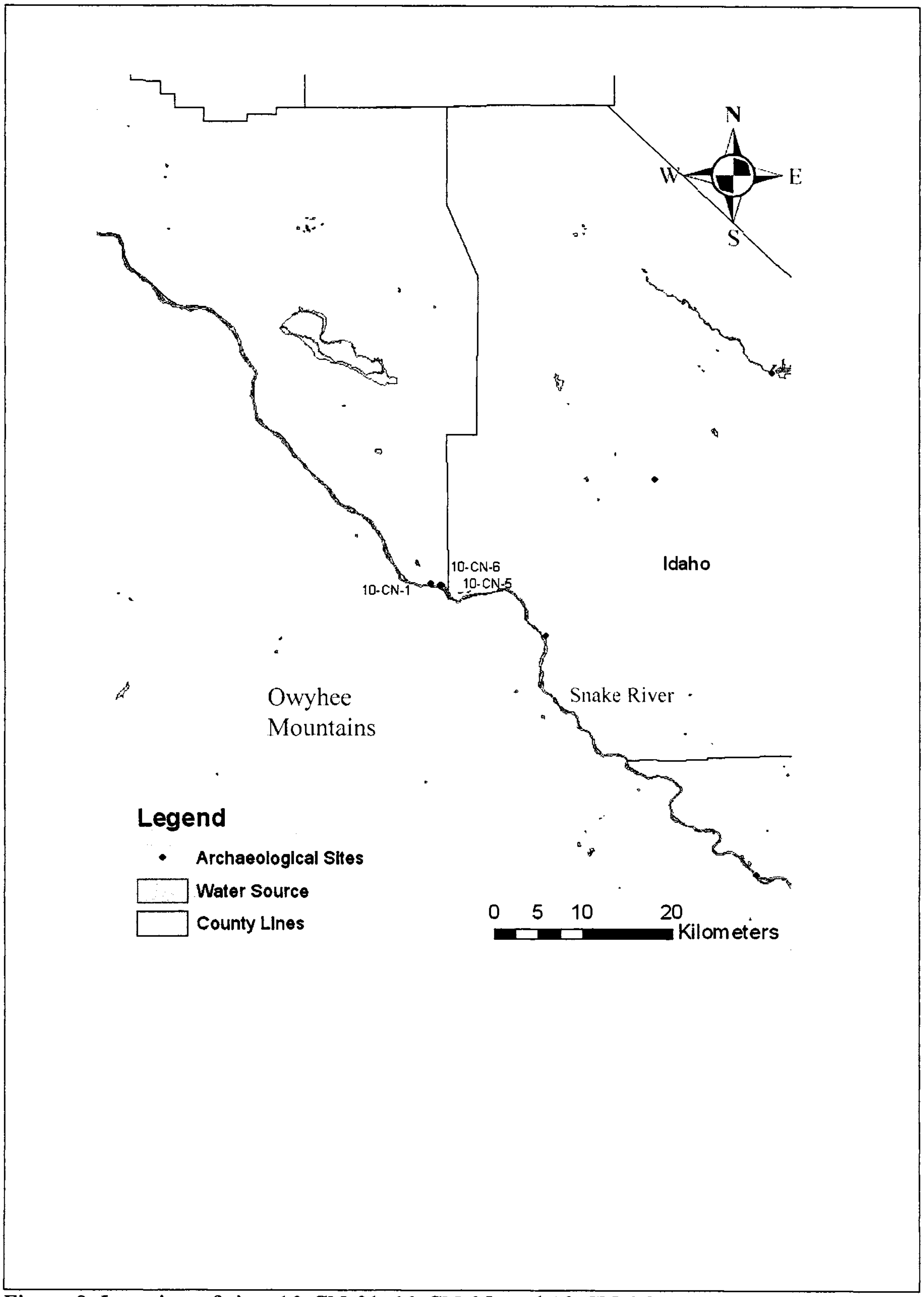



Figure 9. Location of sites 10-CN-01, 10-CN-05, and 10-CN-06.

**10-EL-1577**

10-EL-1577 is located at the western edge of the Hagerman Valley in southwestern Idaho. The site had significant depth (>100 cm) and has been categorized into four strata (Plew et al. 2002). The presence of typologically distinct points and pottery influenced the decision for this site to be included in this study. Given the probability of a Late Archaic occupation, five samples were selected for analysis. Four samples returned positive data. Results included the Bear Gulch, Cannonball Mountain, Brown's Bench, and Owyhee sources. This range of obsidian sources is interesting. All four of these sources are in very different locations ranging from south of the Snake River to north and east. Originally, the eleven obsidian samples selected for analysis returned inconclusive results. It has been postulated that the materials were recovered locally from gravel deposits or from sources yet to be identified. Based on the new results, it appears that the database for obsidian geochemical data has either improved over the last four years or that there are sources of obsidian still to be located in the region. The latter may be due to the high degree of variability near the Brown's Bench area (Skinner 2005). Due to this variation the use of XRF in discerning behavioral patterns becomes problematic. Interesting is the Bear Gulch location nearly 350 km east of the site. This outlier may indicate trade of material but the mechanism for that behavior is unclear.

**10-EL-1367 (Medbury Site)**

Site 10-EL-1367 (Plew and Willson 2005) is located on the north side of the Snake River approximately one and one-half miles southeast of Hammett, Idaho, covering an area of roughly 2800 meters$^2$ and having an overall depth of greater than 80 cm. Initial XRF analysis indicated that materials were geochemically unique to the Cannonball Mountain, Owyhee, and Browns Bench locations. These parent sources lie within a 75 km radius of the site, fitting with patterns described by Holmer (1997) and Plager (2001). Recent analysis of artifacts from this site supports the Cannonball and Brown's Bench locations as parent sources for obsidian but returned no Owyhee data.

**10-EL-1417 (Swenson Site)**

This site, currently being reported (Plew and Willson 2005), is located north of the Snake River near King Hill, Idaho. The presence of ceramics and Late Archaic points fits the scope of the study area. No obsidian was analyzed prior to this project, but seven artifacts selected for analysis in 2005 returned results indicating that obsidian materials originated from the Cannonball Mountain and Brown's Bench locations located less than 75 km from the site.

**10-AA-17**

Test excavations at 10-AA-17 began in August of 1981 and continued through January of 1983 (Ames 1982c). Located some 30 miles south of Boise along the Snake River Canyon near Swan Falls Dam, 10-AA-17 provided Middle and Late Archaic points, various chipped stone tools and a possible structure. In what appeared to be a small wikiup-like structure with a small circular shaped floor, a radiocarbon date suggests an occupation of ranging from 2,300 to 630 B.P. (1982c). Also present were ceramic sherds, mortars, pestles, and pipe fragments.

Five samples sent for analysis returned data for the Owyhee and Timber Butte locations which fit expectations described by Holmer (1997) and supported the pattern that has emerged during this study. Four of the five samples were from the Owyhee source location, but due to the broad extent of that source, no conclusions can be made regarding behavior.

**10-EL-22 (Clover Creek)**

10-EL-22 (Plew and Gould 1990) is located approximately 50 meters north of the Snake River near its confluence with Clover Creek. The site area covers roughly 9000 meters$^2$ of a terrace located about 3.5 meters above the lowest water levels of the river. The recovery of Desert Side-Notched and Rose Spring points, ceramics, and the hydration dates of 1013 +/- 36 B.P., is commensurate with the Late Archaic period. Five points were selected for XRF analysis and the results are geochemically distinct to samples from Timber Butte and Hudson Ridge. Both of these sources are > 50 km to the site.

**10-OE-269 (Bonus Cove Ranch)**

Bonus Cave Ranch (Murphey 1977) is located approximately 15 km north of Grand View, Idaho, situated along a dune-covered top margin of a steep embankment on the west side of the Snake River between Jackass and Black Buttes. Five features were described as concentrations of burned quartzite cobbles, ash, and mussel shell. Of the obsidian materials analyzed all appear to be geochemically distinct to samples at the Owyhee source.

**10-EL-294 (Three Island Crossing)**

Located along the Middle Snake River near Glenns Ferry, Idaho, site 10-EL-294 (Gould and Plew 2001) is situated within the flood plain, and although no inundation was evidenced, major flood cycles would have impacted the area. Radiocarbon analysis of several features provided dates of 500-1000 +/- 300 B.P. In addition to Late Archaic point types, ceramics, and possible structures, the presence of glass trade beads and a brass bipoint indicated a Protohistoric time frame. Early XRF analysis indicated that obsidian materials were obtained from Browns Bench, located a minimum of 65 km south of the site. Six additional samples, all Late Archaic artifacts, provided XRF data for the Brown's Bench, Timber Butte, Owyhee, and Bear Gulch locations. This site has the greatest diversity of obsidian materials with parent source distances ranging from 300 km at Bear Gulch to the Owyhee source some 70 km from the site.

**10-EL-392**

Site 10-EL-392 (Plew and Sayer 1995) is located along the north bank of the Snake River near Grandview, Idaho. Recovered data suggest probable short-term use of the area, and technological diversity in artifact classes suggests generalized activities. The presence of ceramics, as well as Desert Side-Notched and Rose Spring points, indicate a Late Archaic (ca. 1000 B.P.) component. Five samples returned data supporting obsidian materials that originated at the Owyhee and Timber Butte locations with one sample from the Brown's Bench area. All fall within Holmer's (1997) description of obsidian distributions in the region.

**Summary of XRF Results for Southwestern Idaho**

Generally, the obsidian materials found in southwestern Idaho come from three main sources--Timber Butte, Owyhee, and Brown's Bench. These sources occurred collectively 57% of the time with other materials distributed relatively equally (1-3%) from sites in Oregon, Nevada, and eastern Idaho. Due to this pattern, it appears that there is an increase in Timber Butte and Owyhee sources on the western edge of the Snake River region and an increase in the Brown's Bench materials in the southeastern portion.

However, there appears to be no pattern that would suggest mobility as defined by Jones, et al. (2004) but these data do support Holmer's (1997) model regarding relative distance for the region. Overall the pattern is varied, with materials coming from many different sources.

# CHAPTER SIX: SOUTHEASTERN OREGON SITE DESCRIPTIONS AND XRF RESULTS

## 35-ML-1088 Little Owl Cave

Little Owl Cave (Plew et al. 2003) is located within the Owyhee uplands region characterized by Miocene basalt and rhyolite flows, basalt capped mesas, tablelands, buttes, and extensive canyons. Of the artifacts recovered, a tule bag, thought to be part of a cache, was radiocarbon dated to 2580 +/- 70 B.P. (Plew et al. 2003). Although this site is not distinctly Late Archaic, it fits in the Owyhee upland chronology as a Middle Archaic site (ca. 5000-1000 B.P.). XRF analysis indicated that the materials were recovered locally from Sourdough Mountain and Coyote Wells sources, both less than 30 km from the site. Notable however is the primary use of localized non-volcanic glass materials such as rhyolite and basalt.

## 35-ML-148 (Bull Creek Rockshelter)

Also located within the Owyhee uplands, Bull Creek Rockshelter provided evidence of Middle to Late Archaic occupations (Plew and Willson 2004). XRF analysis of obsidian debris indicated that materials were obtained locally but also from as far away as Paradise Valley some 153 km to the south with the majority of materials coming from Indian Creek Butte 166 km to the north. This pattern is problematic because there is no mechanism in place for distinguishing between individual events. Given the disturbed nature of the site, it is difficult to discern whether the materials were brought to the site on different occasions by different groups or during a single occupation.

**35-ML-1527 (Antelope Creek Overhang)**

This site, located within the remote area of Three Forks area of southeastern Oregon and its proximity to Dirty Shame Rockshelter (Aikens et al. 1977) makes the findings particularly interesting as similarities between the two seem to be evident. A radiocarbon date of 1840 +/- 40 B.P (Plew et al. 2004:89) indicated a later Archaic occupation at 35-ML-1527, but interestingly, other dates for this region are framed within the Early to Middle periods.

