OBSIDIAN PROJECTILE POINTS AND HUMAN MOBILITY AROUND THE BIRCH CREEK SITE (35ML181), SOUTHEASTERN OREGON

By

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To the Faculty of Washington State University:

The members of the Committee appointed to examine the thesis of ERIN WALLACE find it satisfactory and recommend that it be accepted.

Chair

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Abstract

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This thesis explores prehistoric human land-use and mobility around the Birch Creek Site (35ML181), Southeastern Oregon. My research evaluates Julian Steward's (1938) ethnographic model of hunter-gatherer land-use to assess continuity of human land-use through time around the Birch Creek Site. The Stewardian model is tested using artifact data in the form of x-ray fluorescence analysis of artifact obsidian. The point data collected from x-ray fluorescence analysis of these artifacts outlines a procurement range around the site, which thus acts as a proxy measure for the scale of land-use exhibited over time by the users of the site.

Three separate lines of evidence are used to explore patterns of human land-use through time: stratigraphic superposition of artifacts, temporally diagnostic projectile points, and radiocarbon dates. Based on the continuity of obsidian procurement through time at the site, it is possible to extend the Stewardian model for low population density hunter-gatherers, organized at the family-level, at least 6,600 years into prehistory, and potentially 9,500 years, at the Birch Creek Site.

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DEDICATION

For Mom and Dad

CHAPTER ONE

INTRODUCTION

My thesis investigates prehistoric human settlement systems and mobility around the Birch Creek Site (35ML181), southeastern Oregon. This research evaluates Julian Steward's (1938) ethnographic model of hunter-gatherer land-use to assess continuity of prehistoric land-use over time in the northern Great Basin. The primary goal of this research is to test whether or not artifact data in the form of x-ray fluorescence (XRF) analysis conform to the Stewardian model and how land-use may have changed through time around the Birch Creek Site.

With a primary focus on ecological and social determinants, Steward (1938) developed an ethnographic model for human land-use in the Great Basin (presented in detail in Chapter Three). Because of the scarcity of resources and generally poor quality of the environment, Steward (1938) argued for family-level organization throughout much of the Great Basin. The environment could not support large, permanent settlements; therefore, extended family groups were the stable economic unit in the Great Basin (Steward 1938). Family groups, by necessity, remained highly mobile throughout much the year and traveled within a 20-30 mile radius, basing their movements on the availability of seasonal resources. Habitation of winter villages, often located in canyons or river valleys, marked one of the few relatively permanent settlements in the region (Steward 1938). In general, however, the northern Great Basin was inhabited by low population density hunter-gatherers, living in extended family groups, who were highly mobile throughout much of the year. The goal of the present study is to test this ethnographic model for human land-use at the Birch Creek Site using artifact data.

The Birch Creek Site works as the geographic center for this analysis, a constant location from which to explore human land-use through time. XRF of artifact obsidian from the site is used as a proxy measure for human land-use. XRF analysis identifies signature chemistry for obsidian artifacts and enables archaeologists to identify specific locations from which obsidian was procured. The dates of the analyzed artifacts can be inferred from other archaeological data (i.e. associated chronometric dates and typological seriations). The obsidian source locations indicate an obsidian procurement range that acts a proxy measure for human land-use. These patterns of human land-use through time are used to explore human settlement systems and mobility around the Birch Creek Site. Obsidian XRF as a method and its implications for human mobility are discussed in detail in Chapter Three.

Chapter One introduces the Birch Creek Site, reviews past environmental data for the region, highlights regional ethnographic literature and culture history, and summarizes the Birch Creek Archaeological Project to date. Chapter Two examines regional XRF data in order to answer questions about obsidian procurement from the area surrounding the Birch Creek Site. Chapter Three outlines the research design for the present study and includes a discussion on the utility of XRF data for examining human land-use patterns. Chapter Three also addresses sample selection, artifact classification, and presents projectile point chronologies for the region. Chapter Four presents the results of the analysis, specifically addressing patterns associated with artifact type, directionality and distance to source, and projectile point chronologies. Radiocarbon dates and associated sourced obsidian artifacts are also considered in Chapter Four. Chapter Five addresses the results of the analysis and their implications for human settlement systems and mobility around the Birch Creek Site. Finally, Chapter Six summarizes the present study and presents concluding remarks.

Site Location

The Birch Creek Site is located in southeastern Oregon (Figure 1.1), approximately 60 km northwest of Jordan Valley, Oregon. The site is situated on an alluvial terrace sequence of the Owyhee River (Walker 2001; Figure 1.2), a tributary of the Snake River. The site is identified by a surface scatter of artifacts located approximately 60 m from the edge of the Owyhee River. The surface scatter of artifacts extends 200 m along the shore of the river (Andrefsky et al. 2003).

Figure 1.1. Location of the Birch Creek Site, 35ML181 (from Andrefsky et al. 2003).

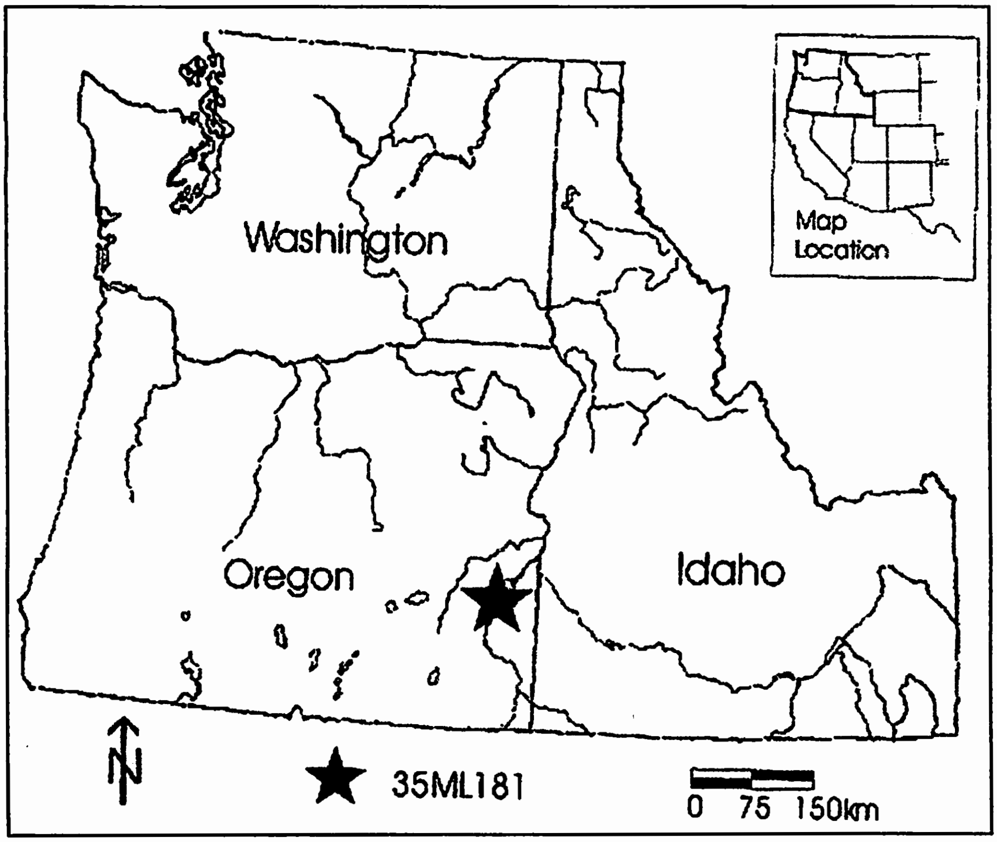
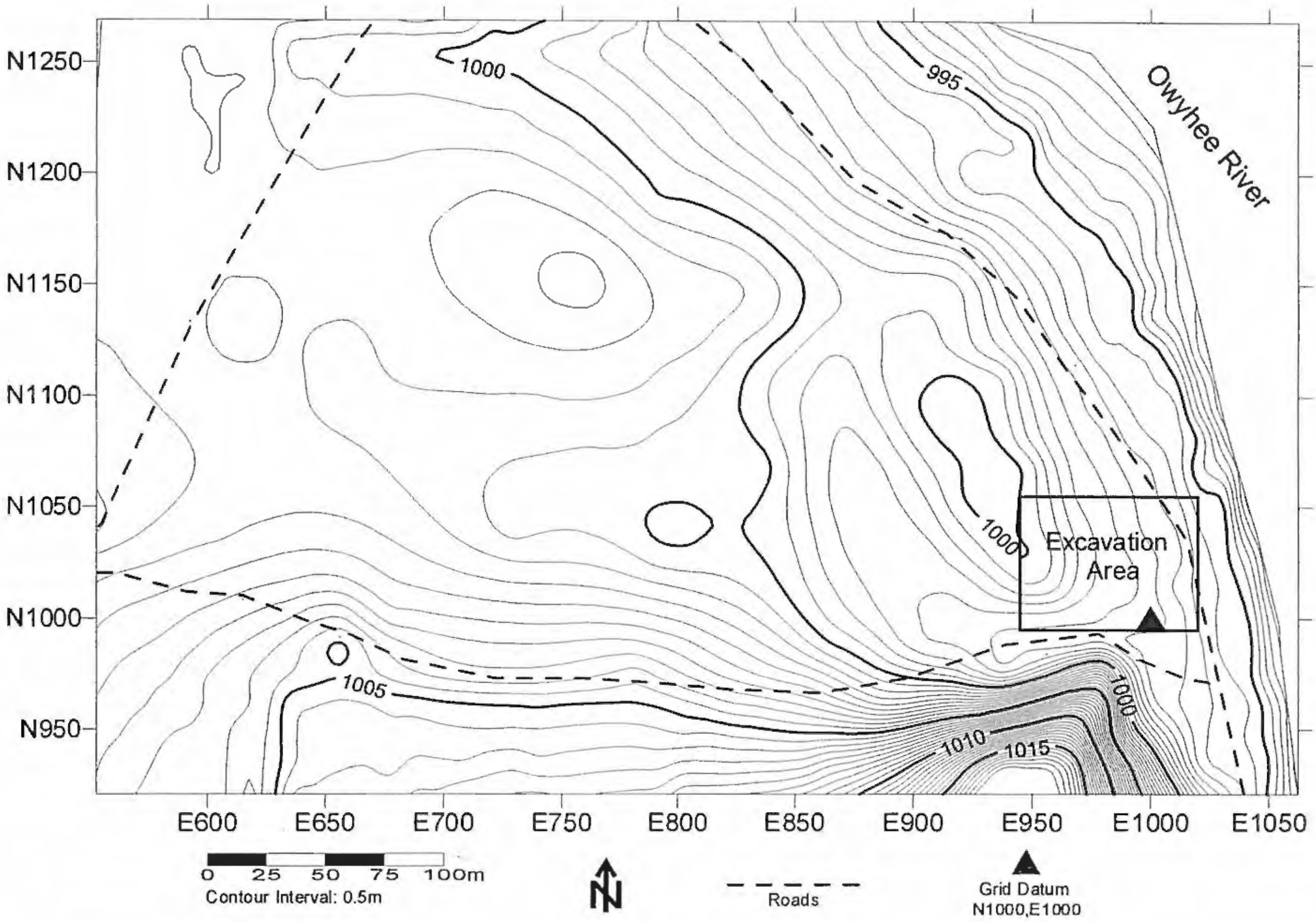


Figure 1.2. Relief map showing location of project area (from Andrefsky et al. 2003).

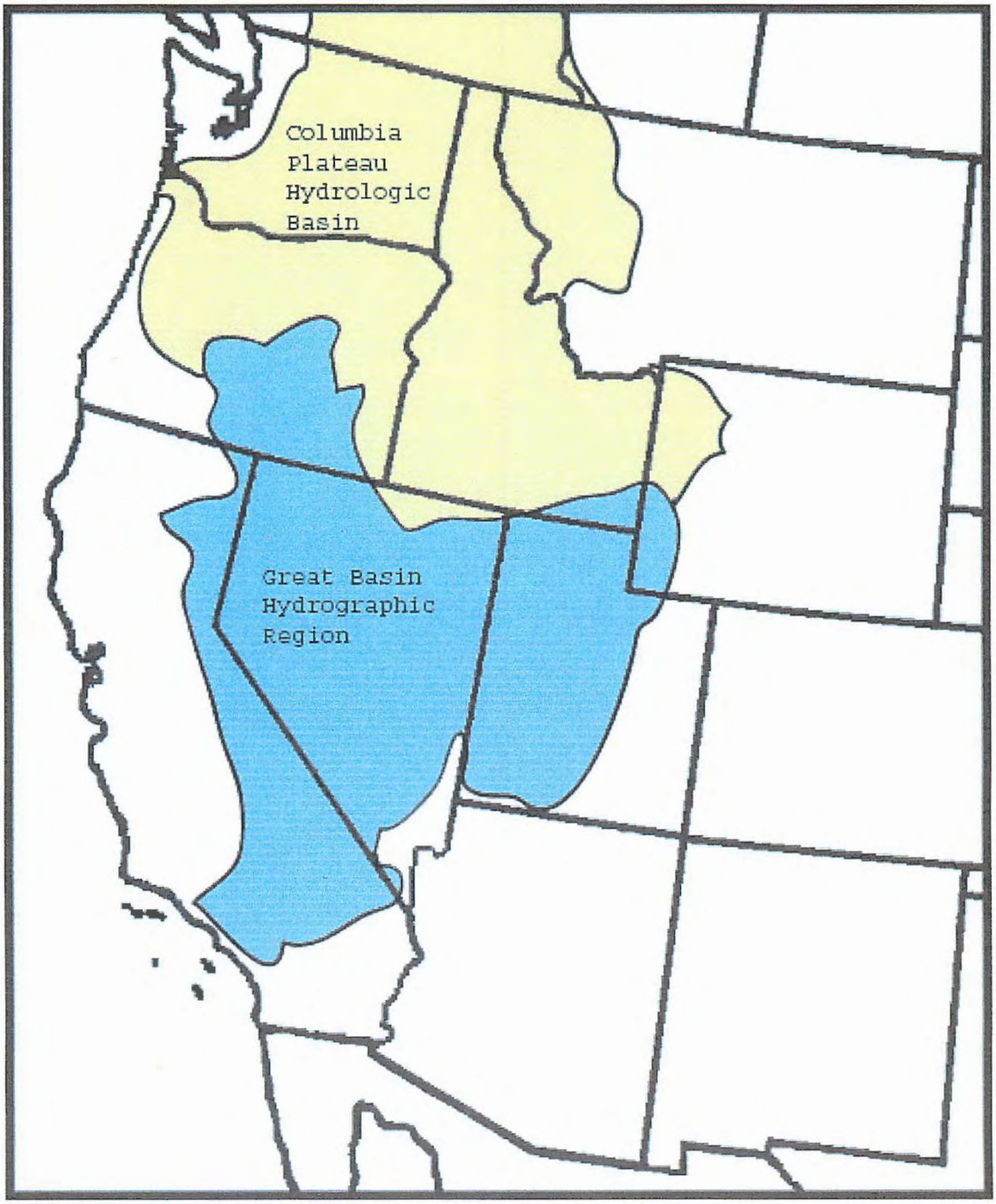


Past Environment

The present study investigates human settlement systems through time around the Birch Creek Site, and this section outlines past environmental data in order to provide historical context for changes that may have occurred in the region through time.

The Birch Creek Site, located in the Owyhee Uplands, is situated near the convergence of two major physiographic regions: the southern Columbia Plateau and the northern Great Basin. The Columbia Plateau is most commonly defined as an outwardly drained region that includes the Columbia River and its major tributaries. The Great Basin, on the other hand, is a large region encompassing much of Nevada and parts of Utah, California, and Oregon that is not outwardly drained (Fenneman 1931; Thornbury 1965; Figure 1.3).

Figure 1.3. Great Basin and Columbia Plateau hydrologic regions.



Although the projectile points recovered from the site would suggest strong ties to the Great Basin, the location of 35ML181 is more typical of the riverside settlements associated with the Columbia Plateau (Ames et al. 1998). This section reviews past environmental data for both the Great Basin and Columbia Plateau regions.

<u>Great Basin</u>

The most recent dramatic environmental change in the Great Basin was the transition from relatively wet conditions to much drier conditions approximately 12,000 years ago. Prior to 12,600 BP, the pluvial lakes in the Great Basin were much larger and more numerous than they are in modern times (Mehringer 1986). All radiocarbon ages presented in text are uncorrected ^{14}C years unless otherwise noted. These relatively wet conditions began to disappear between 12,600 BP and 10,600 BP. Arid conditions continued for thousands of years. Reduced effective moisture continued until 5,100 BP, and increased temperatures persisted until 4,000 BP (Mehringer 1986). Approximately 6,700 BP (Mehringer et al. 1977), the eruption of Mt. Mazama marked a period of high volcanic activity in Oregon, including recurrent volcanic activity at Newberry Craters in central Oregon. After the cessation of this volcanic activity, wetter and cooler conditions prevailed until approximately 2,000 BP (Mehringer 1986).

Grayson (1993) also presents a review of the paleoenvironmental data for the Great Basin. Grayson divides the Holocene into three periods: Early Holocene (10,000-7,500 BP), Middle Holocene (7,500-4,500 BP), and Late Holocene (4,500 BP to present). Paleoenvironmental data from plants, animals, and lakes suggest that the Early Holocene was marked by cooler and wetter conditions. The Middle Holocene, however, was marked by increased temperatures and reduced moisture. Finally, Grayson (1993) concludes that cooler and wetter conditions prevailed in the Late Holocene, though not as drastic as the early Holocene. Relatively modern climatic conditions prevailed in the Great Basin during the late Holocene.

A more recent review of the paleoenvironmental data from the Great Basin is presented by Benson et al. (2002). Benson et al. argue that the period between 11,600 and 10,000 cal yr BP was marked by a general drying trend, but included a brief wet period (200 yr) at 10,300 cal yr BP. Following these arid conditions, wetter conditions prevailed in the Great Basin until 8,000 cal yr BP (Benson et al. 2002). The period between 6,500 and 3,800 cal yr BP is marked by drought conditions in the Great Basin that resulted in shrinking of lakes throughout the region. Benson et al. (2002) place the onset of relatively modern conditions (late Holocene) at approximately 3,000 cal yr BP.