XRF studies conducted in 2004 returned data for the Paradise Valley location in Nevada, local Oregon locations including White Horse and Indian Creek Buttes, and the Owyhee source. All of the materials sent for analysis were projectile points ranging from early to Late Archaic. The pattern for this distribution appears to be mixed as materials were used from distances greater than expected based on Holmer's (1997) distance to k model and fairly localized materials were acquired as well. It may be inferred that the site was utilized multiple times over many years since radiocarbon dates ranged from 9,600 B.P. to 1,800 B.P. This site has been reexamined by Plew et al. (2004), but because the site was originally visited in 1969, much of the data was lost and/or not recovered at the time of excavation.

**35-ML-1325**

Recent excavations along the North Fork of the Owyhee River (Plew and Willson 2005), located in the same region as the Antelope Creek Overhang, provided materials that appear to be Early to Middle Archaic in nature. XRF analysis of four points returned data distinct to samples at White Horse and Grassy Mountain locations but also for the Owyhee source. All of these sources are relatively localized (< 70 km), and due to the level of disturbance it is impossible to distinguish discrete occupations. There is no evidence of long-term occupation at this site, and judging by the enormous numbers of mussel shell (> 600 from bulk sampling) the primary activities may have been specific to the collection of this particular resource.

**Summary of Southeastern Oregon XRF Results**

The patterns associated with the Oregon locations are mixed. If materials were obtained through direct acquisition from the parent sources, Oregon groups appear to have been highly mobile and demonstrate no preference for one material source over another. This is clearly different from the Idaho region where many of the materials appear to have been obtained from a few sources. The most interesting discovery is that there are materials associated with Paradise Valley in Northern Nevada and Whitehorse, Venator, Indian Creek Buttes, Skull Springs, and Coyote Wells locations to the north. These obsidian sources lie along an area more than 320 km apart and appear to be primary sources for obsidian in the region. One may infer a more linear pattern here but without the ability to discretely distinguish between individual or multiple events, or when the events occurred, a clear understanding of the mechanisms involved in the transport or movement of these materials is unrealistic to infer.

# CHAPTER SEVEN: ISSUES IN ADDRESSING BEHAVIOR THROUGH XRF STUDIES

Although regional research regarding obsidian acquisition is fairly extensive, XRF analysis consistently fails to address enough of the variables to adequately discuss the complex behavior of people living in the region. XRF studies often provide what appear to be patterns in behavior (Holmer 1997; Jones 2003; Plager 2001) leading to the development of hypotheses that attempt to relate mobility, trade, and more implicit discrete variables such as value. This is problematic for several reasons:

a) The location of obsidian materials is spatially general and broad in its distribution.

b) Materials are moved naturally in a variety of ways without human agency in both early and later time frames.

c) The relationship between (a) and (b) is not entirely measurable.

d) Mechanisms for anthropogenic agency are hypothetical and not directly demonstrable.

Skinner (2005) suggests that the overall number of unique geochemical sources of obsidian identified at a given site are affected by numerous environmental and cultural variables, most notably the number of available sources, their relative distance to the site, and the number of artifact samples that are characterized. It is expected that in areas of low source diversity (see Hughes 1996), fewer sources were used. Consequently, a smaller number of samples provide data with a range and proportion of utilized sources. Skinner writes, "In areas of high source diversity (e.g., the Fort Rock Basin of Oregon), many sources of obsidian were utilized and it will take a proportionately larger number of samples to reconstruct an accurate scenario of overall procurement patterns" (Skinner 2005).

One clear problem is that the lava flows where obsidian materials occur cover many hundreds of kilometers. Within these flows are pockets and lenses of molten rock that cooled at varied rates, resulting in varied geochemical compositions. Over time, natural agencies such as wind, hydrologic forces, and erosion impact the natural movement and distribution of these materials (Lambert 1988).

For example, the Owyhee source located just southwest of the Snake River in Idaho covers an area of nearly 1600 square $km^2$ and many of the materials geochemically recorded are small nodules and clasts that have been transported several kilometers away from the initial lava flow (Skinner 2005). In addition to the movement of theses materials across a landscape, exposed materials are subjected to further geologic processes, such as soil formations and deflation of pre-existing soils, frost wedging, and chemical erosion (Sheets 1979). In short, materials exposed on the landscape today may or may not have been accessible in the past. Consequently, the people would have been utilizing materials differently from what is expected. This becomes problematic when using XRF data as an indicator of space or time.

Behaviorally, it is expected that materials recovered from resource locations are transported away from the parent source (Holmer 1997; Sheets 1979) and that the material being geochemically tested was directly retrieved from that parent source. But naturally occurring obsidian materials are found in areas many miles away from the original lava flow. This occurrence alone complicates the way in which we discuss behavior using XRF as an indicator of mobility. It is often assumed that materials being analyzed were obtained though direct acquisition (Holmer 1997; Jones 2003; Plager 2001). Due to this assumption, it is inappropriate to juxtapose any human agency of resource acquisition to more specific human behaviors, such as mobility or trade. In addition, materials were undoubtedly recycled and reused from pre-existing lithic scatters and archaeological sites, consequently impacting greatly any patterns hypothesized by simply exploring site to parent source correlations.

Another issue is that the value of obsidian materials is often elevated by archaeologists and researchers, suggesting that hunter-gatherers traveled great distances to obtain it. It is true that obsidian has a sharper cutting edge and it is relatively easy to work into formal tools (Titmus 1980; Titmus and Woods 1986). However, since the debris left behind would have been sufficient (Kelly 2001:79) and would have maintained suitable characteristics for use either as expedient or formal flaked tools, it would be appropriate to infer that the lithic debris has more value and is available in quantity. It follows that recycled materials may have been used many times by many different groups over long periods of time with no direct acquisition from the parent source.

## Natural Movement of Materials

Examination of the existing land forms in and around the documented obsidian source locations revealed elevated potential for the natural movement of stone materials. For example the average slope near the Owyhee source is 33 degrees on the ridge lines to 11 degrees in the valley with four major drainages (Sinker, Picket, Castle, and Birch Creeks) terminating at the Snake River (Figure 10).

A kernel density analysis with a .999 cell value and a search radius at 10837.1313, and an output cell size of 1300 provided densities that suggest that the materials associated with the Owyhee source are concentrated in the higher elevations (< 1080 meters) and drift downward dispersing in frequency over an area of 40 km (Figure 11).

The Timber Butte source is situated at 1080 meters above sea level and covers an area of roughly 66 km with an average slope of 36 degrees on the ridge line moving south. While Brown's Bench is relatively even in its dispersion, the area is expansive (>4400 $km^2$) and not well documented (Skinner, personal communication October 2005). Notably, only seven individual coordinates have been delineated for this area. To date, the sources at Cannonball Mountain has only one coordinate described by Bailey in 1992, and the Venator, Skull Springs and Indian Creek Buttes sources are inter-dispersed within the western edge of Owyhee source, and appear to flow in a southeasterly direction. Due to this geochemical variation and intermixing of source locations, it serves best as a general source location of obsidian for a broader regional discussion rather than an attempt to correlate between archaeological sites and point coordinates for raw materials.

Documented obsidian sources have not been recorded in their entirety. Most analogies being offered are based on point coordinates of materials that have been recovered in and around the area and analyzed for a geochemical signature. This is problematic because there is no way to argue for source boundaries. Using GIS, a buffer model with 16.2 km radii was used to examine any overlap between sites and obsidian sources (Figure 12).

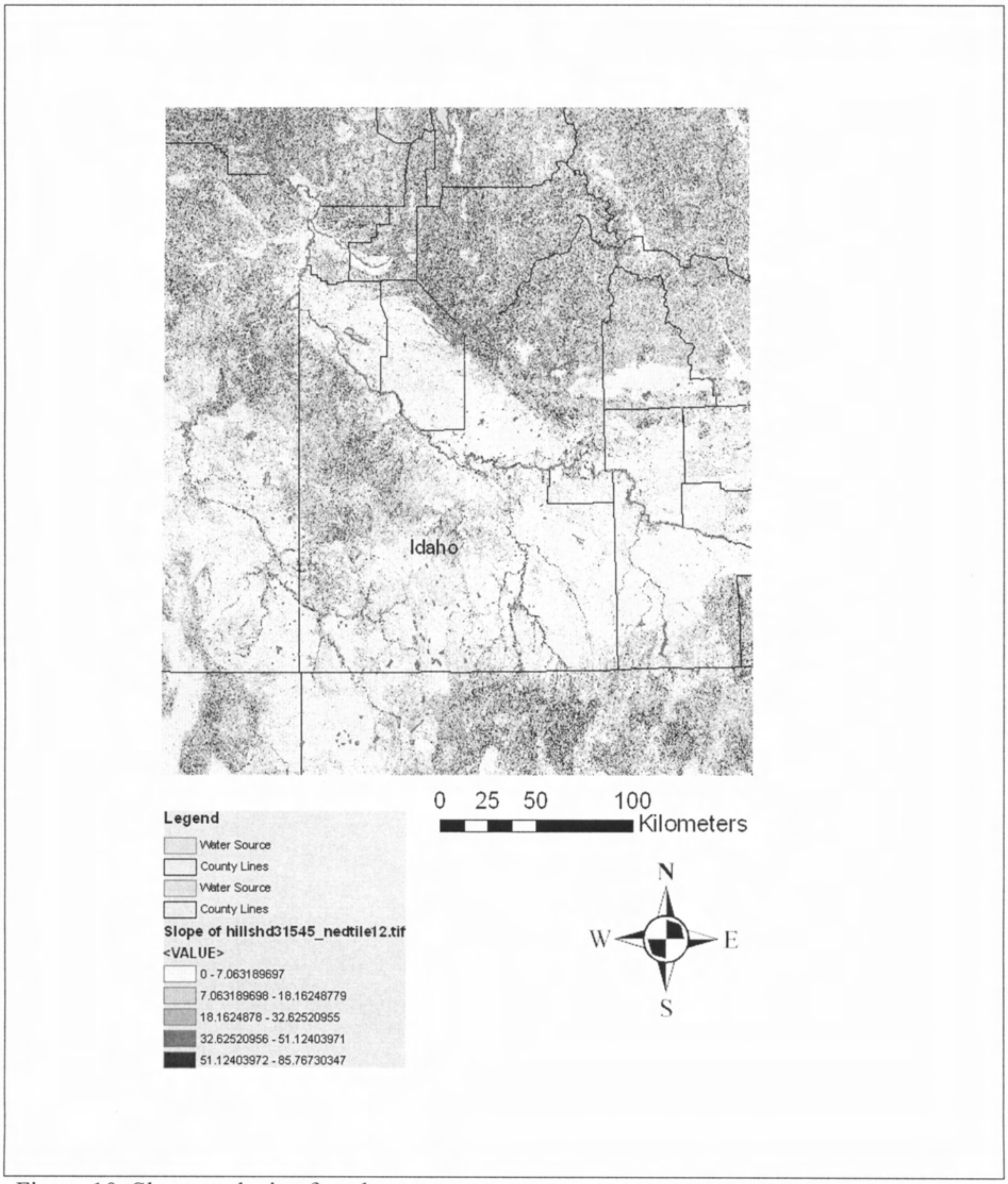



Figure 10. Slope analysis of study area.

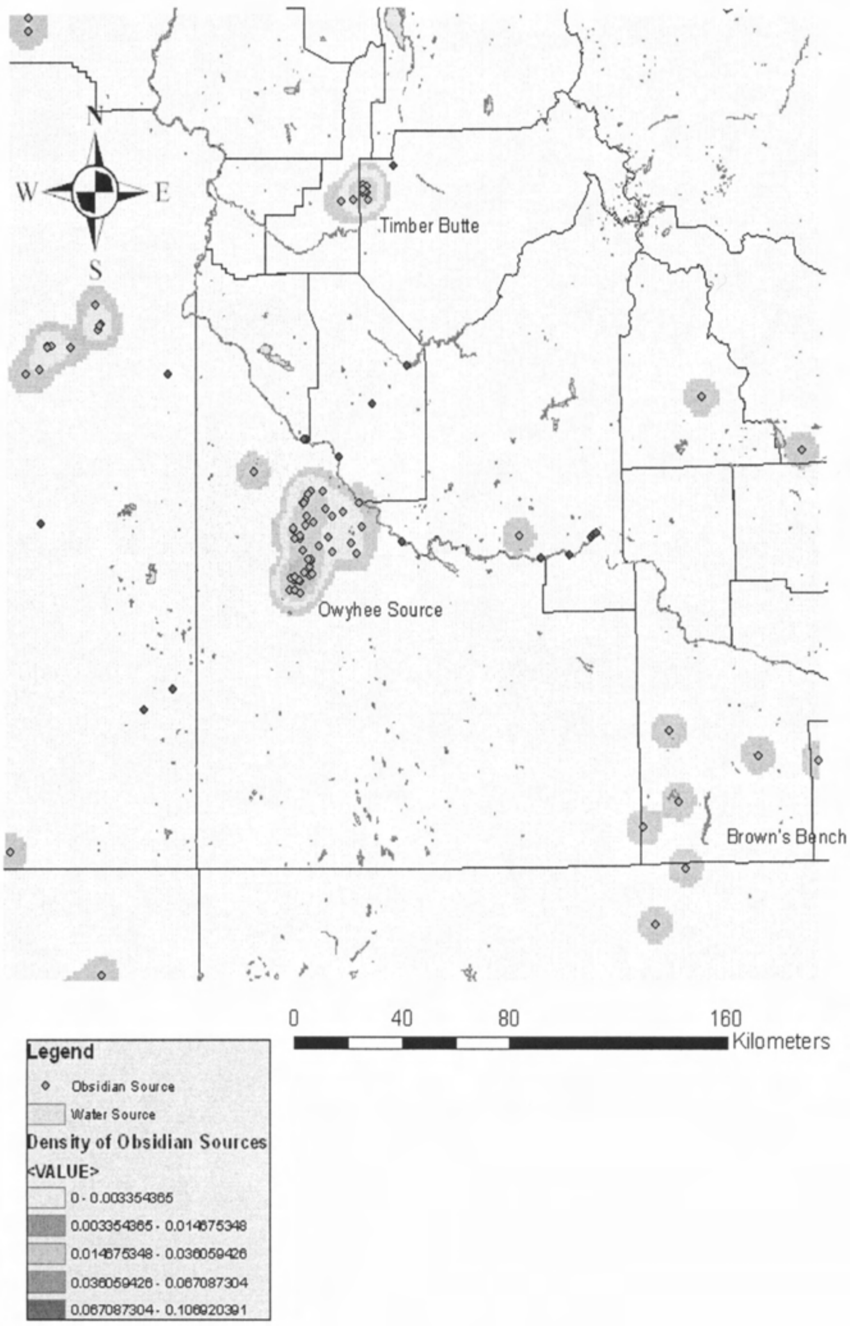



Figure 11. Owyhee source analysis based on kernel density.

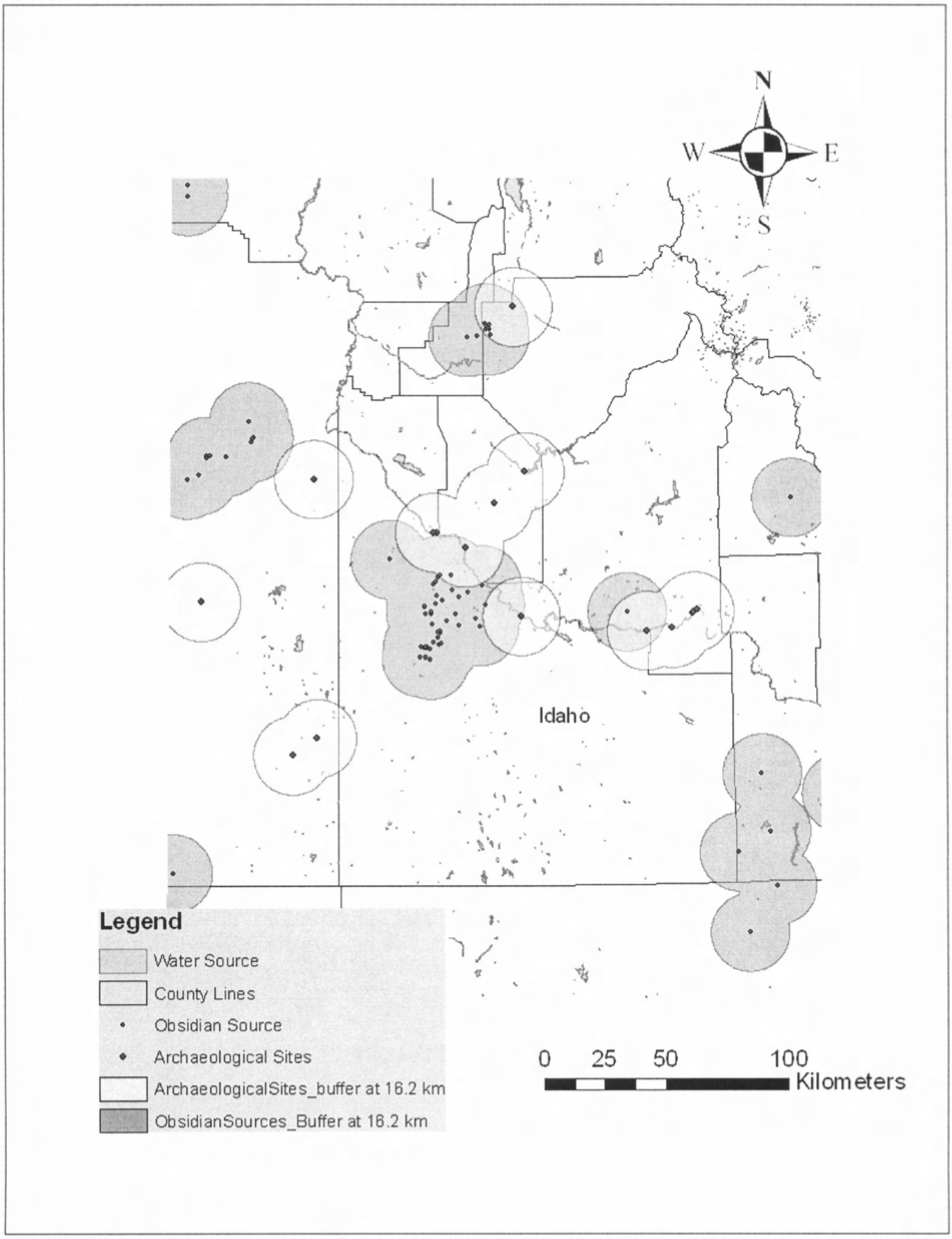



Figure 12. Buffer zones at 16.2 km.

This model visually demonstrates that many of the sites overlap one another and in addition overlap the obsidian sources as well. The problem with this model is due to the nature of the data. Source locations in the area are based on single coordinates that are not critically examined. It is impossible to know whether the obsidian was part of a broader source location or whether it was a single nodule.

Using GIS, it may be possible to spatially explore the relationship of these point coordinates. This model is not conclusive in itself but it serves nicely as a way to examine relative distances and geographic relationships (Figure 12). By examining the elevation data derived through GIS, it is possible to make an argument for the relative locations of materials within a given landscape. It appears that most obsidian materials exist on or near valleys and ridges which in relationship to the archaeological sites are nestled in varied locations within proximity to one or more source locations. This model suggests that relative distances can be examined, but due to the variability in the landscape and the natural movement of materials it does not support an argument for mobility.

**Macro Economic Value Based Analogies**

Before accepting explanations for complex mobility patterns based on the frequency of and the location of lithic resource materials, one must consider the value of one material type relative to another. For example, food staples should, analogically, carry more value than stone, and water more value than food, followed lastly by shelter. Basic biotic models for any mammal suggest this hierarchy for resource need as basic in sustaining life. For most mammals including humans, water, food, and shelter would carry the most value, followed by reproductive practice, then by tools and inanimate objects, stone or otherwise, necessary to obtain these resources. Several arguments can be made:

First, if basic resources of food, water, and shelter are readily available and abundant, the need for tool resources should decrease and leisure time increase, allowing more opportunities for exploring technological innovations (Kelly 2001:73) increasing "low residential mobility or sedentism" which should be evidenced in the archaeological material record (Table 2).

| | **High Residential Mobility or Logistical Mobility** | **Low Residential Mobility or Sedentism** |
|---|---|---|
| Lithic raw material | Cryptocrystalline/obsidian | Siltstone, tuff, rhyolite |
| Evidence of bifaces as cores | Common | Rare |
| Evidence of bifaces as biproducts | Rare | Common |
| Bipolar knapping/scavenging | Rare | Medium to Common |
| Flake/non-biface reduction tools | rare to medium | Common |
| Fire cracked rock | Rare | Common |
| Site-size/density | Small/low | Large/high |
| Tool/debitage ratio | High | Low |
| Biface/flake tool ratio | High | Low |
| Complete flakes | Rare | Common |
| Proximal flake fragments | Common | Rare |
| Distal flake fragments | Common | Rare |
| Angular debris | Rare | Common |
| Assemblage size/diversity | Low Slope | High Slope |

Table 2. Kelly's model for forager mobility studies (2001).

Second, if stone resources are abundant, the value of those materials should decrease, making collecting and procurement times decrease. Given this, the drivers for acquiring materials become less important and consequently affect any patterns that are expected regarding complex behaviors. Also it must be considered what the tool's intended use would be and the time needed to complete that tool. Kelly (2001:123) demonstrates that tool production, whether in creating a biface or a flake tool, would hold a certain value and a cost depending on the environment in which the tool is obtained, manufactured, and used (Kelly

2001:71-73). It is not known whether using a biface over a flaked tool for a specific task is more suitable. Since this is unclear, it is inappropriate to infer that a tool carries more value in a given shape or form. However, it is known that raw materials suitable for creating bifaces is more difficult to obtain, whereas nodules, even those moved downstream by alluvial processes, are suitable for flaked tools (Kelly 2001:70-71).

Third, once a value is established for resources, one must consider the cost of obtaining these resources. If flaked tools can be made in one episode and produced in suitable numbers, then it is likely those raw materials would carry more value in a less sedentary group where less mobile groups can expend more energy in collection of suitable raw materials for the creation of biface reduction tools. Additionally, environmental considerations must be made in order to argue for a task specific acquisition of raw materials. It is likely that occurrences in which stone materials were acquired directly from the source were varied as well. For example, if the group is near the source during winter, when groups were more sedentary there may have been episodes where direct acquisition occurred. Although during this time, where energy is better served providing and consuming calories, it may not have been optimal to employ this strategy. Based on Kelly (2001) it would follow that the flaked tool, which provides more useable material, would carry more value if obtaining material suitable for these tools were readily available. As part of a seasonal round, one would expect that materials would be gathered as they became available and preferences would lean toward maximization as well. This is difficult to sort out because XRF studies do not provide insight into these behavioral strategies and cannot be demonstrated.

**Mobility and Trade**

Renfrew (1982) and Holmer (1997) postulate that there is an expected "distance to k," or a measurable point at which materials begin to diminish, suggesting a "falling off" pattern as one moves away from a source of material. As discussed in the previous sections, due to the dynamic nature of the geologic processes, where the parent materials begin and end are not clearly defined but there is agreement that the further away one gets from a source of material the frequency seen in the archaeological record should decrease.

Furthermore, this pattern as described by Holmer (1997) does not allow for a description regarding the nature of human behavior in the region. Plager (2001) examined the distribution of materials along the eastern Snake River Plain and determined that materials appearing in the record from sources at greater distances may suggest movement of materials by trade or other anthropogenic agency. This may well be true in some instances. For example, the sites at 10-EL-1577 and 10-EL-294 located near King Hill, Idaho, provided materials sourced to Bear Gulch on the eastern extent of the Snake River region nearly 350 km from the sites.