Columbia Plateau

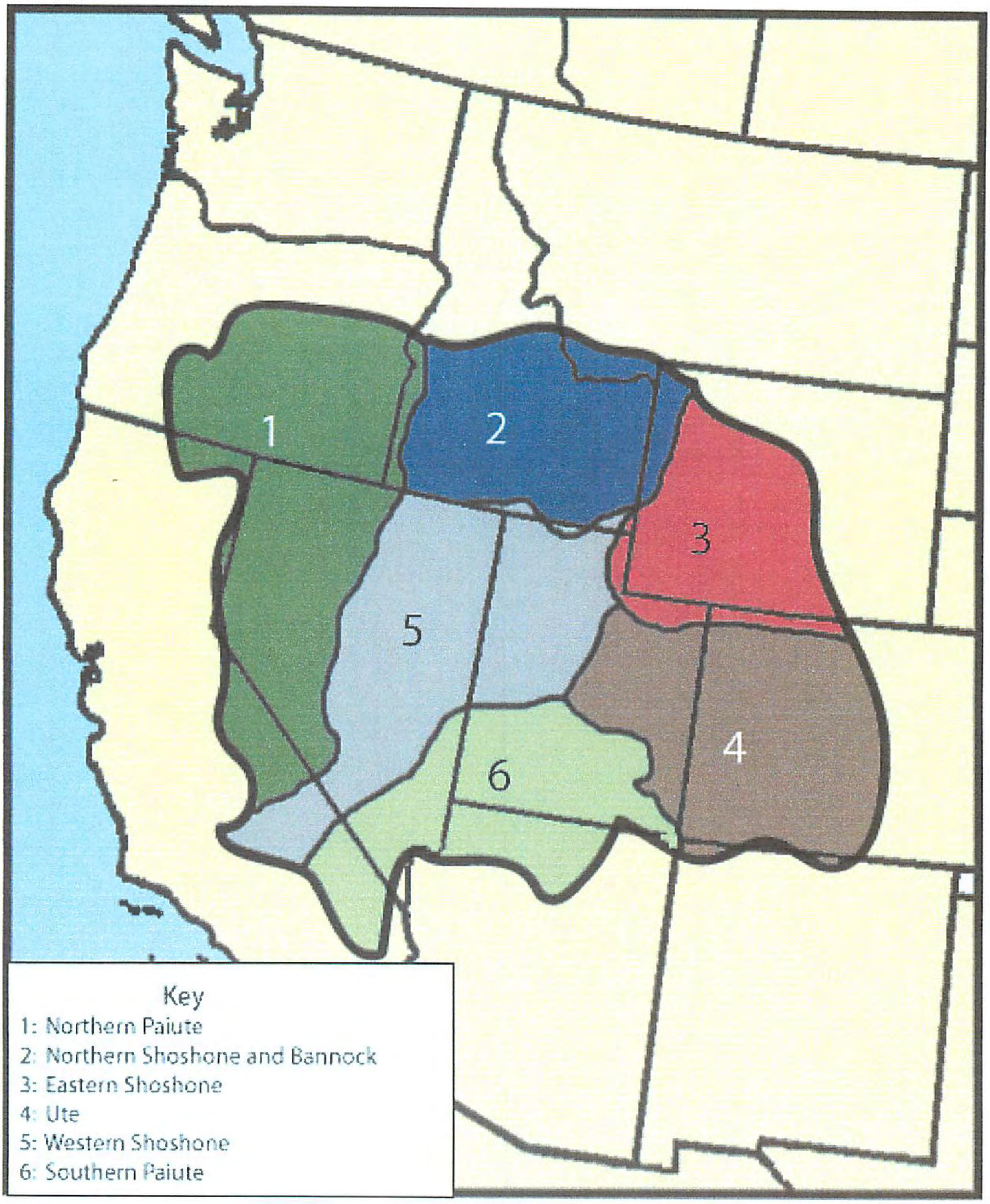
The period between 11,000 BP and 9,500 BP was generally warm and dry throughout much of the Columbia Plateau. Similarly, Mehringer (1996) notes a period of increased temperatures between 12,000 and 10,000 BP in the region. In the northern Columbia Plateau, the period following 9,500 BP was marked by an increase in effective precipitation; however, regions farther south experienced relatively drier conditions (Chatters 1998). Mehringer (1996), however, argues that the period between 10,000 and 7,000 BP marks a period of maximum aridity in the Columbia Plateau during the Holocene. The general pattern between 6,500 BP and 4,500 BP shows a trend toward decreasing temperatures with increasing moisture, primarily between 6,400 BP and 6,000 BP. Increased precipitation and decreasing temperatures continued through 2,800 BP, and following 2,800 BP a transition toward modern environmental conditions occurred. Relatively little environmental change has occurred on the Columbia Plateau for the last 2,000 years (Chatters 1998).

Ethnographic Background

Although the focus of this research is on prehistoric settlement systems and mobility, the ethnographic record offers valuable insight into human lifeways at the time of contact with European settlers. Ethnographic literature provides information about human behavior that cannot always be obtained from archaeological data. The use of ethnographic accounts alongside archaeological data is a powerful tool that allows researchers to develop more complete interpretations about human prehistory.

In addition to a physiographic province, the Great Basin is also identified as a culture area (Steward 1938). Figure 1.4 shows the location of the Great Basin culture area and identifies Native American populations within the region.

Figure 1.4. Great Basin culture area (D'Azevedo 1986).



The Northern Paiute occupied areas of Nevada, Oregon, California, and Idaho (Figure 1.4). The Western Shoshoni occupied the region to the east of the Birch Creek Site, and the Southern Paiute were located to the southeast of 35ML181 in Utah and southern Nevada. Although cultural boundaries are fluid, most ethnographic accounts identify the Northern Paiute as occupying the region surrounding the Birch Creek Site. Therefore, the Northern Paiute provide the ethnographic focus for the following section.

Although my research area is southeastern Oregon, the ethnographic writing included in this paper extends beyond a discussion of only the Northern Paiute in southeastern Oregon. There is a paucity of literature on the Northern Paiute in southeastern Oregon around the turn of the last century. White settlers avoided southeastern Oregon for two reasons: the fear of the Northern Paiute and the scarcity of resources. The fear of encountering the Northern Paiute kept white immigrants out of the region for many years. Plentiful resources were available after crossing the Cascade Mountains heading west, so the valleys in southeastern Oregon did not attract many settlers (Horr 1974).

In addition to keeping out white settlers, the terrain of southeastern Oregon had a tremendous effect on how indigenous people in the area lived. Because the land was arid and sparse, a hunting and gathering lifestyle was the most advantageous. Nonetheless, subsistence in this region was extremely difficult. Unlike other tribes, the Northern Paiute did not have access to the major anadromous fish runs on the Columbia River. Salmon were available in the Owyhee, Malheur, and Snake Rivers, but these were often dominated by the Bannock and Shoshoni tribes from the east (Horr 1974).

Subsistence varied from season to season and with the availability of resources. Seeds and roots were gathered in the summer and autumn and salmon in the spring. It was often difficult to rely on plant resources because they were greatly affected by seasonal rainfall. Fish would have been a stable resource, but limited access to salmon runs and limited storage facilities prevented the Northern Paiute from depending on anadromous fish. Hunting was also part of the subsistence strategy, and animals including antelope, mountain sheep, deer, elk, and rabbits were hunted throughout the year. The Northern Paiute were able to make a living in southeastern Oregon, but the marginal environment prevented any sense of security (Horr 1974).

The Northern Paiute generally moved within a 20-30 mile radius (roughly 32-48 km), and land-use varied from season to season due to the availability of resources (Steward 1938; Steward and Wheeler-Voegelin 1974). In the spring and summer, groups inhabited the valleys in small villages. If resources were stable, many Northern Paiute would winter in the mountains. If plant resources were poor, however, groups remained in valley villages year round. Fall was the only part of the year when large groups of Northern Paiute came together. When seeds were gathered in the fall, groups gathered at villages for a few days of dancing, gambling, and communal hunting. Seed gathering marked one of the only communal activities by the Northern Paiute (Steward 1933).

With the exception of large congregations in the fall, Northern Paiute lived in extended family groups. Due to environmental factors and the division of labor, Steward (1938) argues that family-level sociopolitical organization was the primary economic unit in the Basin-Plateau region. In regards to subsistence, the acquisition of plant resources and most game was done by independent family units. However, the hunting or fishing of certain animals, including buffalo, rabbits, and fish, required a collective effort on the part of multiple family units. As mentioned previously, annual seed harvesting was another activity in which independent family units merged. Overall, however, "ecological and social determinants" resulted in family-level organization for much of the Basin-Plateau region (Steward 1938).

Steward (1938) identified three types of sociopolitical organization for low population density hunter-gatherers: unilineal band, composite band, and family-level organization. Unilineal bands are patrilineal and patrilocal and were generally exogamous because groups consisted of actual relatives. Unilineal bands were most often found in areas in which the environment did not allow for group size to exceed 100 members (Steward 1938). Composite bands were made up of unrelated families and groups were generally larger than unilineal bands, often exceeding 100 people. Steward noted, however, that Western Shoshoni, Southern Paiute, and Northern Paiute did not necessarily fit the description for unilineal or composite bands. Due to ecological factors, such as an emphasis on seed gathering, Steward asserted that family-level organization was the "only stable social and political unit" in these regions (Steward 1938:260).

Regional Archaeology

Archaeological excavations in the Owyhee Uplands are extremely limited; Dirty Shame Rockshelter (DSR) (Aikens et al. 1977; Hanes 1988) and Nahas Cave (Plew 1986) are the largest excavation projects in the region (Figure 1.5). DSR is of particular importance to the Birch Creek Site because 121 obsidian artifacts were submitted for trace element analysis (Hanes 1988). Unfortunately, the results of the analysis are not replicable due to calibration issues at the lab where the analysis was originally conducted. This section briefly reviews the chronological sequences identified for Nahas Cave (Plew 1986) and Dirty Shame Rockshelter (Hanes 1988), and Table 1.1 presents a summary of these chronologies.

Figure 1.5. Location of DSR and Nahas Cave (Adapted from Andrefsky et al. 2003)

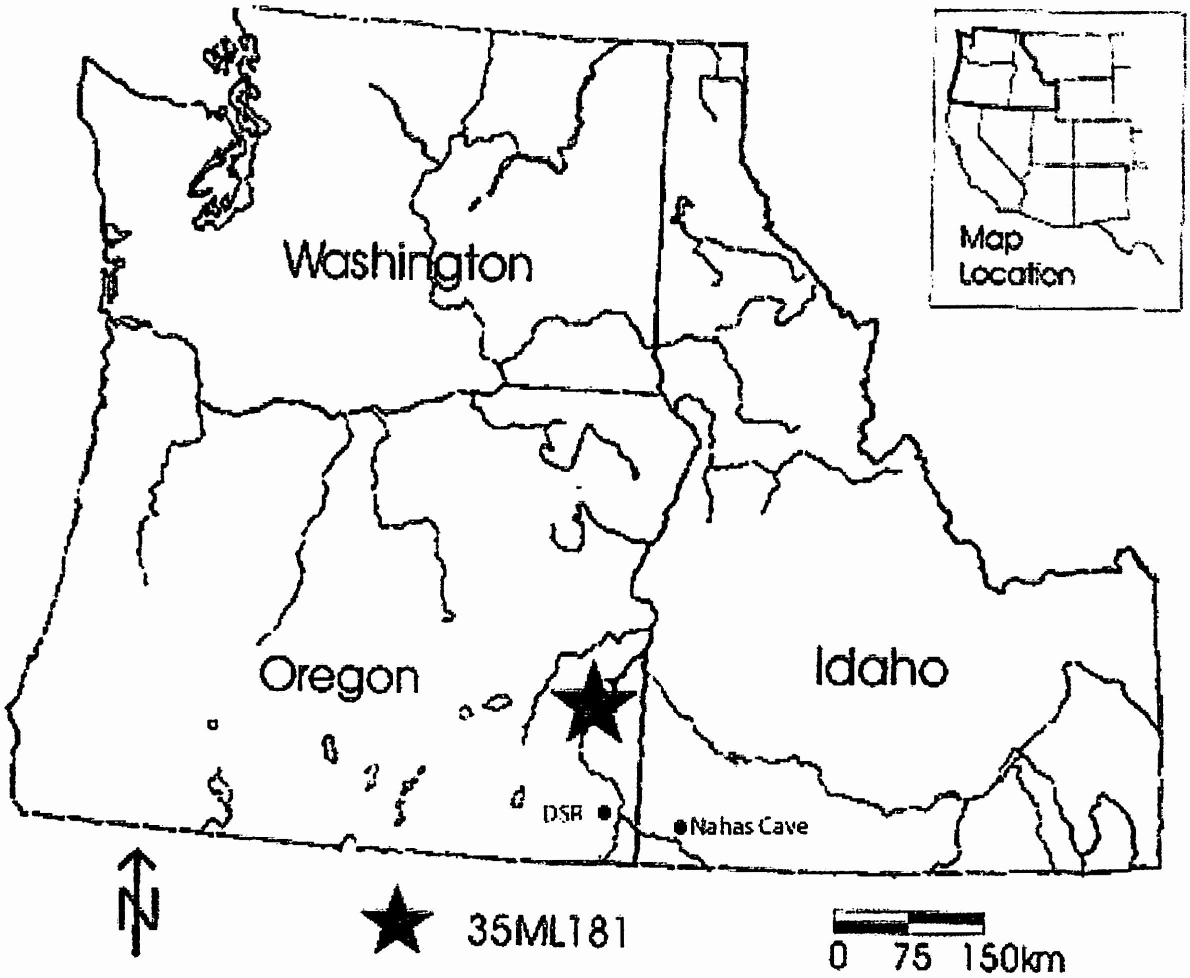


Table 1.1. Cultural Chronologies from the Owyhee Region with Diagnostic Projectile Points.

	Plew (1986)	Hanes (1988)
500 BP		
	Camas Creek IV: Desert Side-Notched, Cottonwood	**Late Archaic Occupational Period**: transition from dart to bow and arrow technology; Rosegate, Desert series projectile points
	Camas Creek III: Rose Spring-Eastgate series points	
1,500 BP	**Camas Creek II**: Elko series projectile points	
2,500 BP		
3,500 BP		
	Camas Creek I: Humboldt and Pinto series projectile points	Hiatus at Dirty Shame Rockshelter
4,500 BP		
5,500 BP		
		Mid Archaic Occupational Period: Northern Side-Notched, Elko, Humboldt
6,500 BP		
7,500 BP		
		Early Archaic Occupational Period: stemmed lanceolate projectile points; Great Basin Stemmed, Windust, and Plano
8,500 BP		
9,500 BP		

Plew (1986) proposed a "working chronology" for the south-central Owyhee region based largely on survey. Camas Creek I, dated between 6000 BP and 2700 BP, is dominated by Humboldt and Pinto series projectile points. Camas Creek II, dated between 2700 BP and 1400 BP, is identified only by the presence of Elko series projectile points (Plew 1986). Camas Creek III, dated between 1400 BP and 800 BP, is typically defined by the presence of Rose Spring-Eastgate series projectile points. The final phase, Camas Creek IV, dates between 800 BP and 700 BP and is marked by the presence of Desert Side-Notched and Cottonwood series projectile points.

A cultural chronology has also been proposed for Dirty Shame Rockshelter (Hanes 1988). The Early Archaic Occupational Period, dated between 9500 BP and 6800 BP, is dominated by the presence of stemmed lanceolate projectile points, including Great Basin Stemmed, Windust, and Plano projectile points. The Mid Archaic Occupational Period, dated between 6800 BP and 5900 BP, shows a move away from lanceolate stemmed points toward notched projectile points, including Northern Side-Notched, Elko and Humboldt series, and Pinto style projectile points. The late Archaic Occupational Period, dated between 2700 BP and 400 BP, marks the shift from dart technology to bow and arrow technology, including Rosegate and Desert series projectile points.

The gap in the archaeological record at Dirty Shame Rockshelter between 5900 BP and 2700 BP is unfortunate because the majority of radiocarbon dates from the Birch Creek Site fall within that time period. However, the contemporaneity of the Dirty Shame Rockshelter hiatus and the occupation of the Birch Creek Site may reflect changing settlement strategies in such a low population density region. As is clear from the archaeological investigations conducted in the Owyhee Uplands, much work remains to be done toward developing a general cultural chronology for the region. Projectile point types, their stratigraphic provenience, and their chronological implications at the Birch Creek Site are discussed in detail in Chapter 4.

Project Background

As a stratified and excavated site, 35ML181 provides an excellent context for identifying and exploring possible changes in human land-use and settlement systems through prehistory. This section reviews all archaeological investigations conducted at the Birch Creek Site (Andrefsky and Presler 2000; Andrefsky and Satterwhite 2002; Andrefsky and Nauman 2003; Andrefsky et al. 2003) so readers are familiar with site components discussed in later chapters.

The Birch Creek Site was initially recorded by Reg Pullen (1976) during a survey for the Bureau of Land Management (BLM) along the Owyhee River. The site was later re-recorded in 1992 by BLM archaeologist Alice Bronsdon after a major flooding of the Owyhee River exposed cultural materials along the river. Excavations began in the summer of 1998 when Washington State University, in conjunction with the BLM, began its multi-year investigation at the Birch Creek Site. During the summers of 1998 and 1999, Washington State University conducted archaeological field schools that focused on the excavation of a large housepit block located on the second of three terraces of the Owyhee River (Figure 6). Ground penetrating radar and magnetometry surveys were conducted during the 2000 field season. The summers of 2001 and 2002 saw the return of the Washington State University Field School when these excavations concentrated on the investigation of a second housepit, located approximately 50 meters north of the housepit block excavated in 1998-1999 (Figure 1.6). During the 2003 field season, the principal investigator, Dr. William Andrefsky Jr., and a small crew of graduate students returned to Birch Creek to continue excavating a cultural component that was initially identified during the 2002 field season.