Kelly (1982a; 2001:71-72) argues a direct correlation between foraging groups and collectors in regards to mobility. He further states, "The distance from a residential camp at which a forager can procure resources at an energetic pace is limited by the return rate of those resources" (Kelly 2001:5-7). Since the sites located along the Snake River seems to have likely comprised high mobility forager sites, Kelly's (2001) model for resource acquisition (T = travel time, and R = the overall return) is a suitable model for this region. Hence, the value of a resource would decrease the farther from the site the forager has to travel to gain the material. Since the return rate of lithic debris is not measurable this model would in fact suggest low value even at short distances.

XRF data provides no insights into complex behaviors such as mobility and trade, and such data should not be used without regard for the potential variables conditioning hunter-gatherer behavior. XRF data append nicely the record and does provide insight to more direct questions regarding the prehistory of the region. It is unquestionable that the distance between a source of material and the site where materials are geochemically similar is significant. This information allows for discussion regarding general patterns and distributions but is not an indicator of mobility.

**Additional Variables**

In addition to known and quantifiable variables such as actual distance, material types, frequency of materials, and return rates for resources, other variables should be considered. Although these variables are speculative, a solid inference can be drawn from them. For example, obsidian is such that the lithic debris is tremendous, resulting in a variety of flake sizes and shapes. Considering the period of time that humans have been in the region and the variations of tool type and technology and the evidence for multiple occupations by different groups over long periods of time, the debris generated at these sites along the Snake River would have likely been reused, recycled, and removed, time again.

Recent experiments in lithic technology (Willson 2004) provided data that substantiates this argument. In a simple, three-stage biface reduction strategy, using a single antler billet, the process generated over 1,500 flakes ranging from > 6.2 mm to <1.2 mm in size. Of the 1,500 flakes, 152 were suitable for bow and arrow technology and >200 were suitable for the creation of flake tools for utilitarian purposes. If this reduction strategy were employed during the Early Archaic before bow and arrow technology, flake sizes suitable for small dart points would not have been collected.

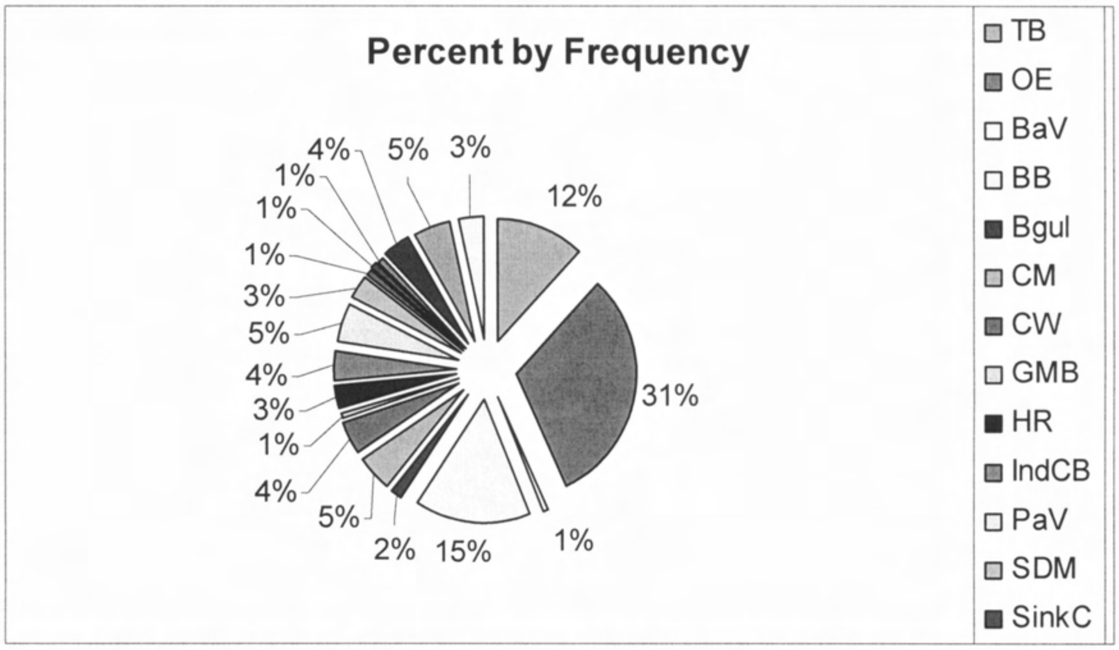
For example, the site at Antelope Creek Overhang (Plew et al. 2004) in southeastern Oregon provided a temporal period of multiple occupations spanning nearly 10,000 years. Of the 265 projectile point artifacts collected, the range of size and typological distinctness suggests that a recycling strategy would have been highly beneficial. In addition, 18 modified flakes and four bifacially worked flakes were also recovered further suggesting use of lithic debris. Unfortunately, debitage was not recorded during the original excavation, but it is suspected that the debris would support of mixed mode-forager group as described by Kelly (2001) and that XRF studies of the debitage would be consistent with data returned on the formal tools.

It is likely that many factors would have influenced the behaviors of people living in the region during the Late Archaic. It is difficult to address all of these variables because of limitations caused by gaps in the material record. Through analogy, it is possible to create a hypothetical description for behavior, including mobility. However, it is due to these limitations that XRF studies fail to provide conclusive data that can be used to infer aboriginal behavior. Mobility is the focus of study for much of the hunter- gatherer research being conducted in the region (Jones et al. 2004; Kelly 2001). Several models have been created to examine potential explanations for variation witnessed in the archaeological record and through these models many attempts have been made to describe the prehistoric lifeway.

The issues raised in this study suggest that many of the conditioners dictating behavioral adaptations cannot be witnessed by a single technique or model. It is important to then consider as many of the variables as possible when attempting to offer explanations regarding behavior. It is through careful consideration of all of the potential variables that contributions are made to understanding of people living in the region during the Late Archaic in Idaho and the surrounding regions.

**CHAPTER EIGHT: CONCLUSIONS**

There are 17 known obsidian sources and 4-5 unknown sources in Idaho, as well as 8 known sources in the southeastern part of Oregon. Of these 25 known sources, 13 have been linked to sites along the Snake River and in southeastern Oregon with the preponderance of materials (31%) coming from the Owyhee source followed by Brown's Bench at 15% and Timber Butte with 12% (Figure 13).




TB=Timber Butte, OE=Owyhee, BaV=Barren Valley, BB=Brown's Bench, Bgul=Bear Gulch, CM=Cannonball Mountain, CW=Coyote Wells, GMB=Grassy Mountain Butte, HR=Hudson Ridge, IndCB=Indian Creek Butte, PaV=Paradise Valley, SDM=Sourdough Mountain, SinkC=Sinker Canyon

Figure 13. Frequency of obsidian sources based on the 2005 XRF study.

Notable is that ten of the best known sources in the region are part of a line of sources associated with the Owyhee uplands extending 144 km northwest and southeast. There are clusters of source coordinates intermixed with differing geochemical signatures. The Coyote Wells, Skull Springs, and northwestern Owyhee sources are geographically dispersed over an area of 400 $km^2$, but are fairly isolated from the main Owyhee source which lies more than 100 km to the south. Within the main Owyhee source as described by Skinner (2005) and Sappington (1981a) lies the Sinker Canyon and Reynolds sources at the northern edge of the expansive lava flow (Figure 14). It is possible that the materials acquired from within this region have intermixed over time by natural agencies. If this is the case, then it would be difficult to control for chemical variations in the obsidian materials. This is problematic to the development of a solid hypothesis that would support a pattern for acquisition of these resources from this geographic area.

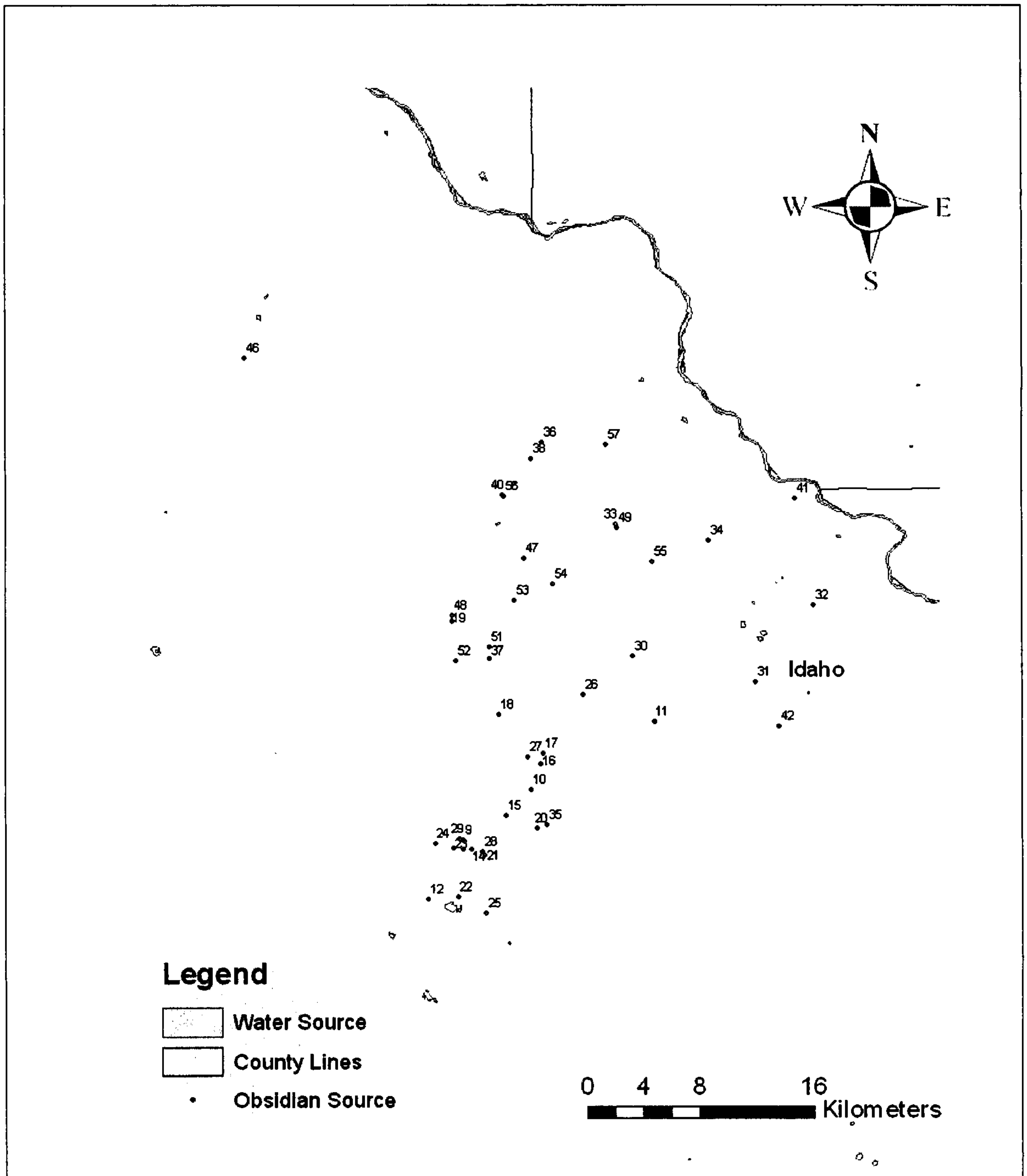
Although there appear to be patterns in obsidian use during the Late Archaic period in sites located along the Snake River region of Idaho and the southeastern Oregon area, these patterns are deceiving. Several behavioral variables exist that would have conditioned decisions made by hunter-gatherers that cannot be witnessed by the XRF process. Inferring that by measuring distances and occurrences of obsidian materials in relationship to the parent-source of that material is inappropriate as an indicator of mobility. This is partly due to the inability to discretely determine whether these distances reflect single or multiple events of acquisition over time.

Obsidian can move through natural agency without human interaction. Materials over time are washed down slope away from the original source point and may have been collected there. These secondary sources of obsidian cannot then be directly correlated to the parent source. Natural movement of materials is undoubtedly influencing the patterns that are witnessed through the XRF analysis process.