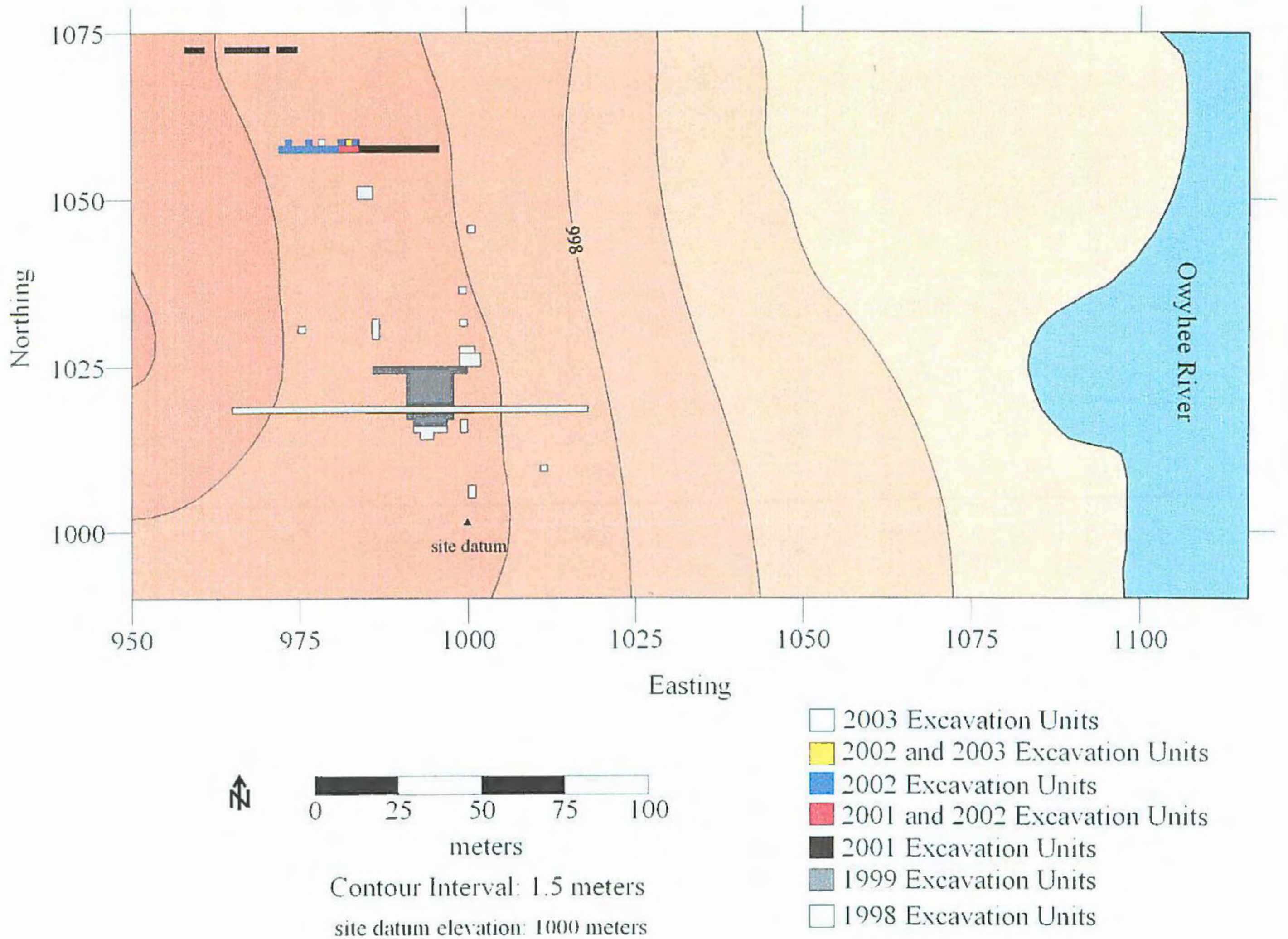


Figure 1.6. Location of 1998-1999, and 2001-2003 excavation units (from Andrefsky et al. 2003).

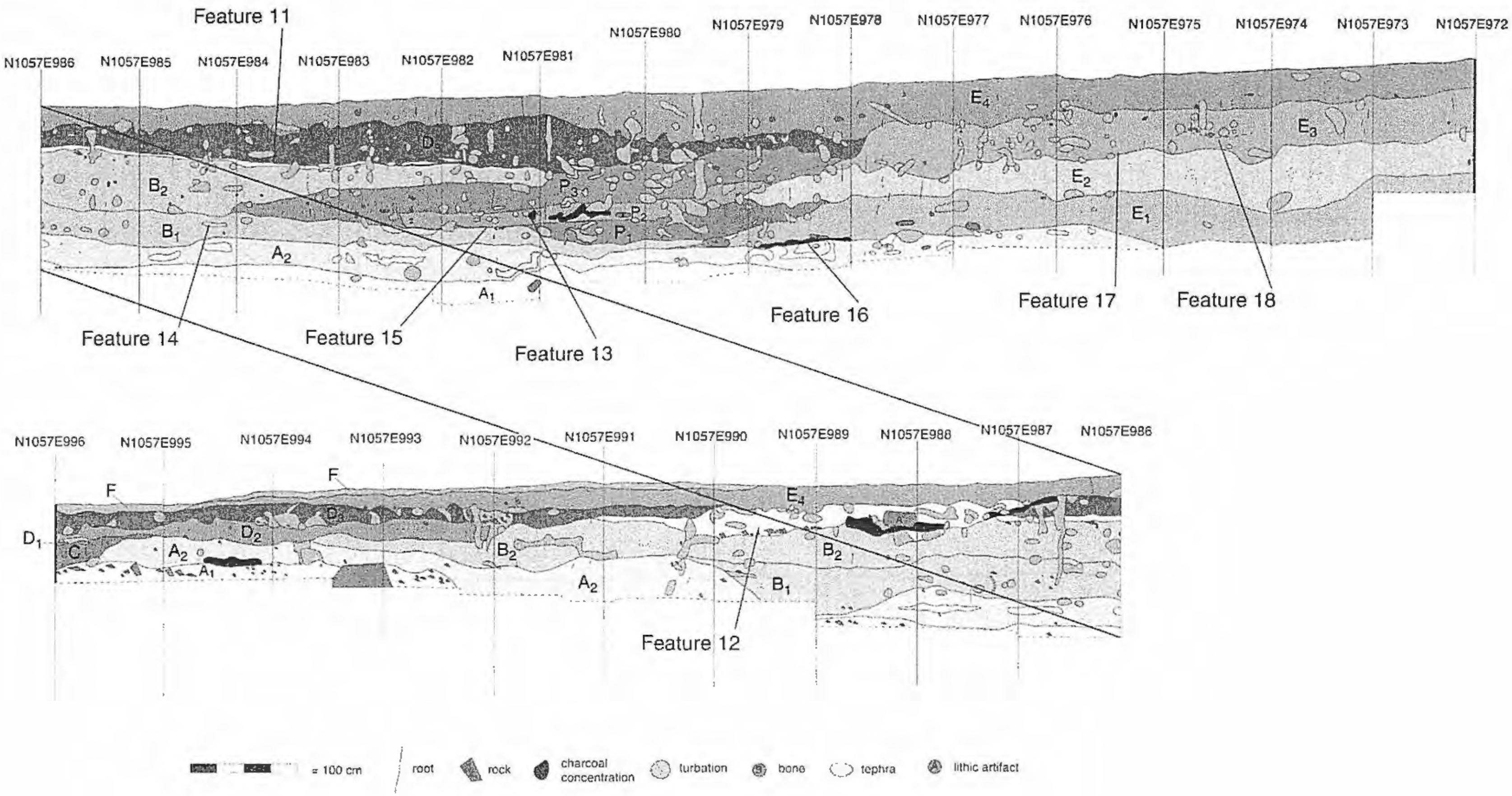


Figure 1.8. Composite profile of the south wall of the N1057 trench, from Andrefsky et al. (2003).

The 2003 field investigations at the Birch Creek Site focused on the further identification and excavation of the cultural component resting below the pithouse, initially identified in 2002. The cultural component rests directly above Mazama tephra. Charred material, collected directed below a metate resting on the Mazama tephra, was dated to 6640 ± 40 BP (Beta-181782). Table 1.2 is a summary of radiocarbon dates from the Birch Creek Site used in the present study. These radiocarbon dates, in addition to the feature stratigraphy presented in this section, provide the chronological control for the sourced obsidian artifacts used in this analysis.

Table 1.2. Radiocarbon Dates from the Birch Creek Site, adapted from Andrefsky et al. (2003)

Measured Radiocarbon Age (yr BP)	Unit	Level	Conventional ^{14}C Age (yr BP)	2 Sigma Calibrated (yr BP)	2 Sigma Calibration BC / AD	Likely Fill or Contact	Sample No.	Radiocarbon Lab
2430 ± 60	N17 W7	13	2410 ± 60	2725 – 2335	775 – 385 BC	Contact II (B)	130363	Beta Analytic
2460 ± 70	N16 W6	10	2420 ± 70	2735 – 2330	758 – 380 BC	Fill B	130362	Beta Analytic
2620 ± 40	N17 W8	5	2620 ± 40	2780 – 2730	830 – 780 BC	Fill A	145557	Beta Analytic
2760 ± 110	N19 W 6	16	2760 ± 110	3160 – 2730	1210 – 780 BC	Fill B	144771	Beta Analytic
3980 ± 50	N1017 E992	NA	3990 ± 50	4560 – 4350 and 4330 – 4300	2600 – 2400 and 2380 – 2360 BC	Contact III (C)	165407	Beta Analytic
4480 ± 70	N17 – W4	55	4480 ± 70	5315 – 4865	3365 – 2915 BC	Contact IV (D)	142362	Beta Analytic
3980 ± 50	N1057 E981	26	3970 ± 50	4540 – 4280	2580 – 2330 BC	Feature 15 living surface	165408	Beta Analytic
6640 ± 40	N1057 – E980	31	6660 ± 40	7595 – 7460	5645 – 5510 BC	Pre-housepit surface	181782	Beta Analytic

The 1998-1999 excavations at the Birch Creek Site focused on the excavation of a prehistoric housepit designated Housepit 1, Feature 2 (Figure 1.7). Four living surfaces, Contacts A-D, interspersed with multiple fill episodes, were identified during field investigations.

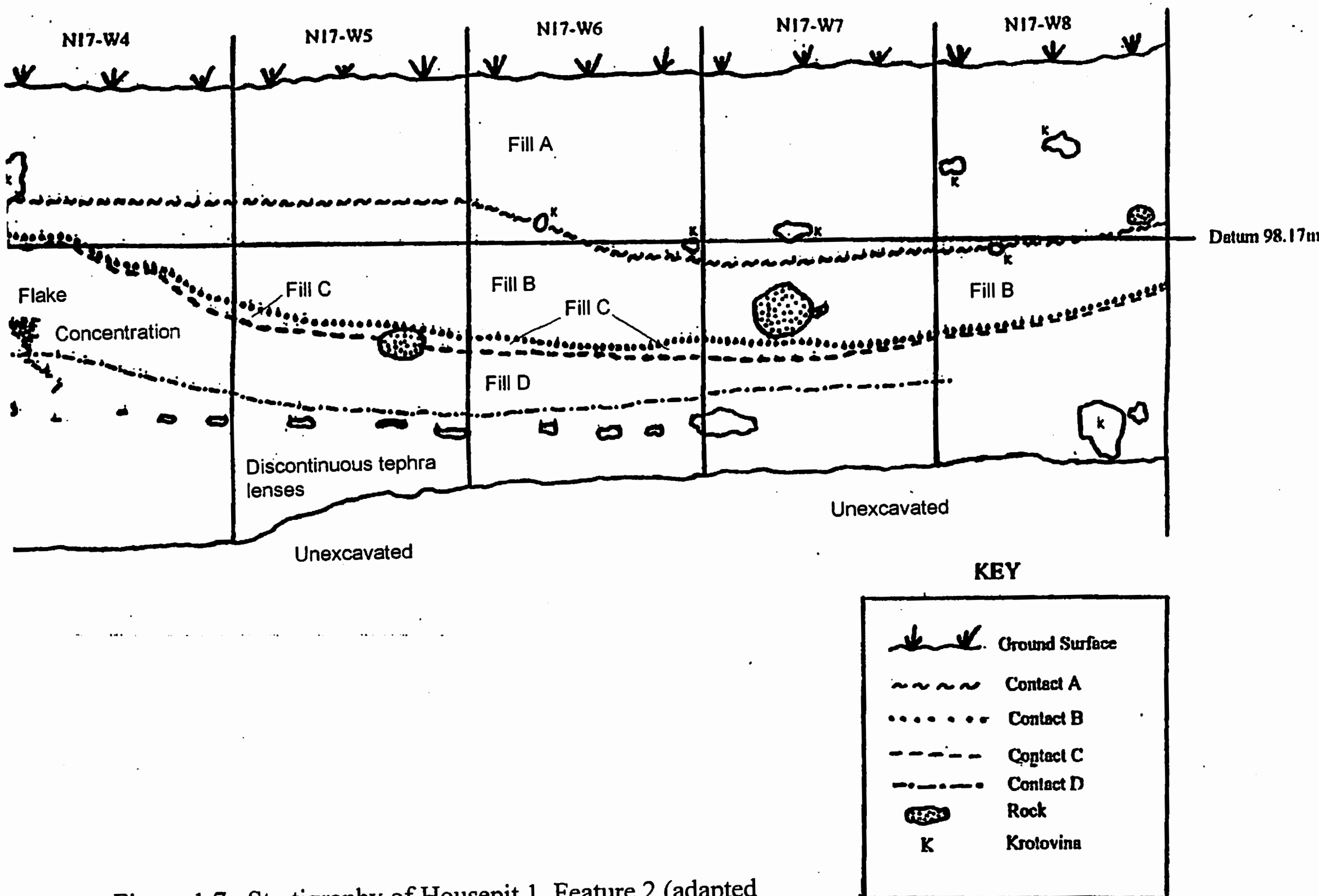


Figure 1.7. Stratigraphy of Housepit 1, Feature 2 (adapted from Andrefsky and Presler 2000 in Cole 2001).

Contact D is the lowermost cultural component identified in Feature 2. Charred material from the surface of Contact D was collected and returned a date of 4480 ± 70 BP (Beta-142362). All radiocarbon dates are uncorrected ^{14}C years unless otherwise noted. Fill D is situated between Contact D and Contact C. Although the excavation of Feature 2 ended in 1999, archaeologists working on the 2001 WSU Field School returned to the feature to collect charred material from the previously undated living surface identified as Contact C. The charcoal sample returned a date of 3980 ± 50 BP (Beta-165407). Fill C sits above Contact C and below Contact B. A carbonized wood fragment collected from the surface of Contact B was dated to 2430 ± 60 BP (Beta-130363). Fill B sits between Contacts B and A \and dates to 2460 ± 70 BP and 2760 ± 110 BP (Beta-130363, Beta-144771). The uppermost living surface, identified as Contact A, is ephemeral in nature and its date suggests possible mixing. Charred material collected from the bottom of Contact A returned a date of 2620 ± 40 BP (Beta-145557). Fill A was deposited after the abandonment of Housepit 1. The University of Washington Calib© program (ver. 4.4) was used to calibrate all radiocarbon dates for the present study. The results of the calibration, as well as the implications for potential mixing in the upper contacts and fills of Feature 2, are addressed in Chapter Four.

No archaeological excavations were conducted during the 2000 field season. However, ground penetrating radar and magnetometry surveys were conducted at the site (Carr et al. 2000). Nearly two dozen "interpreted features" were identified during the surveys, and the 2001 field season focused on the excavation of several of these interpreted features. Two of these interpreted features produced little cultural material, but a cultural feature was identified toward the end of the field season.

The 2002 excavations continued to excavate the cultural feature initially identified in 2001; a stratigraphic profile of the N1057 trench was also completed, as shown in Figure 1.8. The cultural feature was interpreted as another prehistoric housepit, designated Feature 15. Charred wood material thought to represent a part of a burned roof beam from the housepit structure, initially collected in 2001, returned a date of 3980 ± 50 BP (Beta-165408). Toward the end of the 2002 field season, another cultural component was identified below the pithouse living surface.

A detailed description of all field investigations at the Birch Creek Site, as well as all post-field investigations, can be found in Andrefsky and Presler (2000), Andrefsky and Satterwhite (2002), Andrefsky and Nauman (2003), and Andrefsky et al. (2003).

CHAPTER TWO

REGIONAL XRF ANALYSES

In the region surrounding the Birch Creek Site, many studies focus on the initial characterization of geologic sources of obsidian and the representation of these sources at archaeological sites. Ambroz (1997) characterized 622 obsidian samples from Oregon using neutron activation analysis. In order to identify obsidian procurement patterns at Wilson Butte Cave, Idaho, Bailey (1992) had to first visit 76 localities in the lower Snake River Plain so that obsidian could be collected for trace-element characterization. These sources were then compiled into a source library and artifacts from Wilson Butte Cave were matched to them. Nelson (1984) is another example of the initial characterization of geologic sources of obsidian. Other researchers have worked to synthesize trace-element characterizations of specific geologic sources of obsidian and document their presence in archaeological sites throughout Oregon, Washington, and California (Thatcher 2000).

Certain studies, however, use obsidian trace-element studies to investigate specific questions about human behavior. Hess (1997) used distance-decay effects to study obsidian acquisition and mobility in Oregon and Washington. More specifically, Hess compared the Late Pre-Mazama Period (8500-6850 BP) and Late Prehistoric Period (2000-250 BP). He concluded that groups from both periods exhibited similar ranges, although Late Pre-Mazama groups may have made more residential moves throughout the year. Lyons et al. (2001) used obsidian XRF analysis to identify travel patterns during four prehistoric periods at the Lost Dune and McCoy Creek sites in southeastern Oregon.