Additionally, sources of obsidian are not mapped in their entirety. Many sources cover hundreds of square kilometers while others are represented simply as a point on the landscape. Due to this, it is not appropriate to discuss relationships in a point to point manner. By exploring spatially through GIS software, it is demonstrated, unlike the sources located in California and Nevada, that many of the documented sources are varied in size and density and are distributed widely across the landscape.

The exact nature of behavioral strategies is not known for prehistoric hunter-gatherers. Only through analogical inference can a model be developed that examines potential adaptations in the region. For example, recent literature (see Jones et al. 2003) suggests XRF data can be used to infer mobility. These are complicated behaviors that are driven by a number of factors including environmental and cultural adaptations. Kelly's (2001) model regarding mobility based on site formations is valuable in inferring potential and expected behavioral patterns of hunter-gatherers in the region.

There are unknown variables that cannot be witnessed in the material record and any discussions are purely speculative. Missing data due to the incompleteness of the material record, previously collected materials that are not available for study, natural and anthropogenic disturbances to archeological sites, and the indeterminate boundaries for obsidian sources all affect the interpretations of source data.




1-7= Brown's Bench, 8= Cannonball Mtn., 9-45=Owyhee, 46=Reynolds, 47-57=Sinker Canyon, 58-66=Timber Butte, 67 Wedge Butte, 68-69= Paradise Valley, 78 Indian Creek Buttes, 79= Skull Springs, 80= White Horse

Figure 14. Main Owyhee source.

During the last 10,000 years, the environment has fluctuated greatly and the human response to those changes is highly varied. The obsidian sources used throughout this region are highly diverse as well. Some sources appear to cover many hundreds of kilometers while others are represented by a single coordinate. This is due to the present status of XRF data. As more ground surveys are completed, the base in which XRF data is generated will improve. Mobility patterns suggested by Jones et al. (2003) illustrate a pattern that is consistent over a large region. This normative view of the aboriginal use of the region is problematic and XRF data generated though this study does not permit a similar conclusion. Even without considering the many variables that would condition mobility patterns in the region, it appears that there is no definitive pattern. Sources are as varied as the samples used for analysis. Obsidian appears in the record with great frequency and the sources from which these materials originated are unpredictable.

XRF analysis has contributed enormously to the study of archaeology (Holmer 1997; Jones et al. 2004; Plager 2001; Sappington 1981a, 1981b; 1982). The locations of primary obsidian sources have been located and mapped, unique geochemical signatures have been fairly well documented for the region, and the XRF process has been refined greatly, making it more practical and generally more economical. However, it is only one of an arsenal of tools to be used conjunctively when exploring any questions regarding mobility, trade, and the resource acquisition behaviors of people living in the region over time. The locations of source materials are important in developing more significant questions, but interpretations regarding mobility can not be demonstrated through this process.

The variables that would condition decisions of mobility are many. XRF data only allows for the examination of relationships between lithic materials but not the conditioners that would have affected the acquisition of those resources. New technologies do help in developing appropriate discussion regarding analogical research, and since XRF does provide general locations of raw materials, its applicability in discussing general use of materials over a given landscape is useful. Most importantly, these developing technologies assist in new avenues of study that will eventually lead to more thoughtful and careful consideration of the human condition.

There are limitations in XRF studies. The problem is demonstrating conditioners that affect mobility. This study has examined data retrieved through the XRF process and the perused the literature regarding various interpretations of mobility in hunter-gatherers. It is concluded that the XRF data are in themselves inconclusive. The variation of sources utilized during the Late Archaic appears to have been highly diverse. It is expected that materials move in various ways. Cultural transport of tool stone and the natural movement of materials within a landscape are difficult to demonstrate archaeologically. Undoubtedly materials are moved by human agency but it is also the result of many thousands of years of natural geologic processes. Due to the inability to control for time and space and the many behavioral variables that would have conditioned decisions made by hunter-gatherer groups living in the region, the interpretations being made based on the XRF process cannot be adequately demonstrated. Because of the inability to clearly define and understand the mechanisms for the movement of these materials it is inappropriate to infer human mobility based on XRF studies.

**REFERENCES CITED**

Aikens, C. Melvin
1984 Adaptive Strategies and Environmental Change in the Great Basin and its Peripheries as Determinants and the Migration of Numic Speaking Peoples. In *Across the West, Human Population Movement and the Expansion of the Numa*, edited by David B. Madsen and David Rhode, pp. 35-43. University of Utah Press, Salt Lake City.

Aikens, C. Melvin, David L. Cole, and Robert Stuckenrath
1977 Excavations at Dirty Shame Rockshelter, Southeastern Oregon. *Tebiwa, Miscellaneous Papers of the Idaho State University Museum* 4.

Ames, Kenneth M.
1982c *Archaeological Investigations in the Payette River Drainage, Southwestern Idaho, 1979-1981.* Archaeological Reports No. 11. Boise State University, Boise.

Bailey, Jeff
1992 *X-ray Fluorescence Analysis of Volcanic Glass Artifacts from Wilson Butte Cave, Idaho.* M.A. thesis on file, Department of Anthropology, University of Alberta.

Barnosky, Cathy W., Patricia M. Anderson, and Patrick J. Bartlein
1987 The Northwestern U.S. during Deglaciation; Vegetational History and Paleoclimatic Implications. In *The Geology of North America*, edited by W. F. Ruddiman and H. E. Wright Jr, pp. 289-321. The Geological Society of America, Boulder.

Bedwell, Stephen F.
1973 *Fort Rock Basin: Prehistory and Environment.* University of Oregon Books, Eugene.

Bently, Elton B.
1981 Geomorphic History and Soils Analysis of Archaeological Sites 10-GG-1 and 10-TF-352. In *Idaho Archeological Test Excavations at Four Prehistoric Sites in the Western Snake River Canyon near Bliss, Idaho*, edited by Mark G. Plew, pp. 198-233. Project Reports No. 5, Idaho Archaeological Consultants, Boise.

Bradley, Bruce
1987 *Flintknapping:* Video, Produced by Interpark, Colorado.

Butler, B. Robert

1969 Antelope Overhang Excavation Field Notes. Department of Anthropology, Idaho University, Pocatello.

1970 A Surface Collection from Coyote Flat, Southeastern Oregon. *Tebiwa* 13(1):34-58.

1978 *A Guide to Understanding Idaho Archaeology*: The Upper Snake and Salmon River Country. Idaho State Historic Preservation Office, Boise.

Davis, William B.
1939 *The Recent Mammals of Idaho*. Caxton Printers, Caldwell.

Fagan, John L.
1988 Clovis and Western Pluvial Lakes Tradition Lithic Technologies at the Dietz Site in South-Central Oregon. In *Early Human Occupation in Far Western North America: The Clovis Archaic Interface*, edited by Judith A. Willig, C. Melvin Aikens, and John L. Fagan. Nevada State Museum Anthropological Papers 21:389-416. Carson City.

Freeman, Otis W., J. D. Forrester and R. L. Lupher
1945 Physiographic Divisions of the Columbia Intermountane Province. *Association of American Geographers Annuals* 35(2):53-75.

Fowler, Catherine S. and Sven Liljeblad
1986 Northern Paiute. In *Handbook of North American Indians*, Great Basin Vol. 11, edited by W.L. d'Azevedo, pp 435-465, Smithsonian Institution, Washington DC.

Gould, Russell T.
1990 *Prehistoric Hunter-Gatherer Mobility and Anadromous Fish Use along the Middle Snake River, Southwest, Idaho*. B.A. Honors Thesis, Department of Anthropology, Boise State University.

Gould, Russell T. and Mark G. Plew
2001 *Archaeological Excavations at Three Island Crossing*. Department of Anthropology, Boise State University, Boise.

Gruhn, Ruth
1961a The Archaeology of Wilson Butte Cave, Southcentral Idaho. *Occasional Papers of the Idaho State College Museum* No. 6, Pocatello.

Hackett, Bill and Bill Bonnichsen
1995 Volcanic Crest. In *Snake River Plain and Its People*, edited by Todd Shallet, pp. 25-61. Boise State University.

Harper, Kimball T.
1998 Historic Environments. In *Handbook of North American Indians*, Great Basin Vol. 11, edited by W.L. d'Azevedo, pp. 51-63, Smithsonian Institution, Washington DC.

Hanes, Richard C.
1988 Lithic Assemblages of Dirty Shame Rockshelter: Changing Traditions in the Northern Intermountane. *University of Oregon Anthropological Papers* No. 40.

Haynes, C. Vance
1971 Time, Environment, and Early Man. *Arctic Anthropology* 8(2): 3-14.

Henry, Craig
1984 *Holocene Paleoecology of the Western Snake River Plain.* M.S. thesis on file, University of Michigan, Ann Arbor.

Holmer, Richard N.
1997 Volcanic Glass Utilization in Eastern Idaho. *Tebiwa* 26(2):186-204.

Hughes, Richard E.
1986 *Diachronic Variability in Obsidian Procurement Patterns in Northeastern California and Southcentral Oregon.* University of California Press, Los Angeles.

Huter, Pamela, John Kennedy, Sharon Plager, Mark Plew, and Trisha Webb
2000 *Archaeological Test Excavations at 10-CN-05, Southwest Idaho.* Technical Reports No. 10. Snake River Birds of Prey Conservation Area Archaeological Project, Boise State University, Boise.

Jones, George T., Charlotte Beck, Eric E. Jones, and Richard E. Hughes
2003 Lithic Source Use and Paleoarchaic Foraging Territories in the Great Basin. *American Antiquity* 68(1):5-38.

Kelly, Robert L.
1983b Hunter-Gatherer Mobility Strategies. *Journal of Anthropological Research* 39:277-306.

1996 Foraging and Fishing. In *Prehistoric Hunter-Gatherer Fishing Strategies*, edited by Mark G. Plew, pp. 208-214, Boise State University, Boise.

2001 Prehistory of the Carson Desert and Stillwater Mountains: Environment, Mobility, and Subsistence in a Great Basin Wetland. *University of Utah Anthropological Papers* No. 123, Salt Lake City.

King, Glenda L.
1996 *Great Basin Ethnobotony: A Computerized Database*. M.A. thesis on file, Graduate College, University of Oklahoma.

Kuchler, A.W.
1964 Potential Natural Vegetation of the Conterminous United States (Map): *American Geographical Society Special Publication* Vol. 6: 39.

Lambert, David
1988 *The Field Guide to Geology.* Cambridge University Press, UK.

Larrison, Earle J.
1967 Guide to Idaho Mammals. *Journal of the Idaho Academy of Sciences.*

Liljeblad, Sven
1957 *Indian Peoples of Idaho.* M.S. thesis on file, Idaho Museum of Natural History. Pocatello.

Malde Harold E.
1965 Snake River Plain. In *The Quaternary of the United States*, edited by H E. Wright, Jr. and David G. Frey, pp. 255-263. Princeton University Press, Cambridge.

National Atlas Data
2005 http://nationalatlas.gov/articles/geology/features/snakeriver.html

Marshall, D.
1977 Narrative Report 11. Manuscript on file, Stillwater Wildlife Management Area, Fallon, Nevada.

Mehringer, Peter L, Jr.
1985 *Pollen Records of Late-Quaternary North America Sediments*, edited by, V. M Bryant Jr. and D. J. Holloway. pp. 167-189. American. Association of Stratigraphic Palynologists Foundation, Dallas.

Murphey, Kelly A.
1977 Site Forms on file. Idaho State Historical Society, Boise.

Murphy, Robert F., and Yolanda Murphy
1960 Shoshone-Bannock Subsistence and Society. *Anthropological Records* 16:293-338. University of California Press, Berkeley.

1986 Northern Shoshone and Bannock. In *Handbook of North American Indians*, Great Basin, Vol. 11, edited by W.L. d'Azevedo, pp. 284-307, Smithsonian Institution, Washington DC.

Odell, GH.
1996a Economizing Behavior and the Concept of "Curation." In *Stone Tools. Theoretical Insights into Human Prehistory*, edited by G. H. Odell, pp. 51-80. Plenum Press, New York.

Plager, Sharon R.
2001 *Patterns in the Distribution of Volcanic Glass across Southern Idaho*. M.A. thesis on file, Department of Anthropology, Idaho State University, Pocatello.

Plager, Sharon R., Mark G. Plew and Christopher A. Willson
2004 *The Archaeology of Antelope Creek Overhang Southeastern Oregon.* Department of Anthropology, Boise State University, Boise.

Pettigrew, Richard M.
1984 Prehistoric Human Land-use Patterns in the Alvord Basin, Southeastern Oregon. *Journal of California and Great Basin Anthropology* 6(1):61-90.

Plew, Mark G.
1980a *Archaeological Investigations in the Southcentral Owyhee Uplands, Idaho*. Archaeological Reports No. 7. Boise State University, Boise.

1981 A Preliminary Report on Archaeological Excavations at Nahas Cave. *Idaho Archaeologist*, Volume 4 (3):1-8.

1986a *An Introduction to the Archaeology of Southern Idaho.* Hemingway Western Studies Publications, Boise.

1986b *The Archaeology of Nahas Cave: Material Culture and Chronology.* Archaeological Reports No. 13. Boise State University, Boise.

2000 *The Archaeology of the Snake River Plain.* Department of Anthropology, Boise State University. Idaho.

Plew, Mark G., Kenneth M. Ames, and Christen K. Fuhrman
1984 *Archaeological Excavations at Silver Bridge (10-BO-1), Southwest Idaho.* Archaeological Reports No. 12. Boise State University, Boise.

Plew, Mark G. and Russell T. Gould
1990 Archaeological Test Excavations at the Clover Creek Site. *Idaho Archaeologist* 13(1):1-15.

Plew, Mark G., Pamela Huter, and Richard Benedict.
2002 *Archaeological Test Excavations at 10-EL-1577, Near King Hill Idaho.* Department of Anthropology, Boise State University, Boise.

Plew, Mark G., Max G. Pavesic, and Mary Anne Davis
1987 *Archaeological Investigations at Baker Caves I and II: A Late Archaic Component on the Eastern Snake River Plain.* Archaeological Reports No. 15, Boise State University, Boise.

Plew, Mark G. and Camille Sayer
1995 *Archaeological Excavations at 10-AA-256, Orchard Training Range, Birds of Prey Natural Conservation Area, Idaho.* Technical Reports No. 1, Birds of Prey Natural Conservation Area Archaeological Project, Boise State University. Boise.

Plew, Mark G. and Christopher Willson
2004 *Archaeological Investigations at Bullcreek Rock Shelter Southeastern Oregon.* Report Submitted to the Bureau of Land Management, Vale District, Oregon.

Plew, Mark G. and Christopher A. Willson
2005 Archaeological Test Excavations at the Medbury Site (10-EL-1367), Southwest Idaho. *Idaho Archaeologist.* In Press.

Plew, Mark G. and Christopher A. Willson
2005 *Archaeological Test Excavations at the Swenson Site, Southwest Idaho*. Department of Anthropology, Boise State University, Boise. In Press.

Plew, Mark G. and Christopher A. Willson
2005 *Test Excavations at site 35-ML-1325 on the North Fork of the Owyhee River*. Report Submitted to the Bureau of Land Management, Vale District, Oregon. In Press.

Plew, Mark G., Christopher A. Willson, and Richard Benedict
2003 *Archaeological Test Excavations at Little Owl Cave (35-ML-1088) Southeastern Oregon*. Report Submitted to the Bureau of Land Management, Vale District, Oregon.

Plew, Mark G., Christopher A. Willson, Tedd Jacobs, and Christopher Hill
2004 *Archaeological Test Excavations at 10-CN-06, in Southwestern Idaho*. Department of Anthropology, Boise State University, Boise.

Renfrew, Colin
1984 *Approaches to Social Archaeology*. Edinburgh Press, Edinburgh.

Sappington, Robert L.
1981a A Progress Report on the Obsidian and Vitrophyre Sourcing Project. *Idaho Archaeologist* (4):4-17.

1981b Additional Obsidian and Vitrophyre Source Descriptions from Idaho and Adjacent Areas. *Idaho Archaeologist* (1):4-8.

1982 *Obsidian Procurement along the Middle Fork of the Salmon River in Central Idaho. In a Cultural Resource Reconnaissance in the Middle Fork Salmon River Basin, 1978*. U.S. Forest Service *Cultural* Resource Report 7, Ogden.

1984 Appendix I. Debitage Analysis and Variables List and Key. In *Archaeological Test Excavations at Silver Bridge (10-BO-1), Southwest Idaho*. Archaeological Reports No. 12, Boise State University, Boise.

Sayer, Camille, Mark G. Plew, and Sharon Plager
1997 *Archaeological Test Excavations at 10-CN-1, Southwest Idaho*. Snake River Birds of Prey National Conservation Area Archaeological Project, Technical Reports No. 5, Boise State University, Boise.

Sheets, Payson D. and Donald K Grayson
1979 *Volcanic Activity and Human Ecology*. Academic Press Inc., New York.

Skinner, Craig
2005 Electronic source: http://www.obsidianlab.com/info_xrf.html.

Soil Conservation Service
1973 Soil Conservation Service data. In *The Archaeology of the Snake River Plain*. Department of Anthropology Boise State University. Boise.

Steward, Julian H.
1938 Basin-Plateau Aboriginal Sociopolitical Groups. *Bureau of American Ethnology* Bulletin No. 120. Smithsonian Institution, Washington D.C.

1970 The Foundations of Basin-Plateau Shoshonian Society, In *Languages and Cultures of Western North America: Essays in Honor of Sven S. Liljeblad*, edited by E. H. Swanson, Jr., pp.113-151. Idaho State University Press, Pocatello.

Steward, Julian H. and Ermine Wheeler-Voegelin
1974 The Northern Paiute Indians, In *American Indian Ethnohistory, California and Basin Plateau Indians, Paiute Indians III*, edited by D. A. Horr. Garland: New York.

Stewart, Omer C.
1939 The Northern Paiute Bands. *University of California Anthropological Records* 2(3):127-149. Berkley.

Titmus, Gene
1980 Large Obsidian Boulder Reduction. *Flintknappers' Exchange* 3(3):21-22.

Titmus, Gene, and James C. Woods
1986 An Experimental Study of Projectile Point Fracture Patterns. *Journal of California and Great Basin Anthropology* 8(1):37-49.

Thornbury William G.
1965 *Regional Geomorphology of the United States*. John Wiley and Sons, New York.

United States Geological Service (USGS)
2005 Electronic Source: http://capp.water.usgs.gov.

Walker, Deward E.
1978 *American Indians of Idaho*. Anthropological Papers of the University of Idaho No 2, Moscow.

Wells, P.V.
1983 Paleobiogeography of Montane Islands in the Great Basin since the last Glaciological. *Ecological Monographs* 53:341-382.

Wilde, James D.
1985 *Prehistoric Settlements in the Northern Great Basin: Excavations and Collections Analysis in the Steens Mountain Area, Southeastern Oregon*. Unpublished Ph.D. dissertation, Department of Anthropology.

Willig, Judith A.
1988 Paleo-Archaic Adaptations and Lakeside Settlement Patterns in the Northern Alkali Basin, Oregon. In *Early Human Occupations in Far Western North America: The Clovis-Archaic Interface*, edited by Judith A. Willig, C. Melvin Aikens, and John L. Fagan. Nevada State Museum Anthropological Papers 21:417-482. Carson City.

Willson, Christopher A.
2004 *Lithic Analysis: Experiments in Stage Reduction*. Student Paper on File, Department of Anthropology, University of Idaho, Moscow.

Yenson, Dana
1982 *A Grazing History of Southwestern Idaho with Emphasis on the Birds of Prey Study Area*. Report on file, Bureau of Land Management, Boise.

Yohe II, Robert M.
2002 Archaeological Investigations at Milner Rockshelter (10-JE-47), Southern Idaho. *Idaho Archaeologist* 25(2):25-36.

# DATA TABLES

| Site | Rec_Yr | Anal_Yr | Spec_type | Spec_# | Source | Comments |
|---|---|---|---|---|---|---|
| 10-BO-1 | 1982 | 1984 | lithic | | TB | 120 specimens run |
| | | | | | | |
| 10-CN-1 | 1996 | 2005 | point | 137 | TB | |
| | 1996 | 2005 | point | 138 | CW | |
| | 1996 | 2005 | point | 71 | OE | |
| | 1996 | 2005 | point | 105 | TB | |
| | 1996 | 2005 | point | 122 | OE | |
| | | | | | | |
| 10-CN-5 | 1997-98 | 2000 | lithic | 161 | OE | |
| | 1997-98 | 2000 | lithic | 12 | OE | |
| | 1997-98 | 2000 | lithic | 1134 | OE | |
| | 1997-98 | 2000 | lithic | 67 | OE | |
| | 1997-98 | 2000 | lithic | 35 | OE | |
| | 1997-98 | 2000 | lithic | 76 | CW | |
| | 1997-98 | 2005 | point | 50 | OE | |
| | 1997-98 | 2005 | point | 5 | IndCB | |
| | 1997-98 | 2005 | point | 13 | | Missing data |
| | 1997-98 | 2005 | point | 34 | TB | |
| | 1997-98 | 2005 | point | 59 | SDM | |
| 10-CN-6 | 2002-04 | 2003-04 | lithic | 1 | OE | |
| | 2002-04 | 2003-04 | lithic | 2 | CW | |
| | 2002-04 | 2003-04 | lithic | 3 | UNK 1 | |
| | 2002-04 | 2003-04 | lithic | 4 | TB | |
| | 2002-04 | 2003-04 | lithic | 5 | TB | |
| | 2002-04 | 2003-04 | lithic | 6 | OE | |
| | 2002-04 | 2003-04 | lithic | 45 | OE | |
| | 2002-04 | 2003-04 | lithic | 79 | OE | |
| | 2002-04 | 2003-04 | lithic | 92 | OE | |
| | 2002-04 | 2003-04 | lithic | 95 | TB | |
| | 2002-04 | 2003-04 | lithic | 96 | OE2 | |
| | 2002-04 | 2003-04 | lithic | 77 | OE | |
| | 2002-05 | 2005 | point | 110 | TB | |
| | 2002-05 | 2005 | point | 48 | OE | |
| | 2002-05 | 2005 | point | 46 | CW | |
| | 2002-05 | 2005 | point | 34 | OE | |
| | 2002-05 | 2005 | point | 78 | OE | |
| | 2002-05 | 2005 | point | 121 | SinkC | |
| | 2002-05 | 2005 | point | 57 | VR | |
| | 2002-05 | 2005 | point | 35 | TB | |
| | 2002-05 | 2005 | point | 60 | OE | |
| | 2002-05 | 2005 | point | 116 | OE | |
| | 2002-05 | 2005 | point | 32 | | Missing Data |