One of the more recent and comprehensive contributions in obsidian trace-element studies in the Great Basin is the Jones et al. (2003) study of Paleoarchaic foraging territories. Of particular interest in this study is that Jones et al. identify changes in foraging ranges that correlate with climatic events in the region.

The present study centers on the identification of human settlement systems and mobility around the Birch Creek Site. Because trace element analysis of artifact obsidian provides the proxy measure for human land-use, it is important to investigate regional patterns of obsidian acquisition. Any regional patterns identified help determine how the Birch Creek Site fits in to the larger human settlement system in the northern Great Basin and southern Columbia Plateau.

This chapter attempts to address four primary questions: 1) Does the number of artifacts sourced correlate to the number of obsidian sources represented in an assemblage? In other words, does the number of obsidian sources represented in an assemblage increase with sample size? 2) Is the overall percentage of obsidian in a lithic assemblage related to the distance to obsidian sources? For example, does the percentage of obsidian in an assemblage increase as distance to obsidian sources decreases? 3) Is the closest represented source of obsidian most represented in an assemblage? and 4) How does the overall range in distance to obsidian sources correlate to the abundance of obsidian the assemblage? For example, will a preference for certain obsidian sources be evident when obsidian sources are of similar distances from a site?

This chapter begins by reviewing and summarizing the available XRF data from reports of both surveys and excavations in the region surrounding the Birch Creek Site. Second, linear regression analyses are used to explore the four previously mentioned questions. Finally, this chapter reviews XRF data previously obtained for the Birch Creek Site and how these results have been updated over the last three years.

Literature Review

Lake Owyhee Reservoir Survey

The Class III cultural resources survey (Luttrell 2000) on the Lake Owyhee Reservoir in southeastern Oregon recorded 43 prehistoric and historic sites in 1994 and 1995. Although only 16 obsidian artifacts were analyzed using XRF analysis, the results of the analysis are of primary importance to the Birch Creek Site. When the XRF analyses were originally conducted on the Lake Owyhee Reservoir survey material in 1995 and 1997, only four artifacts were assigned to known source locations; the rest of the artifacts were assigned to unknown source locations. A field survey conducted in 1999 by William Lyons identified two of the unknown sources: Sourdough Mountain and Coyote Wells (Luttrell 2000; William Lyons, personal communication). Sourdough Mountain and Coyote Wells are the two most abundant sources represented in the Birch Creek assemblage (Andrefsky et al. 2003; Skinner 2000, 2002, 2003).

FTV Western Fiber Build Project

Northwest Research Obsidian Studies Laboratory, in conjunction with Northwest Archaeological Associates, conducted XRF analysis on 618 obsidian artifacts from 34 archaeological sites in central Oregon (Skinner and Thatcher 2003). The sites parallel Highway 20 from Deschutes County, Lake County, Harney County, and Malheur County. Forty known geologic sources of obsidian were identified by XRF analysis of artifacts. The sample of artifacts from each site ranges between one and forty artifacts, with most sites represented by twenty artifacts. The number of sources identified at each site ranges between one and twelve known sources of obsidian (Skinner and Thatcher 2003).

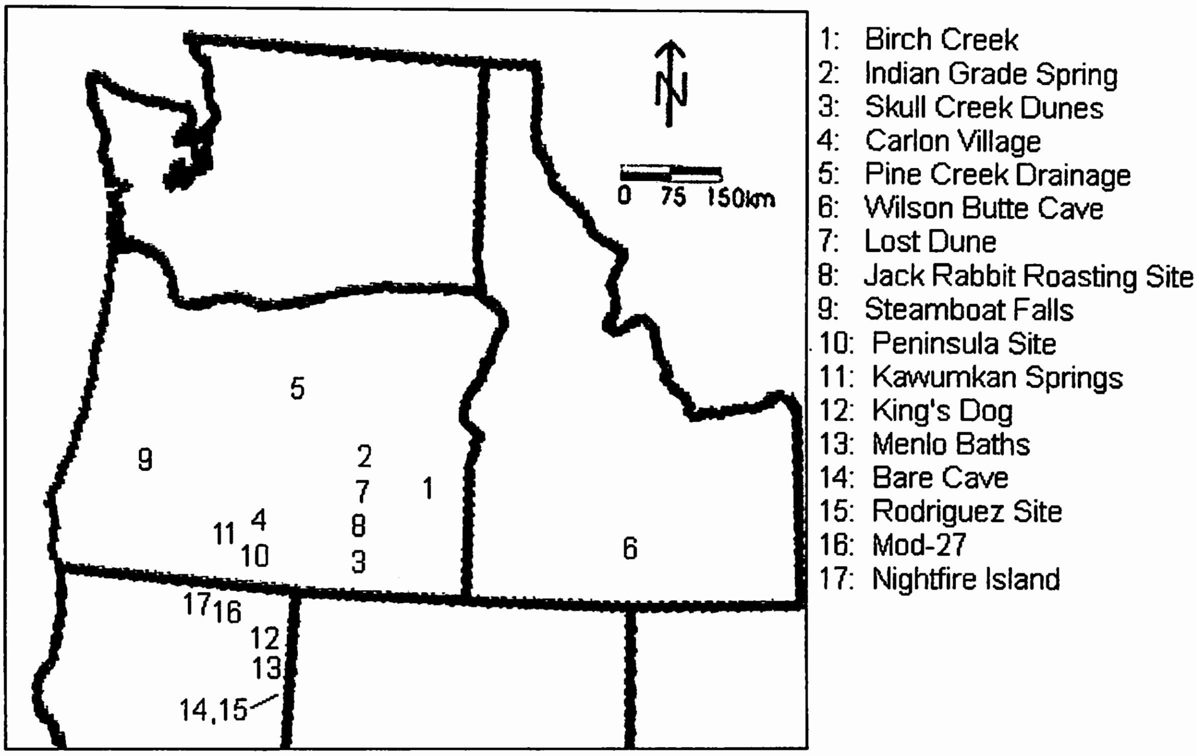
Jack Rabbit Roasting Site (35HA3055)

The Jack Rabbit Roasting Site was identified during the Bureau of Land Management Beatys Butte fire rehabilitation survey in the late summer of 2000 (Thomas et al. 2002; Figure 2.1). Chert and obsidian lithic material, as well as unburned and burned bone fragments, were present on the surface. Two archaeologists, Scott Thomas and Don Braden, later returned to the site and excavated six 1x1 meter units and two 0.5x1 meter units. It was concluded that the Jack Rabbit Roasting Site likely represents a single-use hunting camp. Seventeen artifacts were submitted for XRF analysis. One unknown and three known sources of obsidian were identified (Thomas et al. 2002).

Lost Dune (35HA792)

Numerous seasons of excavation discovered four prehistoric periods of occupation at the Lost Dune and McCoy Creek sites in southeastern Oregon: 3,500-2,000 BP, 2,000-500 BP, AD 1400s, and AD 1500s. Ninety obsidian artifacts were analyzed using trace element analysis. Seventeen known and four unknown geologic sources of obsidian were identified. Coyote Wells/Coyote Wells East and Venator are the two most represented obsidian sources at the site (Lyons et al. 2001).

Figure 2.1 Location of Excavated Sites.



Wilson Butte Cave (10JE6)

Excavations at Wilson Butte Cave were initially conducted during the summers of 1959 and 1960. Researchers returned to the site during the 1988 and 1989 field seasons to conduct further excavations (Bailey 1992). The cave is located 125 meters above the Snake River Plain, and due to the lack of any nearby water source, it is argued that Wilson Butte Cave was a short-term occupation site primarily used in winter and spring. Five major strata have been identified at the site, with the lowermost stratum dating to 15,000 ± 800 BP, and the uppermost stratum dating to 425 ± 150 BP. Two-hundred and forty artifacts were submitted for trace element analysis. Sixteen known geologic sources of obsidian are represented; Big Southern Butte and Brown's Bench obsidian are the two most represented sources (Bailey 1992).

Peninsula Site (35KL87)

Excavations at the Peninsula Site were conducted during the summer of 1986 by the University of Oregon Field School, in conjunction with the Bureau of Land Management (Silvermoon 1994). Twenty-eight circular rock features were identified at the site and they are argued to represent habitation structures. The Peninsula Site likely represents a winter and summer village occupied periodically between 4,000 and 1,000 BP. Thirty two artifacts were submitted for XRF analysis. Eight known geologic sources of obsidian are represented; Drews Creek/Butcher Flat is the most represented obsidian source (Silvermoon 1994).

Skull Creek Dunes Locality-6 (35HA412)

Research began at Skull Creek Dunes in 1979, and excavations at Locality-6 were conducted during the summer of 1996 by the Washington State University Field School (Wegener 1998). Twenty-eight artifacts were selected for trace element analysis. Four known and four unknown geologic sources of obsidian were identified at Locality-6. Beatys Butte obsidian dominates the assemblage.

Indian Grade Spring Site (35HA1421)

The Indian Grade Spring Site (Jenkins and Connolly 1990) is argued to be a hunting-gathering site and three cultural components have been identified. Component III dates between 2,000 and 1,400 BP; Component II was dated to 1150 BP; and Component I was dated to 530 BP. One hundred six artifacts were submitted for XRF analysis. Eight known and three unknown geologic sources of obsidian were identified. Unfortunately, the majority of the analyzed artifacts (82%) come from two unknown source locations (Jenkins and Connolly 1990).

Carlon Village (35LK2736)

Carlon Village, located in the Fort Rock Basin, contains eight large, prehistoric boulder-foundation houses (Wingard 1999). Radiocarbon dates suggest that there were two major periods of occupancy, roughly 1,800 BP and 600 BP. One hundred sixty artifacts were submitted for trace element analysis. Fourteen known and two unknown geologic sources of obsidian were identified in the assemblage. The Silver Lake/Sycan Marsh source is the most abundant obsidian in the assemblage (Wingard 1999).

Pine Creek Drainage

The Pine Creek Drainage is located on the John Day River in central Oregon. The XRF analysis data comes from the following ten sites: 35WH7, 35WH14, 35WH2, 35WH13, 35WH21, 35WH42, 35WH46, 35WH164, 35WH166, and 35WH168 (Endzweig 1994). Ninety artifacts were submitted for trace element analysis. Twelve known geologic sources of obsidian are represented; White Water Ridge and Little Bear Creek are the two most abundant obsidian sources in the assemblage (Endzweig 1994).

Steamboat Falls Site (35DO497)

During late spring 2002, Statistical Research, Inc. conducted archaeological testing at the Steamboat Falls Site (Maxwell et al. 2003). 35DO497 likely represents a short-term camp occupation with an emphasis on the exploitation of fish resources. Nineteen artifacts were submitted for XRF analysis. Six known geologic sources of obsidian are represented; the majority of obsidian artifacts are made from Silver Lake/Sycan Marsh obsidian (Maxwell et al. 2003).

Nightfire Island (4SK4)

Nightfire Island (Hughes 1986) was excavated by the University of Oregon during the mid 1960s. Three hundred ten artifacts were selected for trace element analysis. Seventeen known geologic sources of obsidian were identified. The Grasshopper Flat, Lost Iron Well, and Red Switchback obsidian sources dominate the assemblage (Hughes 1986).

Kawumkan Springs

The Kawumkan Springs midden was excavated during the late 1940s and early 1950s (Hughes 1986). Ninety seven artifacts were submitted for XRF analysis. Eleven known geologic sources of obsidian were identified, with Spodue Mountain obsidian dominating the assemblage (Hughes 1986).

Surprise Valley

Four separate sites are examined in the Surprise Valley region: Bare Cave (CA-Las-202), Rodriguez Site (CA-Las-194), Menlo Baths (CA-Mod-197), and King's Dog (CA-Mod-204). Eighty two artifacts were sourced at Bare Cave, fifty four artifacts were sourced at the Rodriguez Site, seventy artifacts were sourced from Menlo Baths, and one hundred seventy five artifacts were sourced from King's Dog (Hughes 1986).

Regional Patterning

Methods

I recorded seven key variables were recorded for this analysis: 1) project type (survey or excavation; 2) number of obsidian artifacts sourced; 3) number of known geologic sources of obsidian represented; 4) percentage of obsidian in the overall lithic assemblage; 5) range of distances (km) from site to obsidian sources (for example, 25-150 km); 6) distance (km) from site to most abundant obsidian source in the assemblage; and 7) percentage of sourced obsidian from most abundant source (for example, the most abundant obsidian source represented 65% of the XRF sample). The data is summarized in Table 2.1. Due to the nature of some reports, it was not possible to record all variables for all sites, and some sites, such as the group from the Pine Creek Drainage, are multiple sites that have been collapsed into one. Linear regressions were calculated to explore relationships between these variables in order to investigate regional patterns of obsidian acquisition. SPSS version 11.0 was used for all regression analyses.

Table 2.1. Summary Data for Excavated Sites

Site	Artifacts Sourced (n)	Known Sources Represented (n)	Percentage of Obsidian in Lithic Assemblage	Range of Distances (km)	Distance from site to most abundant source (km)	Percentage of Obsidian from most abundant source
Indian Grade Spring	106	7		40-170		
Steamboat Falls	19	6	25	80-330	175	47
Lost Dune	90	17		44-162	47	19
Pine Creek Basin	90	12	1-29	120-200	140	41
Carlon Village	160	14	95	25-160	25	25
Skull Creek Dunes	28	4	80	30-40	30	
Nightfire Island	310	17		34-193	47	57
Kawumkan Springs	97	11		16-145	27	59
Bare Cave	82	10		7-133	27	39
Rodriguez	54	8		7-133	27	33
Mod-27	38	8		23-100	24	32
Menlo Baths	70	13		10-135	38	34
King's Dog	175	14		24-125	24	51
Wilson Butte Cave	240	16		35-280	120	33
Jack Rabbit Roasting Site	17	3	22	"periphery"-145	133	76
Peninsula Site	32	8	77	45-88	26	56

Sampling Issues

Before exploring any regional patterning that may exist, it was necessary to first determine the effects of sample size. It would be premature to make site to site comparisons about the number of obsidian sources exploited without considering the effects of sample size. Linear regression was used to determine how the number of artifacts sourced relates to the number of obsidian sources identified. Not surprisingly, the number of artifacts sourced was positively correlated with number of obsidian sources represented (r^2=.625, p<.000). As sample size increases, so does the number of obsidian sources in the assemblage. Because of this relationship, it is inappropriate to make direct comparisons between sites based on the number of obsidian sources exploited alone.

Relative Percentage of Obsidian in an Assemblage

The overall percentage of obsidian in the chipped stone assemblage for each of the sites examined ranged roughly between 20% and 95%, and it was expected that this percentage may reflect the relative availability of obsidian in regards to distance from site to source. At nearly half of the sites examined in this analysis, prehistoric peoples were not collecting obsidian from the closest available source. The percentage of obsidian in the overall assemblage was compared both with distance to the closest source and distance to most abundant source. Strong correlations were found between both sets of variables (% of obsidian vs. distance to most abundant source [r^2=.858, p=.008]; % of obsidian vs. distance to closest source [r^2=.962, p=.003]). In other words, sites with a large percentage of obsidian in the overall assemblage are closer to obsidian sources than sites containing a small amount of obsidian.

Relative Percentage of Most Popular Source

Due to the strong correlation between the relative percentage of obsidian in the overall lithic assemblage and distance, it was also expected that the relative percentage of the most abundant obsidian source in the sample would also be related to distance. It was predicted that sites exhibiting a heavy preference for a certain obsidian source was likely to be relatively close to that source of obsidian. The percentage of the most abundant obsidian source in the sample ranges between 19% and 76%. Contrary to expectations, the distance to the most popular source was not correlated with its relative percentage in the sample of analyzed artifacts (r^2=.061, p=.395).

Range of Distances to Exploited Obsidian Sources

The final set of relationships investigated examined how the "range" of distances to exploited obsidian sources may affect the relative percentages of exploited obsidian in the assemblage. It was predicted that sites exhibiting a large range in distance to exploited obsidian sources would show a strong preference for more local obsidian sources. It was also predicted that sites exhibiting a small range (i.e. the distance from site to exploited obsidian sources was relatively constant) would not show a preference for certain obsidian sources. Due to the nature of the data, this relationship was not investigated quantitatively. Instead, this relationship was investigated on a site by site basis. The relative percentage of the most abundant obsidian in the sample ranged roughly between 25% and 50%, regardless of distances to exploited sources. For example, in the Pine Creek Drainage, distances from site to exploited obsidian sources are essentially the same (approx. 140-150 km). However, a strong preference is still shown for one geologic source of obsidian.

Discussion

The review of the available XRF data in the northern Great Basin and southern Columbia Plateau, as well as the linear regression analyses, helped to highlight general patterns of obsidian acquisition. The most surprising pattern identified was the strong preference for one obsidian source at each of the sites or site clusters examined. Approximately half of the sites examined showed a preference for obsidian that was not the closest source to the site; the remaining half of the sites primarily exploited the closest geologic obsidian source. Prehistoric peoples showed a preference for certain resources, and these preferences may have related to the quality of the raw material, social pathways, or ease of travel.

In general, sites located relatively close to known geologic sources of obsidian contained a much higher percentage of obsidian in the overall lithic assemblage. In regards to the exploited sources of obsidian, sites relatively close to one another in regions with numerous local obsidian sources exhibited very different patterns of obsidian acquisition. Conversely, sites only 5 km apart in a region containing few obsidian sources displayed very similar patterns of obsidian acquisition.

Previous XRF Analysis at the Birch Creek Site

Initial obsidian trace element analyses were conducted on materials from the Birch Creek Site in 2000 (Cole 2001; Skinner 2000). 108 obsidian artifacts were submitted to Northwest Research Obsidian Studies Laboratory for energy dispersive XRF analysis. The original sample returned 11 known and 14 unknown geologic sources of obsidian. In the spring of 2002, 19 additional obsidian artifacts were submitted to Northwest Research

Obsidian Studies Laboratory for XRF analysis (Skinner 2002). The sample returned nine known geologic sources of obsidian and two unknown sources.