| Site | Rec_Yr | Anal_Yr | Spec_type | Spec_# | Source | Comments |
|---|---|---|---|---|---|---|
| 10-EL-1577 | 2000-01 | 2000-01 | lithic | D3 | UNK 1 | |
| | 2000-01 | 2000-01 | lithic | D10 | UNK 2 | Possibly from Malad |
| | 2000-01 | 2000-01 | lithic | D49 | Nob | |
| | 2000-01 | 2000-01 | lithic | D30 | UNK 3 | |
| | 2000-01 | 2000-01 | lithic | D54 | UNK 4 | |
| | 2000-01 | 2000-01 | lithic | D63 | UNK 1 | |
| | 2000-01 | 2000-01 | lithic | D86 | UNK 1 | |
| | 2000-01 | 2000-01 | lithic | D5 | UNK3 | |
| | 2000-01 | 2000-01 | lithic | D25 | UNK 5 | |
| | 2000-01 | 2000-01 | lithic | D42 | OE | |
| | 2000-01 | 2000-01 | lithic | D60 | UNK3 | |
| | 2000-01 | 2000-01 | lithic | D63 | BB | |
| | 2000-01 | 2000-01 | lithic | D86 | BB | |
| | 2000-01 | 2005 | point | 522 | OE | |
| | 2000-01 | 2005 | point | 393 | | Missing data |
| | 2000-01 | 2005 | point | 537 | BB | |
| | 2000-01 | 2005 | point | 92 | CM | |
| | 2000-01 | 2005 | point | 16 | Bgul | |
| | | | | | | |
| 10-EL-1367 | 1995 | 2004 | lithic | 1 | OE | |
| | 1995 | 2004 | lithic | 2 | BB | |
| | 1995 | 2004 | lithic | 3 | CM | |
| | 1995 | 2004 | lithic | 4 | BB | |
| | 1995 | 2004 | lithic | 5 | OE | |
| | 1995 | 2005 | point | 30 | CM | |
| | 1995 | 2005 | point | 34 | BB | |
| | 1995 | 2005 | point | 10 | BB | |
| | 1995 | 2005 | point | 29 | BB* | BB Area |
| | | | | | | |
| 10EL-1417 | 2001 | 2005 | point | 79 | BB | |
| | 2001 | 2005 | point | 31 | CM | |
| | 2001 | 2005 | point | 30 | BB | |
| | 2001 | 2005 | point | 11 | CM | |
| | 2001 | 2005 | point | 70 | CM | |
| | 2001 | 2005 | point | 4 | | Not sent to be analyzed |
| | 2001 | 2005 | point | 89 | BB | |
| | 2001 | 2005 | point | 69 | BB* | BB area |
| | | | | | | |
| 10-AA-17 | 1981 | 2005 | point | 96 | OE | |
| | 1981 | 2005 | point | 42 | OE | |
| | 1981 | 2005 | point | 110 | OE | |
| | 1981 | 2005 | point | 90 | TB | |
| | 1981 | 2005 | point | 95 | OE | |
| | | | | | | |

| Site | Rec_Yr | Anal_Yr | Spec_type | Spec_# | Source | Comments |
|---|---|---|---|---|---|---|
| 10-EL-22 | 1989 | 1989 | lithic | 488-662 | TB | |
| | 1989 | 1989 | lithic | 488-704 | HR | |
| **Site** | **Rec_Yr** | **Anal_Yr** | **Spec_type** | **Spec_#** | **Source** | **Comments** |
| | 1989 | 1989 | lithic | 488-252 | HR | |
| | 1989 | 1989 | lithic | 488-289 | HR | |
| | | | | | | |
| 10-EL-294 | 1986-87 | 1986-87 | lithic | 660 | BB | |
| | 1986-87 | 1986-87 | lithic | 1508 | BB | |
| | 1986-87 | 1986-87 | lithic | 802 | BB | |
| | 1986-87 | 2005 | point | 569 | BB | |
| | 1986-87 | 2005 | point | 1173 | OE | |
| | 1986-87 | 2005 | point | 970 | BB | |
| | 1986-87 | 2005 | point | 972 | TB | |
| | 1986-87 | 2005 | point | 382 | Bgul | |
| | 1986-87 | 2005 | point | 381 | BB | |
| | | | | | | |
| 10-OE-269 | 1993 | 1993 | lithic | 269-1 | OE | |
| | 1993 | 1993 | lithic | 269-2 | OE | |
| | 1993 | 1993 | lithic | 269-3 | OE | |
| | | | | | | |
| | | | | | | |
| 10-AA-256 | 1989 | 2005 | point | 1 | OE | |
| | 1989 | 2005 | point | 2 | | Missing Data |
| | 1989 | 2005 | point | 3 | OE | |
| | 1989 | 2005 | point | 5 | OE | |
| | 1989 | 2005 | point | 6 | OE | |
| | | | | | | |
| | | | | | | |
| 10-EL-392 | 1994-95 | 2005 | point | 21 | TB | |
| | 1994-95 | 2005 | point | 23 | TB | |
| | 1994-95 | 2005 | point | 5 | BB | |
| | 1994-95 | 2005 | point | 61 | TB | |
| | 1994-95 | 2005 | point | 28 | OE | |
| | | | | | | |
| 35-ML-1088 | 2003 | 2003 | lithic | 1 | SDM | |
| | 2003 | 2003 | lithic | 2 | SDM | |
| | 2003 | 2003 | lithic | 3 | CW | |
| | | | | | | |
| | | | | | | |
| 35-ML-148 | 2004 | 2004 | lithic | 1 | IndCB | |
| | 2004 | 2004 | lithic | 2 | SDM | |
| | 2004 | 2004 | lithic | 3 | PaV | |
| | 2004 | 2004 | lithic | 4 | IndCB | |
| | 2004 | 2004 | lithic | 5 | SkSpr | |
| | 2004 | 2004 | lithic | 6 | IndCB | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 2004 | 2004 | lithic | 7 | UNK1 | |
| | | | | | | |

| Site | Rec_Yr | Anal_Yr | Spec_type | Spec_# | Source | Comments |
|---|---|---|---|---|---|---|
| Antelope Creek | 1969 | 2004 | point | 378 | PaV | |
| | 1969 | 2004 | point | 370 | WH | |
| | 1969 | 2004 | point | 375 | OE | |
| | 1969 | 2004 | point | 64 | WH | |
| | 1969 | 2004 | point | 61 | PaV | |
| | 1969 | 2004 | point | 185 | PaV | |
| | 1969 | 2004 | point | 45 | PaV | |
| | 1969 | 2004 | point | 193 | UNK 1 | |
| | 1969 | 2004 | point | 351 | WH | |
| | 1969 | 2004 | point | 141 | UNK 2 | |
| | 1969 | 2004 | point | 377 | UNK 2 | |
| | 1969 | 2004 | point | 93 | WH | |
| | 1969 | 2004 | point | 329 | IndCB | |
| | 1969 | 2004 | point | 286 | PaV | |
| | | | | | | |
| 35-ML-1325 | 2005 | 2005 | point | 24 | WH | |
| | 2005 | 2005 | point | 25 | OE | |
| | 2005 | 2005 | point | 15 | GMB | |
| | 2005 | 2005 | point | 18 | OE | |

***Northwest Research Obsidian Studies Laboratory***

Table A-1. Results of XRF Studies: Several Sites in Canyon, Ada, Elmore, and Malheur Counties, Idaho and Oregon

| Site | Specimen No. | Catalog No. | | Trace Element Concentrations | | | | | | | | | | | Ratios | | Geochemical Source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Zn | Pb | Rb | Sr | Y | Zr | Nb | Ti | Mn | Ba | $Fe_2O_3^T$ | Fe:Mn | Fe:Ti | |
| 10-CN-1 | 1 | A71 | | 55 | 32 | 230 | 35 | 31 | 124 | 13 | NM | NM | NM | NM | 56.7 | 51.7 | Owyhee * |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-CN-1 | 2 | A105 | | 43 | 29 | 185 | 22 | 43 | 58 | 33 | NM | NM | NM | NM | 7.4 | 61.9 | Timber Butte * |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-CN-1 | 3 | A122 | | 39 | 24 | 220 | 30 | 30 | 106 | 9 | NM | NM | NM | NM | 55.7 | 73.9 | Owyhee * |
| | | | ± | 12 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-CN-1 | 4 | A137 | | 57 | 31 | 178 | 26 | 43 | 61 | 34 | NM | NM | NM | NM | 9.3 | 48.1 | Timber Butte * |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-CN-1 | 5 | A138 | | 111 | 23 | 126 | 31 | 65 | 440 | 31 | NM | NM | NM | NM | 31.9 | 47.3 | Coyote Wells * |
| | | | ± | 12 | 6 | 5 | 9 | 3 | 11 | 2 | NM | NM | NM | NM | | | |
| 10-CN-5 | 6 | A5 | | 65 | 25 | 182 | 32 | 51 | 163 | 30 | NM | NM | 147 | NM | 28.0 | 72.1 | Indian Creek Buttes * |
| | | | ± | 10 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | 32 | NM | | | |
| 10-CN-5 | 8 | A34 | | 64 | 31 | 181 | 21 | 38 | 58 | 34 | NM | NM | NM | NM | 7.3 | 50.6 | Timber Butte * |
| | | | ± | 10 | 4 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-CN-5 | 9 | A50 | | 51 | 26 | 239 | 35 | 30 | 111 | 10 | 593 | 346 | 163 | 0.98 | 24.7 | 55.6 | Owyhee |
| | | | ± | 9 | 4 | 5 | 9 | 3 | 10 | 2 | 89 | 28 | 32 | 0.11 | | | |
| 10-CN-5 | 10 | A59 | | 36 | 19 | 134 | 35 | 37 | 207 | 21 | NM | NM | 425 | NM | 46.2 | 40.4 | Sourdough Mountain * |
| | | | ± | 11 | 5 | 4 | 9 | 3 | 10 | 2 | NM | NM | 32 | NM | | | |
| 10-CN-6 | 12 | A34 | | 31 | 20 | 222 | 32 | 25 | 109 | 8 | NM | NM | NM | NM | 72.0 | 67.9 | Owyhee * |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-CN-6 | 13 | A35 | | 59 | 30 | 188 | 23 | 44 | 59 | 33 | NM | NM | NM | NM | 7.1 | 65.1 | Timber Butte * |
| | | | ± | 10 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-CN-6 | 14 | A46 | | 74 | 20 | 114 | 25 | 61 | 428 | 34 | NM | NM | NM | NM | 34.1 | 50.1 | Coyote Wells * |
| | | | ± | 10 | 5 | 4 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-CN-6 | 15 | A48 | | 38 | 31 | 238 | 41 | 30 | 117 | 8 | NM | NM | NM | NM | 61.3 | 46.5 | Owyhee * |
| | | | ± | 10 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-CN-6 | 16 | A57 | | 41 | 19 | 101 | 154 | 26 | 95 | 14 | NM | NM | 891 | NM | 17.8 | 81.6 | Venator * |
| | | | ± | 10 | 5 | 4 | 9 | 3 | 10 | 2 | NM | NM | 33 | NM | | | |
| 10-CN-6 | 17 | A60 | | 36 | 31 | 251 | 34 | 27 | 115 | 9 | 436 | 168 | 137 | 0.89 | 47.3 | 68.0 | Owyhee |
| | | | ± | 10 | 4 | 5 | 9 | 3 | 10 | 1 | 88 | 27 | 32 | 0.11 | | | |
| 10-CN-6 | 18 | A78 | | 50 | 27 | 226 | 35 | 31 | 107 | 13 | 514 | 160 | 135 | 0.93 | 51.6 | 60.5 | Owyhee |
| | | | ± | 10 | 4 | 5 | 9 | 3 | 10 | 1 | 88 | 27 | 32 | 0.11 | | | |

All trace element values reported in parts per million; ± = analytical uncertainty estimate (in ppm). Iron content reported as weight percent oxide.
NA = Not available; ND = Not detected; NM = Not measured.; * = Small sample.

***Northwest Research Obsidian Studies Laboratory***

Table A-1. Results of XRF Studies: Several Sites in Canyon, Ada, Elmore, and Malheur Counties, Idaho and Oregon

| Site | Specimen No. | Catalog No. | | Trace Element Concentrations | | | | | | | | | | | Ratios | | Geochemical Source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Zn | Pb | Rb | Sr | Y | Zr | Nb | Ti | Mn | Ba | $Fe_2O_3^T$ | Fe:Mn | Fe:Ti | |
| 10-CN-6 | 19 | A110 | | 55 | 34 | 198 | 20 | 42 | 61 | 35 | NM | NM | NM | NM | 7.5 | 74.0 | Timber Butte * |
| | | | ± | 9 | 4 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-CN-6 | 20 | A116 | | 46 | 32 | 255 | 39 | 31 | 124 | 10 | 563 | 281 | 227 | 0.89 | 27.6 | 53.1 | Owyhee |
| | | | ± | 9 | 4 | 5 | 9 | 3 | 10 | 1 | 89 | 27 | 32 | 0.11 | | | |
| 10-CN-6 | 21 | A121 | | 141 | 39 | 254 | 26 | 91 | 208 | 39 | NM | NM | NM | NM | 86.1 | 75.2 | Sinker Canyon * |
| | | | ± | 10 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-AA-17 | 22 | A17 | | 31 | 19 | 215 | 33 | 29 | 102 | 11 | NM | NM | NM | NM | 57.1 | 73.9 | Owyhee * |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-AA-17 | 23 | A42 | | 37 | 32 | 209 | 38 | 29 | 113 | 11 | NM | NM | NM | NM | 58.4 | 43.1 | Owyhee * |
| | | | ± | 10 | 4 | 5 | 9 | 3 | 10 | 1 | NM | NM | NM | NM | | | |
| 10-AA-17 | 24 | A90 | | 54 | 26 | 190 | 23 | 41 | 57 | 36 | NM | NM | NM | NM | 6.6 | 20.4 | Timber Butte * |
| | | | ± | 9 | 4 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-AA-17 | 25 | A95 | | 49 | 23 | 208 | 32 | 28 | 106 | 9 | NM | NM | NM | NM | 22.4 | 49.0 | Owyhee * |
| | | | ± | 10 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-AA-17 | 26 | A96 | | 34 | 18 | 216 | 32 | 29 | 103 | 10 | NM | NM | NM | NM | 55.2 | 73.0 | Owyhee * |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-AA-256 | 27 | A1 | | 12 | 20 | 205 | 30 | 28 | 99 | 10 | 525 | 137 | 146 | 0.90 | 58.3 | 57.3 | Owyhee |
| | | | ± | 22 | 5 | 5 | 9 | 3 | 10 | 2 | 88 | 27 | 32 | 0.11 | | | |
| 10-AA-256 | 29 | A3 | | 33 | 36 | 192 | 45 | 23 | 112 | 23 | NM | NM | NM | NM | NM | NM | Owyhee * |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-AA-256 | 30 | A5 | | 44 | 22 | 222 | 38 | 27 | 115 | 10 | NM | NM | NM | NM | NM | NM | Owyhee * |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-AA-256 | 31 | A6 | | 28 | 24 | 208 | 33 | 26 | 113 | 11 | NM | NM | NM | NM | 50.4 | 58.1 | Owyhee * |
| | | | ± | 13 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-EL-294 | 32 | A381 | | 58 | 25 | 208 | 52 | 61 | 420 | 42 | NM | NM | NM | NM | 79.6 | 40.0 | Browns Bench * |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-EL-294 | 33 | A382 | | 53 | 22 | 190 | 52 | 45 | 309 | 59 | NM | NM | NM | NM | 48.5 | 32.3 | Bear Gulch* |
| | | | ± | 10 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-EL-294 | 34 | A569 | | 58 | 26 | 205 | 43 | 71 | 393 | 47 | NM | NM | NM | NM | 70.1 | 44.4 | Browns Bench * |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-EL-294 | 35 | A970 | | 62 | 31 | 213 | 56 | 65 | 463 | 45 | NM | NM | 1107 | NM | 39.3 | 36.9 | Browns Bench * |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | 34 | NM | | | |

All trace element values reported in parts per million; ± = analytical uncertainty estimate (in ppm). Iron content reported as weight percent oxide.
NA = Not available; ND = Not detected; NM = Not measured.; * = Small sample.

***Northwest Research Obsidian Studies Laboratory***

Table A-1. Results of XRF Studies: Several Sites in Canyon, Ada, Elmore, and Malheur Counties, Idaho and Oregon

| Site | Specimen No. | Catalog No. | | Trace Element Concentrations: Zn | Pb | Rb | Sr | Y | Zr | Nb | Ti | Mn | Ba | $Fe_2O_3^T$ | Ratios: Fe:Mn | Fe:Ti | Geochemical Source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10-EL-294 | 36 | A972 | | 53 | 36 | 181 | 19 | 40 | 64 | 31 | 263 | 707 | 55 | 0.44 | 5.9 | 57.4 | Timber Butte |
| | | | ± | 10 | 5 | 5 | 9 | 3 | 10 | 2 | 88 | 28 | 33 | 0.11 | | | |
| 10-EL-294 | 37 | A1173 | | 62 | 32 | 216 | 46 | 26 | 127 | 12 | NM | NM | NM | NM | NM | NM | Owyhee * |
| | | | ± | 9 | 5 | 5 | 9 | 3 | 10 | 1 | NM | NM | NM | NM | | | |
| 10-EL-392 | 38 | A5 | | 65 | 31 | 214 | 53 | 69 | 449 | 42 | NM | NM | 1151 | NM | 74.2 | 38.3 | Browns Bench |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | 33 | NM | | | |
| 10-EL-392 | 39 | A21 | | 66 | 31 | 181 | 22 | 45 | 58 | 31 | NM | NM | NM | NM | 7.2 | 49.4 | Timber Butte * |
| | | | ± | 10 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-EL-392 | 40 | A23 | | 55 | 38 | 185 | 24 | 39 | 58 | 33 | NM | NM | NM | NM | 7.1 | 46.3 | Timber Butte * |
| | | | ± | 10 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-EL-392 | 41 | A28 | | 31 | 26 | 228 | 36 | 28 | 114 | 10 | NM | NM | NM | NM | 59.7 | 40.6 | Owyhee * |
| | | | ± | 10 | 5 | 5 | 9 | 3 | 10 | 1 | NM | NM | NM | NM | | | |
| 10-EL-392 | 42 | A61 | | 53 | 28 | 174 | 23 | 38 | 55 | 34 | NM | NM | NM | NM | 6.9 | 61.9 | Timber Butte * |
| | | | ± | 10 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-EL-1367 | 43 | A10 | | 73 | 32 | 211 | 56 | 63 | 433 | 46 | NM | NM | NM | NM | 79.2 | 41.4 | Browns Bench * |
| | | | ± | 10 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-EL-1367 | 44 | A29 | | 53 | 33 | 237 | 33 | 62 | 346 | 41 | NM | NM | 444 | NM | 75.6 | 39.8 | Browns Bench Area * |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | 33 | NM | | | |
| 10-EL-1367 | 45 | A30 | | 206 | 56 | 376 | 7 | 118 | 1066 | 117 | NM | NM | NM | NM | 65.3 | 115.5 | Cannonball Mountain * |
| | | | ± | 12 | 5 | 5 | 9 | 3 | 11 | 2 | NM | NM | NM | NM | | | |
| 10-EL-1367 | 46 | A34 | | 62 | 24 | 188 | 56 | 72 | 485 | 55 | 1441 | 265 | 1098 | 1.92 | 61.0 | 44.6 | Browns Bench |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | 92 | 28 | 33 | 0.11 | | | |
| 10-EL-1577 | 47 | A16 | | 44 | 25 | 185 | 48 | 46 | 293 | 55 | NM | NM | NM | NM | 46.2 | 32.1 | Bear Gulch* |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-EL-1577 | 48 | A92 | | 183 | 49 | 363 | 11 | 116 | 1067 | 115 | NM | NM | NM | NM | 65.0 | 96.7 | Cannonball Mountain * |
| | | | ± | 12 | 6 | 5 | 10 | 3 | 11 | 2 | NM | NM | NM | NM | | | |
| 10-EL-1577 | 50 | A522 | | 58 | 19 | 223 | 34 | 28 | 110 | 12 | NM | NM | NM | NM | 55.1 | 69.0 | Owyhee * |
| | | | ± | 10 | 5 | 5 | 9 | 3 | 10 | 1 | NM | NM | NM | NM | | | |
| 10-EL-1577 | 51 | A537 | | 54 | 35 | 216 | 47 | 59 | 394 | 42 | NM | NM | NM | NM | 82.8 | 38.7 | Browns Bench * |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-EL-1417 | 52 | A11 | | 198 | 57 | 381 | 10 | 114 | 1024 | 113 | NM | NM | NM | NM | 63.7 | 111.5 | Cannonball Mountain * |
| | | | ± | 12 | 5 | 5 | 10 | 3 | 11 | 2 | NM | NM | NM | NM | | | |

All trace element values reported in parts per million; ± = analytical uncertainty estimate (in ppm). Iron content reported as weight percent oxide.
NA = Not available; ND = Not detected; NM = Not measured.; * = Small sample.

***Northwest Research Obsidian Studies Laboratory***

Table A-1. Results of XRF Studies: Several Sites in Canyon, Ada, Elmore, and Malheur Counties, Idaho and Oregon

| Site | Specimen No. | Catalog No. | | Trace Element Concentrations | | | | | | | | | | | Ratios | | Geochemical Source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Zn | Pb | Rb | Sr | Y | Zr | Nb | Ti | Mn | Ba | $Fe^2O^{3T}$ | Fe:Mn | Fe:Ti | |
| 10-EL-1417 | 53 | A30 | | 43 | 29 | 200 | 57 | 62 | 453 | 43 | NM | NM | NM | NM | 71.9 | 41.6 | Browns Bench * |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-EL-1417 | 54 | A31 | | 212 | 53 | 369 | 8 | 112 | 1022 | 114 | NM | NM | 0 | NM | 62.3 | 84.4 | Cannonball Mountain * |
| | | | ± | 11 | 5 | 5 | 12 | 3 | 11 | 2 | NM | NM | 31 | NM | | | |
| 10-EL-1417 | 55 | A69 | | 68 | 29 | 223 | 31 | 59 | 339 | 43 | NM | NM | 522 | NM | 52.0 | 38.2 | Browns Bench Area * |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | 33 | NM | | | |
| 10-EL-1417 | 56 | A70 | | 200 | 55 | 376 | 12 | 111 | 1020 | 118 | NM | NM | NM | NM | 67.5 | 81.9 | Cannonball Mountain * |
| | | | ± | 12 | 5 | 5 | 10 | 3 | 11 | 2 | NM | NM | NM | NM | | | |
| 10-EL-1417 | 57 | A79 | | 49 | 29 | 209 | 48 | 58 | 387 | 38 | NM | NM | NM | NM | 77.1 | 39.8 | Browns Bench * |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 10-EL-1417 | 58 | A89 | | 71 | 20 | 210 | 51 | 60 | 407 | 40 | NM | NM | NM | NM | 72.1 | 37.8 | Browns Bench * |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | NM | NM | NM | NM | | | |
| 35-ML-1325 | 59 | A024 | | 153 | 41 | 191 | 13 | 77 | 424 | 21 | 1122 | 455 | 0 | 2.40 | 43.8 | 70.6 | Whitehorse |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | 90 | 28 | 31 | 0.11 | | | |
| 35-ML-1325 | 60 | A025 | | 39 | 24 | 219 | 32 | 29 | 103 | 8 | 411 | 160 | 141 | 0.93 | 51.4 | 74.2 | Owyhee |
| | | | ± | 10 | 5 | 5 | 9 | 3 | 10 | 2 | 88 | 27 | 32 | 0.11 | | | |
| 35-ML-1325 | 61 | A015 | | 142 | 52 | 305 | 10 | 108 | 215 | 37 | 382 | 346 | 0 | 1.18 | 29.4 | 99.9 | Grassy Mountain B? |
| | | | ± | 11 | 5 | 5 | 10 | 3 | 10 | 2 | 88 | 28 | 31 | 0.11 | | | |
| 35-ML-1325 | 62 | A018 | | 33 | 22 | 222 | 33 | 31 | 115 | 11 | 540 | 284 | 199 | 1.01 | 30.9 | 62.2 | Owyhee |
| | | | ± | 11 | 5 | 5 | 9 | 3 | 10 | 2 | 89 | 28 | 32 | 0.11 | | | |
| NA | RGM-1 | RGM-1 | | 21 | 25 | 155 | 107 | 22 | 218 | 10 | 1672 | 278 | 782 | 1.86 | 56.2 | 37.3 | RGM-1 Reference Standard |
| | | | ± | 12 | 5 | 5 | 9 | 3 | 10 | 2 | 92 | 28 | 32 | 0.11 | | | |

All trace element values reported in parts per million; ± = analytical uncertainty estimate (in ppm). Iron content reported as weight percent oxide.
NA = Not available; ND = Not detected; NM = Not measured.; * = Small sample.