Ongoing survey in southeastern Oregon has helped to locate and characterize previously unknown geologic sources of obsidian (Skinner, personal communication; Lyons, personal communication). Fourteen unknown geologic sources of obsidian were initially represented at the Birch Creek Site, and the continued work in the region has reduced this number to eight. Table 2.2 lists the numbers of the previously unknown sources and their new identifications. Through continued communication with Craig Skinner at Northwest Research Obsidian Studies Laboratory, many artifacts previously assigned to unknown sources have been reassigned to known geologic sources of obsidian in southeastern Oregon.

Table 2.2. New Source Assignments for Previously Unknown Sources

Previously Unknown	New Source Assignment
Unknown 1	Barren Valley
Unknown 2	Sourdough Mountain
Unknown 3	Bretz Mine
Unknown 4	Unknown 4
Unknown 5	Coyote Wells
Unknown 9	Unknown 5 (GGOV)
Unknown 10	Sourdough Mountain
Unknown 11	Unknown 3
Unknown 13	Coyote Wells East
Unknown 14	Unknown 1

In addition to these changes, the artifacts originally submitted for Cole's (2001) research were later reanalyzed and some artifacts were reassigned to different source locations. As increasing samples are characterized from known geologic sources of obsidian, the chemical signature of certain sources can change. While some geologic sources of obsidian are extremely homogenous in their chemical composition, others are much more variable. Characterization studies of these relatively more variable sources helps to more correctly identify their chemical composition. Therefore, artifact obsidian that was initially thought to belong to an unknown source may actually belong to a more variable known source. Also, some artifacts no longer have a confident chemical source assignment due to their small size and were not used in the present study. All updated tables can be found in Appendix A.

CHAPTER THREE

RESEARCH DESIGN

The primary goal of this thesis is to evaluate Steward's (1938) ethnographic model for hunter gatherer land-use and assess continuity of land-use through time around the Birch Creek Site. Steward's model is presented in detail in the following section. Five sub-goals are also addressed in this chapter, which are instrumental in evaluating Steward's (1938) model at the Birch Creek Site: 1) Explain x-ray fluorescence analysis and why it is important to the present study; 2) Present expectations regarding the exploitation of obsidian sources under the Stewardian model; 3) Address sample selection and how the sample relates to the overall lithic assemblage at the Birch Creek Site; 4) Introduce the artifact typology employed for the present study; and 5) Present a projectile point chronology developed from regional archaeological investigations.

Steward's Ethnographic Model

Steward's (1938) goal in the Basin-Plateau region was to evaluate what affect ecology had on sociopolitical organization. With a primary emphasis on ecological and social determinants, Steward developed an ethnographic model for human land-use in the Great Basin. The following sections present the ecological and social determinants, as evaluated by Steward (1938), and discuss how these affect economic and social group organization in the Great Basin.

Ecological Determinants

Social groups in the Great Basin depended largely on the natural environment. Characteristics such as population density, group size, distribution of groups, and mobility were principally determined by attributes of the natural environment (Steward 1938). The collection of plant foods was the primary subsistence activity in the region, and the scarcity of such resources prevented the settlement of large, permanent groups under most circumstances. Individual family units were the primary economic group in the region (Steward 1938).

Plant foods were critical in regards to subsistence, but hunting was also extremely important to survival and was usually done independently by families. Cooperative hunts were limited and varied by species, so predictable yearly hunts were rare (Steward 1938).

Although the availability of plant and animal resources prevented economic groups larger than the family unit throughout most of the year, some resources, including pine nuts, crickets, grasshoppers, and salmon, were collected by larger groups depending on their location (Steward 1938). In general, however, the scarcity of resources made it necessary to travel in small groups throughout much of the year over a very large area. The Northern Paiute generally traveled within a 20-30 mile radius during their seasonal movements throughout the year (Steward 1938; Steward and Wheeler-Voegelin 1974). Seasonal activities varied depending on the availability of resources and kept populations on the move for much of the year. Groups generally wintered in canyons or valleys, paying particular attention to the availability of water (Steward 1938).

The scarcity of resources also greatly affected population densities in the region. Areas with abundant resources saw relatively high population densities, while relatively poor environments had extremely low population densities (Steward 1938). For Basin-Plateau groups generally, the scarcity of resources and poor environment created very low population densities throughout much of the region.

Social Determinants

Three primary social activities brought family groups together during the year: festivals, the sweat house, and warfare. Festivals were often the result of a temporary increase in certain food resources in specific areas. The relative temporary abundance of resources allowed larger social groups to form for brief periods during the year (Steward 1938).

Sweat houses and warfare also brought larger groups of people together. However, many groups were too small and "unsettled" to invest time and resources in these structures (Steward 1938:237). Warfare also resulted in larger social groupings, but this was only witnessed in the eastern region of the Great Basin (Steward 1938).

In summary, these ecological and social determinants resulted in family-level organization throughout much of the Great Basin. Particularly among regions with scarce resources, it was impossible for families to remain in large, permanent settlements throughout the year and population densities generally remained extremely low. Groups were highly mobile for much of the year, generally moving within a 20-30 mile radius during their seasonal hunting and gathering activities (Steward 1938; Steward and Wheeler-Voegelin 1974).

The following sections turn their attention to the five sub-goals presented in the introduction of this chapter.

What is XRF Analysis?

X-ray fluorescence analysis is a non-destructive technique that identifies trace element concentrations in obsidian samples. This trace element concentration is often referred to as a chemical "fingerprint." X-ray fluorescence analysis measures trace element concentrations (Ti, Mn, Fe_2O_3, Zn, Ga, Rb, Sr, Y, Zr, Nb, and Ba) in obsidian in order to identify these unique chemical fingerprints (Northwest Research Obsidian Studies Laboratory webpage).

Each geologic source of obsidian has a unique chemical composition. After known geologic sources of obsidian are analyzed using x-ray fluorescence, a reference library of obsidian trace element concentrations can be developed. Obsidian artifacts should be analyzed using the same technique. It should be noted, however, that it is also possible to identify obsidian chemistry through neutron activation analysis. It is then possible to match the trace element concentrations of artifact obsidian to the trace element concentrations of known geologic sources of obsidian. This chemical match up reveals the location where the raw material obsidian was initially procured. Occasionally, the trace element concentration of an obsidian artifact does not match up with any known source of geologic obsidian. This is referred to as an unknown source of obsidian because it has yet to be located and characterized in the geologic universe.

XRF Analysis and Human Land-Use

Obsidian x-ray fluorescence analysis is a powerful tool that enables archaeologists to gather point data about specific artifacts. For example, if an obsidian biface from the Birch Creek Site is chemically matched to the Sourdough Mountain source, it is possible to pinpoint the location on a map where the tool stone was originally procured. For any artifact from the Birch Creek Site that has been identified to the Sourdough Mountain source, we know, minimally, that the piece of obsidian traveled the 38 km distance from Sourdough Mountain to 35ML181.

Using Binford's (1979) concept of embedded procurement, the working assumption is that obsidian tool stone was collected by hunter-gatherers during their movements across the landscape. As a hunter-gatherer moves across the landscape, obsidian was collected from numerous sources of geologic obsidian. When prehistoric people returned to the Birch Creek Site, artifact obsidian from different geologic sources may have entered the archaeological record. The point data collected from x-ray fluorescence analysis of these artifacts outlines a procurement range around the site, which thus acts as a proxy measure for the scale of land-use exhibited over time by the users of that site.

Predictions for Obsidian Procurement

The present study centers on pattern recognition in human land-use in order to answer questions about human settlement systems and mobility. This section discusses expectations regarding obsidian tool stone procurement and its implications for human mobility. For example, what types of patterns should we expect to see if prehistoric occupants of the Birch Creek Site were employing a land-use strategy similar to Steward's (1938) ethnographic model? Are there patterns that may suggest prehistoric occupants were using a different settlement strategy? What obsidian procurement patterns should we expect to see if land-use around the Birch Creek Site changed through time?

The main implications of Steward's (1938) model for obsidian tool stole procurement are 1) If prehistoric occupants of the Birch Creek Site were employing a settlement strategy similar to the Stewardian model, obsidian sources falling within a 48 km radius of 35ML181 should be abundant at the site; and 2) 35ML181 should exhibit high obsidian source variability if prehistoric occupants exhibited a land-use pattern similar to the model described by Steward (1938).

In regards to the first expectation, a radius of 48 km around 35ML181 was selected because the Northern Paiute generally traveled within a 32-48 km (20-30 mile) radius during their seasonal moves in the northern Great Basin (Steward 1938; Steward and Wheeler-Voegelin 1974). Because the majority of movements are occurring within this 48 km range, the majority of obsidian sources encountered should also fall within this range.

For the second expectation, we must return once again to Binford's (1979) concept of embedded procurement. If hunter gatherers are collecting obsidian tool stone during their movements across the landscape, highly mobile groups are likely to encounter numerous obsidian sources in a region with many geologic sources of obsidian, such as southeastern Oregon. Therefore, the obsidian procurement pattern at the Birch Creek Site should exhibit high source variability.

The present study attempts to test the Stewardian model for land-use at the Birch Creek Site, but also to investigate how land-use patterns may or may not change through time. It is assumed that a consistent obsidian procurement pattern throughout site occupation reflects continuity in human settlement systems and mobility. Similarly, changes in obsidian procurement pattern have implications for changes in human mobility and settlement strategies through time.

Obsidian XRF Sample

This section addresses sample selection and how the sample relates to the overall lithic assemblage at the Birch Creek Site.

<u>Sample Selection</u>

In addition to the obsidian artifacts that were previously sourced in 2001 and 2002 (Cole 2001; Skinner 2000, 2002), a lab grant from Northwest Research Obsidian Studies

Laboratory as well as funding from the College of Liberal Arts, Meyer Fund allowed for 60 additional artifacts to be submitted for trace element analysis (see Skinner 2003).

Physical size was the initial consideration for selection of the 60 artifacts submitted in the fall of 2003. As outlined by Northwest Research Obsidian Studies Laboratory, samples for trace element analysis must be at least 10 mm in diameter and at least 1.5 mm thick. Preferably, samples should be at least 15 mm in diameter and at least 2 mm thick, as "larger samples produce better trace element results and higher-quality results mean a greater number of successful source assignments" (Northwest Research Obsidian Studies Laboratory webpage).

Because the method of analysis for the present study identifies patterns of human land-use through time, artifacts that provided the greatest chronological control were selected for trace element analysis. Specifically, temporally diagnostic projectile points were favored over any other artifact type. While a piece of debitage out of context may not provide any chronological control, a temporally diagnostic projectile point may be able to. Quite simply, a Northern Side-Notched projectile point in the Great Basin is assumed to be much older than a Rosegate series projectile point. In regards to testing Steward's (1938) model, if all Northern Side-Notched projectile points are made from tool stone originating from 100+ kilometers away from 35ML181, while all Rosegate series points are made from tool stone originating less than 45 kilometers from the site, it would be argued that prehistoric populations associated with the Rosegate series projectile point tradition are more likely to fit the Stewardian model than prehistoric populations who manufactured Northern Side-Notched series points. Projectile point chronologies for the region surrounding the Birch Creek Site are presented later in this chapter.

Consideration was also given to artifact provenience such that artifacts were selected throughout the stratigraphic sequence at 35ML181. Preference was also given to artifacts from the 2001-2003 excavations because all prior x-ray fluorescence analysis at the Birch Creek Site was conducted on artifacts from the earlier housepit excavations of Feature 2. Finally, obsidian artifacts were selected from the pre-housepit component initially identified in 2002 and excavated in 2003.

Sample as it Relates to Overall Assemblage

As mentioned in Chapter 2, Northwest Research Obsidian Studies Laboratory reanalyzed the 2001 materials and updated all reports prepared for the Birch Creek Archaeological Project. As a result, some artifacts were deemed too small to be confidently characterized and assigned to a specific geologic source of obsidian. After all analysis and updates were completed, 163 obsidian artifacts were confidently assigned to both known and unknown source locations.

Although 163 artifacts is a relatively large sample of obsidian source characterizations, the sample must be considered in relation to the overall population of obsidian artifacts at the Birch Creek Site, as well as the overall population of chipped stone artifacts. Table 3.1 shows artifact frequencies by type for all chipped stone artifacts from 35ML181, all obsidian recovered, and the sourced obsidian sample. Table 3.2 shows what percentage of the total chipped stone population, and the obsidian population, is represented by sourced artifact obsidian. Artifact types listed in Table 3.1 and Table 3.2 are as defined in Andrefsky et al. (2003). Table 3.3 provides the detailed artifact typology utilized in the present study.

Table 3.1. Chipped Stone Artifact Frequencies

Artifact Type	Total Count	Obsidian	Sourced Obsidian
Points	141	106	64
Point tips or Midsections	82	57	9
Drills	25	3	0
Other Bifaces and Preforms	356	117	24
Scrapers	48	4	0
Cores	497	22	2
Proximal Flakes	79,724	15,176	37
Flake Shatter	113,193	21,974	16
Angular Shatter	71,637	3,184	7
Retouched Flakes	995	129	4
Retouched Cobble Spalls	18	3	0
Other Chipped Stone	75	2	0
Total	**286,791**	**40,777**	**163**

Table 3.2. Percentages Represented by Sourced Artifact Obsidian

Artifact Type	Percentage of Chipped Stone Population	Percentage of Obsidian Population
Points	45.4%	60.4%
Point tips or Midsections	11.0	15.8
Drills	0	0
Other Bifaces and Preforms	6.7	20.5
Scrapers	0	0
Cores	.40	9.1
Proximal Flakes	.05	.24
Flake Shatter	.01	.07
Angular Shatter	.01	.22
Retouched Flakes	.40	3.1
Retouched Cobble Spalls	0	0
Other Chipped Stone	0	0
Overall Percentage	**.06%**	**.40%**

Table 3.3. Definition of Artifact Types

Artifact Type	Definition	References
Angular Shatter	Debitage without a platform or bulb of percussion; no identifiable dorsal or ventral surface	Andrefsky et al. (2003) Andrefsky (1998)
Core	Non-bifacial tool produced during chipped stone manufacture	Andrefsky et al. (2003) Andrefsky (1998)
Elko Corner-Notched	Corner-notched projectile point; triangular blade; concave base; narrow, deep notching; prominent, downward projecting shoulders	Hanes (1988) Justice (2002) Heizer and Hester (1978)
Elko Drill	Elko point resharpened as a drill; evidence of haft element	
Elko Eared	Corner-notched projectile point; triangular blade; straight base; narrow, deep notching; shoulder barbs wider than basal ears	Hanes (1988) Justice (2002) Heizer and Hester (1978)
Flake Shatter	Debitage without a platform or bulb of percussion; identifiable dorsal and ventral surface	Andrefsky et al. (2003) Andrefsky (1998)
Gatecliff	Contracting stem projectile point; bifurcate stem; marked basal indentation	Thomas (1981)
Gypsum	Contracting stemmed projectile point; triangular blade; haft element widens as it meets the blade	Justice (2002) Heizer and Hester (1978)
Humboldt	Lanceolate in form; leaf-shaped blade; maximum width is typically halfway between tip and base	Hanes (1988) Heizer and Hester (1978) Justice (2002)
Lanceolate Leaf-Shaped	Lanceolate in form; leaf-shaped blade; considerably wider than Humboldt series	Hanes (1988)
Pinto	Triangular blade; indented or bifurcate base; expanding stem; often regarded as crude	Hanes (1988) Heizer and Hester (1978) Justice (2002)
Preform	Refined biface lacking evidence of haft element; represents final stage of hafted biface production prior to hafting/notching	Andrefsky et al. (2003) Andrefsky (1998)
Proximal Flake	Debitage with a platform and bulb of percussion; identifiable dorsal and ventral surface	Andrefsky et al. (2003) Andrefsky (1998)
Retouched Flake	Flake tools exhibiting use wear or intentional chipping	Andrefsky et al. (2003) Andrefsky (1998)
Rosegate	Small, triangular shape; corner or basally-notched; bow and arrow technology	Hanes (1988) Thomas (1981) Justice (2002)
Side-Notched	Triangular blade; side-notched; straight or concave base	
Biface Fragment, Other Biface, Unidentified Biface	Refined bifaces too small to classify or unidentifiable to temporally diagnostic biface categories	

Although projectile points, point tips and midsections, performs, and bifaces are well represented in the sample of sourced obsidian artifacts, it is important to note that this is only a small fraction of the overall chipped stone population from the Birch Creek Site. Fewer than 200 sourced obsidian artifacts are being used to make broad implications about human behavior in and around the Birch Creek Site. For example, confident conclusions may be drawn regarding projectile points in which 45% of all projectile points recovered from the site, and 60% of all obsidian points recovered from the site, have been sourced. However, it is necessary to proceed with some caution when making interpretations about certain artifact types, such as cores or debitage, when less than 1% of the obsidian population has been submitted for trace element analysis.

Projectile Point Chronology

Projectile point chronologies developed for the Great Basin have largely emphasized sites located in the heart of the Great Basin physiographic province (Thomas 1981; Heizer and Hester 1978; Hockett 1995; O'Connell and Inoway 1994). Hockett's (1995) projectile point chronology developed for northeastern Nevada and O'Connell and Inoway's (1994) chronology developed for Surprise Valley, California are two good examples of how archaeologists have attempted to reconcile the issue of projectile points as chronological markers in the Great Basin. However, chronologies such as these clearly demonstrate that the effectiveness of projectile points as time markers is largely region specific. As Figure 3.1 shows, projectile point types can have vastly different chronological implications in the Great Basin depending on geographic location and the interpretation of individual archaeologists. For example, Holmer (1986) places Elko series projectile points as early as 7000 BP while other researchers (Clewlow 1967, O'Connell 1975, Thomas 1981) place the introduction of Elko series points at approximately 2500 BP.

Figure 3.1. Age Ranges for Projectile Point Types in the Great Basin, from O'Connell and Inoway (1994)

Time (^{14}C years BP)	Short Chronology (Clewlow 1967)	Surprise Valley Chronology (O'Connell 1975)	Monitor Valley Chronology (Thomas 1981)	Long Chronology (Holmer 1986)
0	Desert series	Desert Side-notched	Desert series	Desert series
1000	Rosegate series	Rosegate series	Rosegate series	Rosegate, Elko series
2000	Elko series	Elko series	Elko series	Gatecliff Contracting-stem
3000				
4000		Bare Creek series		Gatecliff, Elko series
	Pinto series		Gatecliff series	
5000		Northern Side-notched		Northern Side-notched
6000				
7000				Northern Side-notched, Elko series
8000				Pinto series

The Birch Creek Site is situated on the northern edge of the Great Basin and it may be inappropriate to apply projectile point chronologies that were developed for the Great Basin proper. This research looks to local archaeological investigations to develop a projectile point chronology for the region surrounding the Birch Creek Site. Projectile point chronologies from reports at Dirty Shame Rockshelter (Hanes 1988), the south-central

Owyhee Region (Plew 1986), and the Steens Mountains region (Wilde 1985) are summarized in Table 3.4. The final column in the table is summarized from Justice (2002) and provides a general chronology for the Great Basin.

Table 3.4. Age Ranges for Projectile Point Types: Dirty Shame Rockshelter (Hanes 1988), South-central Owyhee Region (Plew 1986), Steens Mountains (Wilde 1985), and Great Basin and California (Justice 2002).

Projectile Point Type	Dirty Shame Rockshelter	South-central Owyhee Region	Steens Mountains	Great Basin and California
Lanceolate Leaf-Shaped	9500-6800 BP			
Northern Side-Notched	6800-5900 BP		7000-4000BP	8000-5000 BP
Humboldt	6800-5900 BP	6000-2700 BP	5200-4000 BP	8000-1400 BP
Elko	6800-5900 BP	2700-1400 BP	7000-1500 BP	3500-1400 BP
Pinto	6800-5900 BP	6000-2700 BP		8000-5000 BP
Gatecliff			4000-2800 BP	5000-2300 BP
Gypsum			4000-2800 BP	4000-2800 BP
Rosegate	2700-400BP	1400-800 BP	2800 BP-contact	1500-700 BP
Desert Series	2700-400BP	800-700 BP	1500 BP-contact	900 BP-contact

As Table 3.4 shows, there is still some dispute regarding age ranges for certain projectile point types. For the present study, the earliest and latest dates are selected for projectile point age ranges (Table 3.5). This chronology is used in the following chapter to highlight patterns of human land-use through time at 35ML181.

Table 3.5. Proposed Projectile Point Chronology for Southeastern Oregon

Projectile Point Type	Age Range
Lanceolate Leaf-Shaped	9500-6800 BP
Northern Side-Notched	7000-4000 BP
Humboldt	6800-2700 BP
Elko	7000-1400 BP
Pinto	6800-2700 BP
Gatecliff	4000-2800 BP
Gypsum	4000-2800 BP
Rosegate	2800 BP-contact
Desert Series	2700 BP-contact

CHAPTER FOUR

RESULTS OF OBSIDIAN ANALYSIS

This chapter presents the results of the obsidian x-ray fluorescence analysis from the Birch Creek Site and begins by addressing the overall procurement pattern observed at 35ML181. From there, this analysis moves on to discuss patterns regarding distance to source, directionality, and projectile point chronology and what these imply about human land-use through time around the Birch Creek Site.

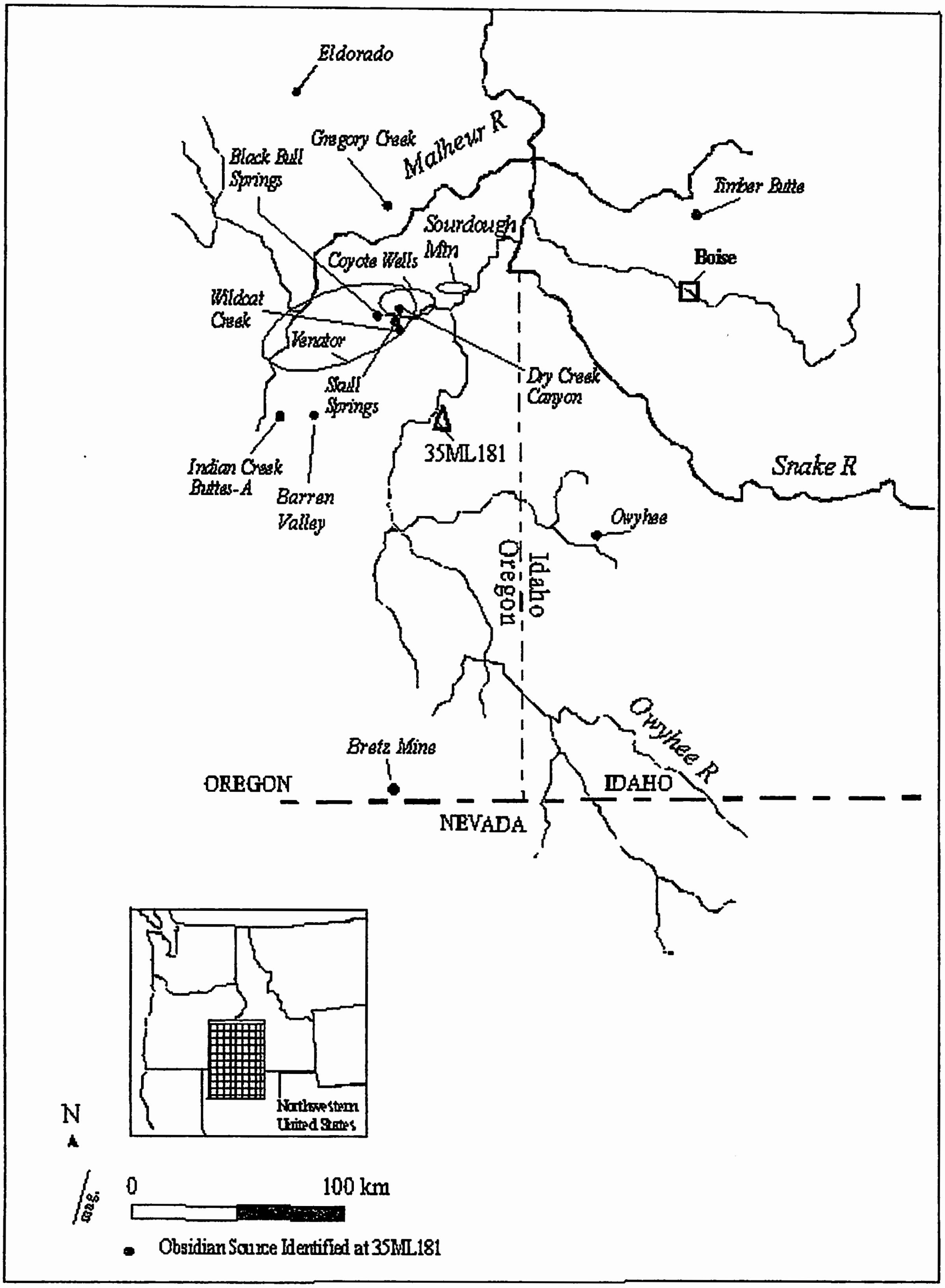
Overall Obsidian Procurement at 35ML181

This section reviews the obsidian procurement pattern at the Birch Creek Site for all sourced artifacts regardless of artifact type or provenience.

Table 4.1. Frequencies and Percentages of Artifacts by Source.

Source	**Count**	**Percentage**
Barren Valley	11	6.75%
Bretz Mine	1	.61
Coyote Wells	23	14.11
Coyote Wells East	3	1.84
Dry Creek Canyon (GGOV)	2	1.23
Eldorado	1	.61
Gregory Creek	8	4.91
Indian Creek Buttes-A	13	7.98
Owyhee	8	4.91
Skull Springs	6	3.68
Sourdough Mountain	52	31.90
Sourdough Mountain Unknown A	1	.61
Timber Butte	5	3.07
Twin Springs Bench (GGOV)	1	.61
Venator	18	11.04
Wildcat Creek	2	1.23
Unknowns (n=7)	8	4.91
Total	**163**	**100%**

Figure 4.1. Location of Obsidian Sources identified at 35ML181 (adapted from Lyons et al. 2001 in Cole 2001).



The overall obsidian procurement pattern suggests a strong preference for Sourdough Mountain obsidian (Table 4.1). Nearly one-third of the sourced artifacts from the Birch Creek Site are assigned to the Sourdough Mountain source, located to the northeast of 35ML181 (Figure 4.1). Of the remaining artifacts, the Coyote Wells and Venator sources are most abundant, while all other obsidian sources individually represent less than 10% of the sourced obsidian. In other words, most obsidian sources represented at the Birch Creek Site are far less abundant than Sourdough Mountain.

Table 4.1 also clearly demonstrates the high obsidian source variability at the site, with 15 known and 7 unknown geologic sources of obsidian represented. Unknown sources of geologic obsidian provide no point data in which to explore human land-use patterns; therefore, unknowns are not considered for the remainder of this analysis.

In addition to obsidian source variability, distance from site to source also plays an important role in evaluating the Stewardian model at 35ML181. Table 4.2 lists the distances from the Birch Creek Site to each source, as well as directionality by quadrant. Any obsidian source that falls between due north and due west of the Birch Creek Site is placed in the NW quadrant; any obsidian source situated between due north and due east of the site is placed in the NE quadrant, etc.

Table 4.2. Distance and Direction to Known Sources from the Birch Creek Site.

Source	**Direction (by quad)**	**Distance (km)**
Wildcat Creek	NW	31
Dry Creek Canyon (GGOV)	NW	32
Skull Springs	NW	32
Venator	NW	35
Coyote Wells East	NW	36
Coyote Wells	NW	37
Twin Springs Bench (GGOV)	NW	37
Gregory Creek	NW	55
Eldorado	NW	130
Sourdough Mountain	NE	38
Timber Butte	NE	122
Barren Valley	SW	40
Indian Creek Buttes-A	SW	48
Bretz Mine	SW	125
Owyhee	SE	76

One of the most striking patterns in Table 4.2 is that the large majority of exploited obsidian sources at the Birch Creek Site are located to the north of the site, primarily to the northwest. Also equally striking is that the most represented source, Sourdough Mountain, is not the closest obsidian source to the Birch Creek Site. There are seven sources of obsidian represented at the Birch Creek Site that are located closer than Sourdough Mountain, but they are individually represented at 35ML181 in much fewer numbers. If the relative abundances of these seven sources (Wildcat Creek, Dry Creek Canyon, Skull Springs, Venator, Coyote Wells East, Coyote Wells, and Twin Springs Bench) are combined, they represent almost 34% of all sourced obsidian from the Birch Creek Site. It is important to note, however, that Sourdough Mountain is one of the first obsidian sources one would encounter traveling downstream along the Owyhee River from the Birch Creek Site.

It is also important to note the skewed spatial distribution of the obsidian sources represented at 35ML181. There are no obsidian sources represented at the Birch Creek Site that are located within 30 km of the site, while nine of the fifteen obsidian sources represented at the site are located between 30 km and 40 km of the site.

The overall pattern of obsidian procurement at the Birch Creek Site shows high source variability and a strong preference for obsidian sources within 40 km from the site. As predicted in Chapter Three, high obsidian source variability and exploited obsidian *sources* within a 48 kilometer radius of the site is indicative of the Stewardian hunter gatherer land-use strategy. The following sections of this chapter use artifact types, stratigraphic superposition of artifacts, projectile point chronologies, and radiocarbon dates to further identify and investigate patterns of human land-use around the Birch Creek Site.

Artifact Types and Implications for Human Mobility

The following section turns its attention to artifact types in order to identify obsidian procurement patterns through time. Table 4.3 shows the artifact types, as defined in Chapter 3, which have been sourced at the Birch Creek Site. Table 4.4 shows summary data for all sourced material from 35ML181 organized by artifact type and increasing distance to source. All artifacts falling within a 48 km radius of the Birch Creek Site are highlighted. Table 4.4 clearly shows that the source material for a large majority of the artifacts from 35ML181 was procured within a 48 kilometer radius of the site.

Table 4.3. Summary of Artifact Types for Sourced Obsidian Artifacts.

Artifact Type	**Artifact Count**
Angular Shatter	7
Core	2
Elko Corner-Notched	8
Elko Drill	1
Elko Eared	16
Flake Shatter	16
Gatecliff	4
Gypsum	1
Humboldt	13
Lanceolate Leaf-Shaped	3
Pinto	3
Preform	2
Proximal Flake	37
Retouched Flake	4
Rosegate	1
Side-Notched	6
Biface Fragments, Other Bifaces, Unidentified Biface	39
Total	**163**

Table 4.4. Frequencies by Artifact Type and Known Source Location for all Sourced Material. Highlighted values denote obsidian sources located within 48 km of 35ML181.

	Wildcat Creek (31 km)	Dry Creek Canyon (32 km)	Skull Springs (32 km)	Venator (35 km)	Coyote Wells East (36 km)	Coyote Wells (37 km)	Twin Springs Bench (37 km)	Sourdough Mountain (38 km)	Barren Valley (40 km)	Indian Creek Buttes-A (48 km)	Gregory Creek (55 km)	Owyhee (76 km)	Timber Butte (122 km)	Bretz Mine (125 km)	Eldorado (130 km)
Angular Shatter						2		5							
Flake Shatter				1		2		7	2		1				
Proximal Flake	2			5	1	7		15	3	1	2				
Retouched Flake						1	1	1		1					
Core						1									
Elko CN					1			3		1		2			
Elko Drill			1												
Elko Eared				3		1		6	1			1	1		1
Gatecliff				1		1				1					
Gypsum				1											
Humboldt				3		2		2		2	2		2		
Lanceolate Leaf-Shaped			2							1					
Pinto			1	1								1			
Preform			1					1							
Rosegate									1						
Side-Notched						2		1	1	1	1				
Other Bifaces		2	1	3	1	4		11	3	5	2	4	2	1	

Temporally Diagnostic Projectile Points

As discussed in Chapter 3, projectile point types offer chronological control that other artifact types cannot offer. Using the obsidian source locations of projectile point types with known age ranges allows for patterns to be identified regarding human land-use through time. For example, if Humboldt series projectile points are all manufactured from local obsidian and Rosegate series projectile points are manufactured from obsidian sources 75 kilometers away, it could be argued that populations associated with Rosegate series projectile points are not likely to represent a settlement system or land-use strategy similar to each other or to the Stewardian model.

For each projectile point type, average distance from the Birch Creek Site to obsidian source was calculated. For example, three Gatecliff projectile points have been sourced using trace element analysis: one from Venator (35 km), one from Coyote Wells (37 km), and one from Indian Creek Buttes-A (48 km). Therefore, the average distance between 35ML181 and obsidian source for Gatecliff projectile points is 40 km. Table 4.5 shows the average procurement distances and median procurement distances for temporally diagnostic projectile points from the Birch Creek Site.

Table 4.5. Average Procurement Distance and Median Procurement Distance by Projectile Point Type.

Projectile Point Type	**Sample Size (n)**	**Age Range**	**Average Distance (km)**	**Median Distance (km)**
Lanceolate Leaf-Shaped	3	9500-6800 BP	37.3	32
Side-Notched	6	7000-4000 BP	42.5	39
Humboldt	13	6800-2700 BP	54.2	38
Elko*	23	7000-1400 BP	50.3	38
Pinto	3	6800-2700 BP	47.7	35
Gatecliff	3	4000-2800 BP	40	37
Gypsum	1	4000-2800 BP	35	35
Rosegate	1	2800 BP-contact	40	40
All Projectile Points	53		48.5	38

*Elko Corner-notched, Elko Eared, Elko Drill

For the Birch Creek Site, the average distance for each projectile point type ranges between 35 and 54.2 km, with Humboldt series projectile points exhibiting the highest average distance. Although the average procurement distance for Humboldt and Elko series projectile points is slightly larger than the 48 kilometer distance predicted by the Stewardian model, the difference is very slight. The median procurement distance for each projectile point type ranges between 32 and 40 km and the median procurement distance for all projectile points is 38 km. Once again, the pattern of continuity at the Birch Creek Site is striking. Based on projectile point age ranges and radiocarbon dates from 35ML181, it is possible to extend the Stewardian model for human land-use minimally 6600 years back into prehistory and potentially 9500 years.

Stratigraphic Superposition of Artifacts

The following section of this chapter works to identify patterns related to the stratigraphic superposition of artifacts and obsidian source location. The underlying assumption is that the relative depth of obsidian artifacts, and their associated source location, should also reveal patterns about human land-use. For example, if all sourced obsidian from the earliest and deepest contacts came from obsidian sources less than 35 kilometers away, and artifacts associated with the most recent, uppermost contacts are associated with obsidian sources more than 60 kilometers away, it can be argued that a change in human land-use occurred. It can also be argued that earlier populations are more representative of the Stewardian model than later inhabitants of the site.

Table 4.6 shows frequencies for obsidian artifacts grouped by fills and contacts for Housepit 1, Feature 2, as defined by Cole (2001); obsidian sources are arranged by increasing distance from 35ML181.

Table 4.6. Artifact Frequencies for Known Source Locations from Feature 2. Highlighted values denote obsidian sources located within 48 km of 35ML181.

	Wildcat Creek (31 km)	Dry Creek Canyon (32 km)	Skull Springs (32 km)	Venator (35 km)	Coyote Wells East (36 km)	Coyote Wells (37 km)	Twin Springs Bench (37 km)	Sourdough Mountain (38 km)	Barren Valley (40 km)	Indian Creek Buttes-A (48 km)	Gregory Creek (55 km)	Owyhee (76 km)	Timber Butte (122 km)	Bretz Mine (125 km)	Eldorado (130 km)
Fill AB: 2430 ± 60 BP 2460 ± 70 BP 2760 ± 100 BP		1		2		3		14	2	2		2	1		
Contact B: 2430 ± 60 BP					1	2	1	6	1	2					
Fill C	1		1	1				8		1	3	1			
Contact C: 3980 ± 50 BP		1		2					1	1					
Fill D	1			3		2		7	1	2		1		1	

The overall pattern for the sourced obsidian artifacts from Housepit 1, Feature 2 is extremely continuous. There are no distinct changes in obsidian source procurement through the stratigraphic sequence. High source variability and an emphasis on obsidian from sources 48 km or less from the Birch Creek Site are exploited throughout the stratigraphic sequence. Venator, Sourdough Mountain, Barren Valley, and Indian Creek Buttes-A are consistently exploited through time, and all four sources fall within the predicted procurement range for hunter gatherers employing the Stewardian model for human land-use. The consistency in obsidian procurement patterns for all fills and contacts suggests inhabitants of Housepit 1, Feature 2 exhibited similar settlement and land-use strategies through time.

Table 4.7 shows artifact frequencies for sourced obsidian artifacts located within the N1057-1058 trench excavated during the 2001-2003 field seasons. The table is organized by depth (relative to site datum), and by obsidian source, as they increase in distance from the Birch Creek Site.

Table 4.7. Artifact Frequencies for Known Source Locations for N1057-1058 Trench. Highlighted values denote obsidian sources located within 48 km of 35ML181.

	Wildcat Creek (31 km)	Dry Creek Canyon (32 km)	Skull Springs (32 km)	Venator (35 km)	Coyote Wells East (36 km)	Coyote Wells (37 km)	Twin Springs Bench (37 km)	Sourdough Mountain (38 km)	Barren Valley (40 km)	Indian Creek Buttes-A (48 km)	Gregory Creek (55 km)	Owyhee (76 km)	Timber Butte (122 km)	Bretz Mine (125 km)	Eldorado (130 km)
1001.64-1001.625*						1		1							
1001.28-1001.23						1									
1001.23-1001.18											1				
1000.33-1000.28					1	1					1				
1000.28-1000.20								1		1					
1000.20-1000.15									1						
1000.13-1000.08				2											
1000.08-1000.03			1					1							
999.98-999.93												1			
999.89-999.78								3				1			
999.70-999.65													1		
999.62-999.57													1		
999.56-999.25			2	2	1	2		1	3		2		1		
999.25-999.10			1			1				1					
999.08-999.03						1							1		
999.03-998.98						2									
998.95-998.90										1					
998.88-998.73						3		1			1				

*Depth relative to site datum. Datum elevation is 1000 m.

Obsidian sources falling within the Stewardian range are heavily favored through time at the Birch Creek Site. The Coyote Wells and Sourdough Mountain sources are exploited throughout the stratigraphic sequence. Both sources are between 37 and 38 km of the site, falling well within the predicted range for hunter gatherers under the Stewardian model.

As another cross-reference, Table 4.8 and Table 4.9 have the same layout as Table 4.6 and Table 4.7, but instead of artifact frequencies, projectile point types are placed in the tables.

Table 4.8. Projectile Point Types* from Feature 2 for Known Source Locations. Highlighted values denote obsidian sources located with 48 km of 35Ml181.

	Wildcat Creek (31 km)	Dry Creek Canyon (32 km)	Skull Springs (32 km)	Venator (35 km)	Coyote Wells East (36 km)	Coyote Wells (37 km)	Twin Springs Bench (37 km)	Sourdough Mountain (38 km)	Barren Valley (40 km)	Indian Creek Buttes-A (48 km)	Gregory Creek (55 km)	Owyhee (76 km)	Timber Butte (122 km)	Bretz Mine (125 km)	Eldorado (130 km)
Fill AB				EE		EE		EE, EE		G		EC, EC	EE		
Contact B								EC, EC							
Fill C			P												
Contact C															
Fill D				H				S	S						

*Elko Corner-Notched=EC; Elko Drill=ED; Elko Eared=EE; Gatecliff=G; Humboldt=H; Lanceolate Leaf-Shaped=L; Pinto=P; Side-Notched=S

Table 4.9. Projectile Point Types* from the N1057-1058 Trench for known source locations. Highlighted values denote obsidian sources located within 48 km of 35ML181.

	Wildcat Creek (31 km)	Dry Creek Canyon (32 km)	Skull Springs (32 km)	Venator (35 km)	Coyote Wells East (36 km)	Coyote Wells (37 km)	Twin Springs Bench (37 km)	Sourdough Mountain (38 km)	Barren Valley (40 km)	Indian Creek Buttes-A (48 km)	Gregory Creek (55 km)	Owyhee (76 km)	Timber Butte (122 km)	Bretz Mine (125 km)	Eldorado (130 km)
1001.64-1001.625**						G									
1001.28-1001.23															
1001.23-1001.18											H				
1000.33-1000.28															
1000.28-1000.20								EE		H					
1000.20-1000.15									EE						
1000.13-1000.08				G											
1000.08-1000.03			ED					EE							
999.98-999.93															
999.89-999.78												EE			
999.70-999.65															
999.62-999.57													H		
999.56-999.25			L		EC						H		H		
999.25-999.10										S					
999.08-999.03															
999.03-998.98						S									
998.95-998.90										L					
998.88-998.73											S				

*Elko Corner-Notched=EC; Elko Drill=ED; Elko Eared=EE; Gatecliff=G; Humboldt=H; Lanceolate Leaf-Shaped=L; Side-Notched=S
**Depth relative to site datum. Datum elevation is 1000 m.

Table 4.8 and Table 4.9 provide support for the projectile point chronology proposed in the present study. Although the locations of two Humboldt projectile points in Table 4.9 are slightly problematic (1001.23-1001.18, Gregory Creek; 1000.28-1000.20, Indian Creek Buttes-A), a general transition from Lanceolate Leaf-Shaped and Northern Side-Notched projectile points, to Humboldt and Elko series points, and finally to Gatecliff points is observed. These tables again provide support for the argument that a relatively continuous pattern of obsidian procurement is observed through time at the Birch Creek Site.

Radiocarbon Dates and Implications for Continuity

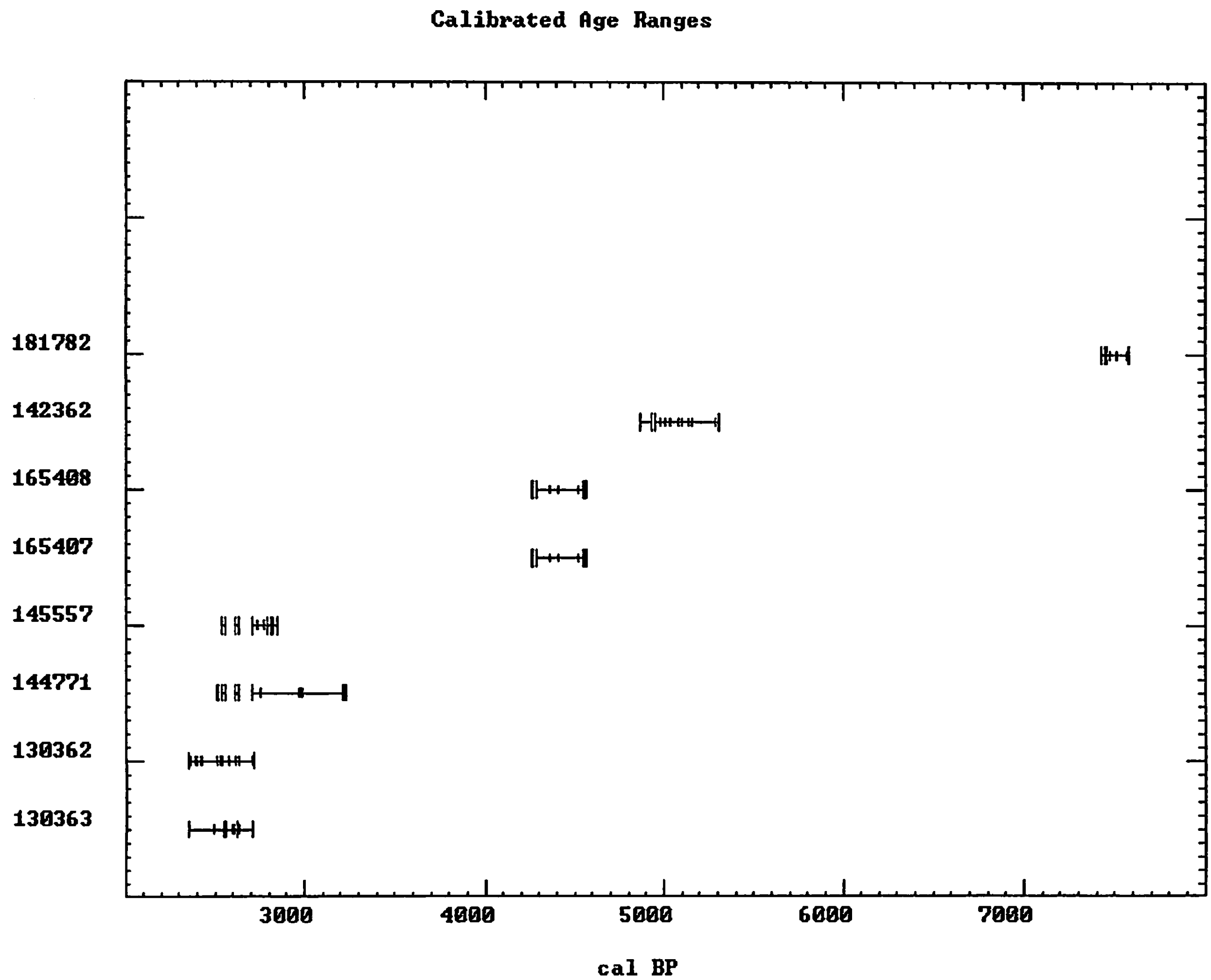
The section examines radiocarbon dates from the Birch Creek Site (Table 4.10) and the sourced obsidian artifacts in direct association with each date. A detailed review of the radiocarbon dates used in this analysis was presented in Chapter One. The following discussion reviews the results of calibrating (Calib©) radiocarbon dates from 35ML181 and its implications for the present study.

Table 4.10. Radiocarbon Dates from the Birch Creek Site, adapted from Andrefsky et al. (2003).

Measured Radiocarbon Age (yr BP)	Unit	Level	Conventional ^{14}C Age (yr BP)	2 Sigma Calibrated (yr BP)	2 Sigma Calibration BC / AD	Likely Fill or Contact	Sample No.	Radiocarbon Lab
2430 ± 60	N17 W7	13	2410 ± 60	2725 – 2335	775 – 385 BC	Contact II (B)	130363	Beta Analytic
2460 ± 70	N16 W6	10	2420 ± 70	2735 – 2330	758 – 380 BC	Fill B	130362	Beta Analytic
2620 ± 40	N17 W8	5	2620 ± 40	2780 – 2730	830 – 780 BC	Fill A	145557	Beta Analytic
2760 ± 110	N19 W 6	16	2760 ± 110	3160 – 2730	1210 – 780 BC	Fill B	144771	Beta Analytic
3980 ± 50	N1017 E992	NA	3990 ± 50	4560 – 4350 and 4330 – 4300	2600 – 2400 and 2380 – 2360 BC	Contact III (C)	165407	Beta Analytic
4480 ± 70	N17 – W4	55	4480 ± 70	5315 – 4865	3365 – 2915 BC	Contact IV (D)	142362	Beta Analytic
3980 ± 50	N1057 E981	26	3970 ± 50	4540 – 4280	2580 – 2330 BC	Feature 15 living surface	165408	Beta Analytic
6640 ± 40	N1057 – E980	31	6660 ± 40	7595 – 7460	5645 – 5510 BC	Pre-housepit surface	181782	Beta Analytic

Calibrated radiocarbon age ranges for Contact A, Fill B, Contact B, Contact C, and Contact D (located in Feature 2), as well as Feature 15 and the pre-housepit component resting below, are shown in Figure 4.2.

Figure 4.2. Calibrated (Calib©) radiocarbon age ranges.



The calibrated radiocarbon ages for Contact A, Fill B, and Contact B suggest that these three stratigraphic components should not be treated as separate chronological events. It is also clear from these radiocarbon age ranges that Contact C and Feature 15 should not be treated as separate chronological events. Contact D and the pre-housepit component resting below Feature 15, however, clearly represent separate chronological events. For the present study, all obsidian artifacts associated with Contact A, Fill B, and Contact B are condensed into Fill AB (see Cole 2001 for similar discussion). In addition, all obsidian artifacts associated with Contact C of Feature 2 and Feature 15 are placed into one chronological zone. Finally, all artifacts associated with the pre-housepit component resting below Feature 15 represent a separate chronological zone. Unfortunately, no obsidian artifacts are in direct association with Contact D.

As seen in Table 4.11, the extreme continuity in obsidian procurement is again suggested by the artifact obsidian associated with radiocarbon dates. Although there are small differences between the patterns for each age rage, the overall continuity is striking. Once again, obsidian sources within 48 kilometers of the Birch Creek Site are heavily favored through time. A preference is again shown for Coyote Wells and Sourdough Mountain obsidian, which are located 37 and 38 km from 35ML181, respectively. Very few obsidian artifacts fall outside of the predicted range for the Stewardian model of human land-use.

Table 4.11. Sourced Obsidian Artifact Frequencies Associated with Calibrated Radiocarbon Dates. Highlighted values denote obsidian sources located within 48 km of 35ML181.

	Wildcat Creek (31 km)	Dry Creek Canyon (32 km)	Skull Springs (32 km)	Venator (35 km)	Coyote Wells East (36 km)	Coyote Wells (37 km)	Twin Springs Bench (37 km)	Sourdough Mountain (38 km)	Barren Valley (40 km)	Indian Creek Buttes-A (48 km)	Gregory Creek (55 km)	Owyhee (76 km)	Timber Butte (122 km)	Bretz Mine (125 km)	Eldorado (130 km)
Fill AB		1		2	1	5	1	20	3	4		2	1		
Contact C, Feature 15		1		3		3			2	1			1		
Pre-housepit component						4		3			1				

All lines of evidence suggest that obsidian procurement around the Birch Creek Site was strikingly consistent throughout site occupation. The projectile point chronology and average procurement range for each projectile point type suggests that the Stewardian model can be extended into prehistory potentially 9500 years. As a second line of evidence, the stratigraphic superposition of artifacts suggested a pattern of continuity throughout the stratigraphic sequences at the Birch Creek Site. Finally, sourced artifact obsidian from the Birch Creek Site associated with radiocarbon dates suggests a pattern of continuity beginning approximately 6600 years ago.

The following chapter addresses the implications this patterning has for human settlement systems and land-use around the Birch Creek Site.

CHAPTER FIVE

INTERPRETATIONS

This chapter discusses the results presented in Chapter 4 and their implications for human settlement systems and land-use around the Birch Creek Site. It is argued in the previous chapter that Julian Steward's (1938) model for hunter gatherer land-use can be extended well into prehistory at the Birch Creek Site. The overall pattern of obsidian procurement at the Birch Creek Site shows extreme continuity in human land-use and suggests that mobile low population density hunter-gatherers occupied 35ML181 for the duration of site occupation.

The overall continuity in obsidian procurement at the Birch Creek Site is striking considering the possibilities. Why were Sourdough Mountain and Coyote Wells so highly exploited while Wildcat Creek, Dry Creek Canyon, and Skull Springs were rarely exploited? Why isn't there strong preference shown for different obsidian sources within a 40 kilometer radius of 35ML181? What can explain such extreme continuity in obsidian procurement patterns?

Given the large number of obsidian sources surrounding the Birch Creek Site in southeastern Oregon, the consistency in obsidian procurement through time at the site is extremely surprising. There is no reason to assume that prehistoric inhabitants of the site should be using the same obsidian resources for thousands of years. However, this is the pattern that is observed at 35ML181. Despite the wide range of possibilities, a heavy preference is shown for certain obsidian sources, specifically Coyote Wells and Sourdough Mountain. Both of these sources are approximately 37-38 km from the site; Coyote Wells is located to the northwest of the Birch Creek Site, and Sourdough Mountain is located to the northeast.

Although this analysis would be strengthened with a presentation of a map displaying all known obsidian sources surrounding the Birch Creek Site, comprehensive maps of known geologic sources of obsidian have not yet been produced. Further to this, it would be misleading to create such a map because much work remains to be done to locate, identify, and characterize sources of geologic obsidian in the region (Craig Skinner, personal communication).

As previously mentioned, however, there are numerous obsidian sources that are located more closely to the site than Coyote Wells and Sourdough Mountain: Wildcat Creek, Dry Creek Canyon, Skull Springs, and Venator. Based on distance to source alone, is it surprising that these sources are represented in relatively low numbers. One possible explanation for the strong preference for Coyote Wells and Sourdough Mountain obsidian, despite there being more local sources of obsidian, is that prehistoric travel routes may have existed along the Owyhee River and its tributaries. Although certain sources are located closer to the Birch Creek Site in a straight line direction, this may not accurately represent travel pathways between 35ML181 and certain obsidian sources. The more likely scenario is that prehistoric inhabitants of the Birch Creek Site traveled along the Owyhee River and its tributaries to access geologic sources of obsidian. Assuming travel along the river, the Coyote Wells and Sourdough Mountain sources are two of the first obsidian sources one would encounter traveling downstream (north) from the Birch Creek Site. Regardless of the travel pathways that may have existed along the Owyhee River, the point still remains that the pattern of obsidian procurement at the Birch Creek Site is strikingly continuous throughout site occupation.

The question still remains however, as to why we should expect to see such extreme continuity in human settlement systems and mobility over thousands of years at the Birch Creek Site? The introduction to the present study reviewed the ethnographic literature from the region surrounding the Birch Creek Site and outlined Steward's (1938) concept of ecological and social determinants and their implications for sociopolitical organization. Steward argued that for many low population density hunter-gatherer groups in the Basin-Plateau region, ecological and social determinants allowed only for family-level organization. If, for example, the same ecological and social determinants that were affecting the populations observed by Steward, were affecting the prehistoric populations inhabiting the Birch Creek region prehistorically, it could be argued that family-level organization was the stable form of sociopolitical organization thousands of years ago.

Based on the continuity in human land-use patterns observed at the Birch Creek Site, it may be appropriate to extend Steward's (1938) ethnographic model back into prehistory. The Stewardian model centers on seasonal land-use based on the availability of resources, with Northern Paiute groups typically moving within a 20-30 mile (32-48 km) radius. If the Birch Creek Site was a seasonal occupation one would expect that prehistoric populations were moving primarily within a maximum radius of 48 kilometers from 35ML181. Table 5.1 shows cumulative frequencies of artifacts as distance from the Birch Creek Site decreases.

Table 5.1. Cumulative Frequencies for Sourced Artifact Obsidian from 35ML181.

Source	Distance (km)	All Sourced Artifacts	Cumulative Frequencies
Eldorado	130	0.6%	0.6%
Bretz Mine	125	0.6	1.2
Timber Butte	122	3.1	4.3
Owyhee	76	4.9	9.2
Gregory Creek	55	4.9	14.1
Indian Creek Buttes-A	48	8.0	22.1
Barren Valley	40	6.8	28.9
Sourdough Mountain, Sourdough Mountain Unknown A	38	32.5	61.4
Twin Springs Bench (GGOV)	37	0.6	62.0
Coyote Wells, Coyote Wells East	36-37	16.0	78.0
Venator	35	11.0	89.0
Skull Springs	32	3.7	92.7
Dry Creek Canyon (GGOV)	32	1.2	93.9
Wildcat Creek	31	1.2	95.1
Unknowns		4.9	100
Total		100%	

Roughly 80% of all sourced artifacts from the Birch Creek Site were procured within 48 kilometers from the site. It is also important to note that the abundance of material from sources within 40 km of the site is consistent with distance decay expectations (Renfrew 1977). Using obsidian procurement range as a proxy for human land-use, this percentage demonstrates that the majority of movements around the Birch Creek Site fall within the observed movement range for Northern Paiute groups during the ethnographic period.

While it is clear that the overall pattern of obsidian procurement at the Birch Creek Site falls in line with the Stewardian model, one of the goals of the this research was to explore possible changes in human land-use through time. Based on the multiple lines of evidence presented in the previous chapter, it is argued here that the Stewardian model can be extended well into prehistory at the Birch Creek Site based on continuity in obsidian procurement.

Three separate lines of evidence were used to explore possible changes in human land-use through time: stratigraphic superposition of artifacts, projectile point age ranges, and artifacts associated with radiocarbon dates. Based on artifact provenience alone, the obsidian x-ray fluorescence data suggests a pattern of continuity in human land-use through time around the Birch Creek Site. In regards to average procurement distances, the projectile point chronology suggests that the Stewardian model for hunter gatherer land-use may be extended at least 6600 years into prehistory and possibly 9500 years based on the regional projectile point chronology. In addition to these two lines of evidence, the sourced obsidian artifacts in direct association with radiocarbon dates also suggest a pattern of continuity. The present study concludes that Steward's (1938) model for low population density hunter-gatherers, organized at the family-level, can be extended at least 6600 years into prehistory, and potentially 9500 years, at the Birch Creek Site.

CHAPTER SIX

SUMMARY AND CONCLUSIONS

The Birch Creek Site provides a unique opportunity to explore prehistoric human behavior in the Owyhee Uplands. Archaeological investigations in the region have been extremely limited, and research conducted at the Birch Creek Site can potentially make a large impact on archaeological understanding in the region.

Southeastern Oregon is a unique area due to its high concentration of geologic obsidian sources. Even in the short time that has passed since Cole's (2001) research, the reference library of characterized obsidian sources in southeastern Oregon has increased tremendously, helping to form a clearer picture about obsidian procurement around the Birch Creek Site. As more obsidian sources are characterized through ongoing survey in the region, it is possible to identify more detailed patterns of obsidian procurement. It is hoped that future research in the Owyhee Uplands will continue to use x-ray fluorescence data to explore broader questions about human behavior.

The Birch Creek Site is but one location within the middle Owyhee River drainage. It would be interesting to explore other site locations and the extent to which obsidian was procured over time. A more detailed chronology at other sites where provenience analysis of obsidian is undertaken may strengthen and modify the results found in this study.

The present study concludes that prehistoric inhabitants of the Birch Creek Site were low density population hunter-gatherers who exhibited a settlement strategy similar to Julian Steward's (1938) ethnographic model for family-level sociopolitical organization. It is argued that the same ecological and social determinants affecting ethnographic populations affected prehistoric populations at the Birch Creek Site. This continuity in human land-use and settlement system is reflected in the extreme continuity in obsidian procurement patterns for thousands of years at the Birch Creek Site. The overall pattern of obsidian procurement demonstrates that prehistoric inhabitants of the site exhibited similar settlement strategies and patterns of human land-use throughout site occupation.

The goal of this research was to test Steward's (1938) ethnographic model for hunter gatherer land-use at the Birch Creek Site, using x-ray fluorescence data as a method of analysis. Along with its stated goals, it is hoped that this research has also shown the utility of x-ray fluorescence analysis for investigating important questions about human behavior.

REFERENCES CITED

Aikens, C. Melvin, David Cole, and Robert Stuckenrath
1977 *Excavations at Dirty Shame Rockshelter, Southeastern Oregon.* Tebiwa: Miscellaneous Papers of the Idaho State University Museum of Natural History, No. 4. Pocatello.

Ambroz, Jessica A.
1997 *Characterization of Archaeologically Significant Obsidian Sources in Oregon by Neutron Activation Analysis.* Unpublished M.S. thesis. Department of Chemistry, University of Missouri, Columbia.

Ames, Kenneth M., Don E. Dumond, Jerry R. Galm, and Rick Minor
1998 Prehistory of the Southern Plateau. In *Plateau,* edited by D.E. Walker, Jr., pp. 103-119. Handbook of North American Indians, Vol. 12, William C. Sturtevant, general editor, Smithsonian Institution Press, Washington, D.C.

Andrefsky, Jr., William, Lisa Centola, Jason Cowan, and Erin Wallace
2003 *An Introduction to the Birch Creek Site (35ML181): Six Seasons of WSU Archaeological Field Study, 1998-2003.* Center for Northwest Anthropology, Contributions in Cultural Resource Management, No. 69. Washington State University, Pullman.

Andrefsky, Jr., William, and Alissa Nauman
2003 *A Preliminary Report on the Birch Creek Site (35ML181): Five Seasons of WSU Archaeological Field School Study 1998-2002.* Center for Northwest Anthropology, Contributions in Cultural Resource Management, No. 68. Washington State University, Pullman.

Andrefsky, Jr., William, and Kira Presler
2000 *Archaeological Investigations at Birch Creek (35ML181): 1998-1999 Interim Report.* Contributions in Cultural Resource Management, No. 66, Center for Northwest Anthropology. Washington State University, Pullman.

Andrefsky, Jr., William, and R. David Satterwhite
2002 *Archaeological Investigations at Birch Creek (35ML181): 1998-2001 Interim Report.* Center for Northwest Anthropology, Contributions in Cultural Resource Management, No. 67. Washington State University, Pullman.

Bailey, Jeff
1992 *X-Ray Fluorescence Characterization of Volcanic Glass Artifacts from Wilson Butte Cave, Idaho.* Unpublished MA thesis. Department of Anthropology, University of Alberta, Edmonton.

Benson, Larry, Michaele Kashgarian, Robert Rye, Steve Lund, Fred Paillet, Joseph Smoot, Cynthia Kester, Scott Mensing, Dave Meko, and Susan Lindström

2002 Holocene Multidecadal and Multicentennial Droughts Affecting Northern California and Nevada. *Quaternary Science Reviews* 21:659-682.

Binford, Lewis R.

1979 Organization and Formation Processes: Looking at Curated Technologies. *Journal of Anthropological Research* 35:255-273.

Carr, Tom, Tom Bailey, Don Johnson, and R. David Satterwhite

2000 Geophysical Investigations at the Birch Creek Site (35ML181). *Hemisphere Field Services Report of Investigation, No. 641.* Minneapolis.

Chatters, James C.

1998 Environment. In *Plateau,* edited by D.E. Walker, Jr., pp. 29-48. Handbook of North American Indians, Vol. 12, William C. Sturtevant, general editor, Smithsonian Institution Press, Washington, D.C.

Clewlow, E. William, Jr.

1967 Time and Space Relations of Some Great Basin Projectile Point Types. *University of California Archaeological Survey Reports* 70:141-150.

Cole, Clint R.

2001 *Raw Material Sources and the Prehistoric Chipped-stone Assemblage of the Birch Creek Site (35ML181), Southeastern Oregon.* Unpublished M.A. thesis, Department of Anthropology, Washington State University, Pullman.

D'Azevedo, Warren L. (editor)

1986 *Great Basin.* Handbook of North American Indians, Vol. 11, William C. Sturtevant, general editor, Smithsonian Institution Press, Washington D.C.

Endzweig, Pamela E.

1994 *Late Archaic Variability and Change on the Southern Columbia Plateau: Archaeological Investigations in the Pine Creek Drainage of the Middle John Day River, Wheeler County, Oregon.* Unpublished PhD Dissertation. Department of Anthropology, University of Oregon, Eugene.

Fenneman, N.

1931 *Physiology of the Western United States.* Academic Press, N.Y.

Grayson, Donald K.

1993 *The Deserts' Past: A Natural Prehistory of the Great Basin.* Smithsonian Institution Press, Washington D.C.

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

Heizer, Robert F., and Thomas R. Hester
1978 *Great Basin Projectile Points: Forms and Chronology.* Publications in Archaeology, Ethnology, and History No. 10. Ballena Press, Ballena.

Hess, Sean C.
1997 *Rocks, Range, and Renfrew: Using Distance-Decay Effects to Study Late Pre-Mazama Period Obsidian Acquisition and Mobility in Oregon and Washington.* Unpublished Ph.D. dissertation. Department of Anthropology, Washington State University, Pullman.

Hockett, Bryan S.
1995 Chronology of Elko Series and Split Stemmed Points from Northeastern Nevada. *Journal of California and Great Basin Anthropology* 17(1):41-53.

Holmer, Richard N.
1986 Common Projectile Points of the Intermountain West. In *Anthropology of the Desert Wes: Essay in Honor of Jesse D. Jennings*, edited by C.J. Condie and D.D. Fowler, pp. 89-115. Anthropological Papers No. 110. University of Utah, Salt Lake City.

Horr, David A.
1974 *Paiute Indians III: The Northern Paiute Indians.* Garland Publishing, New York.

Hughes, Richard E.
1986 *Diachronic Variability in Obsidian Procurement Patterns in Northeastern California and Southcentral Oregon.* University of California Publications, Anthropology Volume 17. University of California Press, Berkeley.

Jenkins, Dennis L., and Thomas J. Connolly
1990 *Archaeology of Indian Grade Spring: A Special Function Site on Stinkingwater Mountain, Harney County, Oregon.* University of Oregon Anthropological Paper No. 42. Department of Anthropology, University of Oregon, Eugene.

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* 68:5-38.

Justice, Noel D.
2002 *Stone Age Spear and Arrow Points of California and the Great Basin.* Indiana University Press, Bloomington.

Luttrell, Charles T.
2000 *A Report on a Class III Cultural Resources Inventory at the U.S. Bureau of Reclamation's Lake Owyhee Reservoir, Malheur County, Oregon.* Eastern Washington University Reports in Archaeology and History 100-96. Archaeological and Historical Services, Eastern Washington University, Cheney.

Lyons, William H., Scott P. Thomas, and Craig Skinner
2001 Changing Obsidian Sources at the Lost Dune and McCoy Creek Sites, Blitzen Valley, Southeastern Oregon. *Journal of California and Great Basin Anthropology* 23(2): 273-296.

Maxwell, David, Edgar K. Huber, Robert M. Wegener, and Karry L. Blake
2003 *The Steamboat Falls Site, Archaeological Testing at 35DO497, Umpqua National Forest, Douglas County, Oregon.* Prepared for the U.S. Forest Service. Technical Report 02-70, Statistical Research, Inc, Tucson.

Mehringer, Peter J., Jr.
1986 Prehistoric Environments. In *Great Basin,* edited by W.L. D'Azevedo, pp. 31-50. Handbook of North American Indians, Vol. 11, W.C. Sturtevant, general editor. Smithsonian Institution, Washington D.C.

1996 Columbia River Basin Ecosystems: Late Quaternary Environments. U.S. Forest Service and Bureau of Land Management, Walla Walla, WA.

Mehringer, Peter J., Jr., S.F. Arno, and K.L. Peterson
1977 Postglacial history of Lost Trail Pass Bog, Bitterroot Mountains, Montana. *Arctic and Alpine Research* 9:345-368.

Nelson, Fred W.
1984 X-Ray Fluorescence Analysis of some Western North American Obsidians. In Richard E. Hughes (ed.) *Obsidian Studies in the Great Basin.* Contributions of the University of California, Archaeological Research Facility, Berkeley.

Northwest Research Obsidian Studies Laboratory webpage
2003 http://www.obsidianlab.com

O'Connell, James F.
1975 The Prehistory of Surprise Valley. *Ballena Press Anthropological Papers* 4. Ramona, California.

O'Connell, James F., and Cari M. Inoway
1994 Surprise Valley Projectile Points and Their Chronological Implications. *Journal of California and Great Basin Anthropology* 16(2):162-198.

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

Pullen, Reg
1976 Archaeological Survey of the Owyhee River Canyon. Report on File, Bureau of Land Management, Vale District. Vale, Oregon.

Renfrew, Colin
1977 Egalitarian Exchange Systems in California: A Preliminary View. In *Exchange Systems in Prehistory*, edited by T.K. Earle and J.E. Ericson, pp. 109-126. Academic Press, New York.

Silvermoon, Jon M.
1994 *Archaeological Investigations at the Peninsula Site, 35KL87, Gerber Reservoir, South-Central Oregon*. Cultural Resource Series No. 11. U.S. Department of the Interior, Bureau of Land Management, Portland.

Skinner, Craig E.
2000 *X-Ray Fluorescence Analysis of Artifact Obsidian from the Birch Creek Site (35ML181), Malheur County, Oregon.* Northwest Research Obsidian Studies Laboratory Report 2000-53. Northwest Obsidian Studies Laboratory, Corvallis, Oregon.

2002 *X-Ray Fluorescence Analysis of Artifact Obsidian from the Birch Creek Site (35ML181), Malheur County, Oregon.* Northwest Research Obsidian Studies Laboratory Report 2002-16. Northwest Research Obsidian Studies Laboratory, Corvallis, Oregon.

2003 *X-Ray Fluorescence Analysis of Artifact Obsidian from the Birch Creek Site (35ML181), Malheur County, Oregon.* Northwest Research Obsidian Studies Laboratory Report 2003-56. Northwest Research Obsidian Studies Laboratory, Corvallis, Oregon.

Skinner, Craig E. and Jennifer J. Thatcher
2003 *X-Ray Fluorescence Analysis and Obsidian Hydration Rim Measurement of Artifact Obsidian from 34 Archaeological Sites Associated with the Proposed FTV Western Fiber Build Project, Deschutes, Lake, Harney, and Malheur Counties, Oregon.* Report 98-56 prepared for Northwest Archaeological Associates, Seattle, Washington, by Northwest Research Obsidian Studies Laboratory, Corvallis, Oregon.

Steward, Julian H.
1933 Ethnography of the Owens Valley Paiute. *University of California Publications in American Archaeology and Ethnology* 33(3):233-350.

1938 *Basin-Plateau Socio-Political Groups.* Bureau of American Ethnology Bulletin, No. 120.

Steward, Julian H., and Ermine Wheeler-Voeglin
1974 *The Northern Paiute Indians.* Garland Publishing, New York.

Thatcher, Jennifer J.
2000 *The Distribution of Geologic and Artifact Obsidian from the Silver Lake/Sycan Marsh Geochemical Source Group, South-Central Oregon.* Unpublished M.A. thesis. Interdisciplinary Studies, Oregon State University, Corvallis.

Thomas, David H.
1981 How to Classify the Projectile Points from Monitor Valley, Nevada. *Journal of California and Great Basin Archaeology* 3(1):7-43.

Thomas, Scott, Patrick O'Grady, Craig Skinner, and Jennifer Thatcher
2002 Return to a Jack Rabbit Roasting Site (35HA3055) in Southeastern Oregon: The Obsidian Sourcing and Hydration Evidence. Paper presented at the 2002 Northwest Anthropological Conference, Boise, Idaho.

Thornbury, W.D.
1965 *Regional Geomorphology of the United States.* John Wiley and Sons, N.Y.

Walker, Leanna M.
2001 *The 1998 Geoarchaeological Investigation of the Birch Creek Site (35ML181), Southeastern Oregon.* Unpublished M.A. thesis. Department of Anthropology, Washington State University, Pullman.

Wegener, Robert M.
1998 *Late Holocene Stone Technology and Seed and Faunal Remains from Skull Creek Dunes Locality-6, Catlow Valley, Southeastern Oregon.* Unpublished MA thesis. Department of Anthropology, Washington State University, Pullman.

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, University of Oregon, Eugene.

Wingard, George F.
2001 *Carlon Village: Land, Water, Subsistence, and Sedentism in the Northern Great Basin.* University of Oregon Anthropological Papers No. 57. Department of Anthropology, University of Oregon, Eugene.

APPENDIX A

XRF ANALYSIS

Northwest Research Obsidian Studies Laboratory

Table A-1. Results of XRF Studies: Birch Creek Site (35-ML-181), Malheur County, Oregon [NWROSL 2000-53]

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
35-ML-181	2	7747	76	19	104	181	27	114	11	952	560	930	1.61	27.1	53.4	Twin Springs Bench (GGOV)
			± 6	4	3	6	3	5	2	80	45	18	0.11			
35-ML-181	3	14541	135	19	135	32	32	206	19	662	313	447	0.57	19.9	29.8	Sourdough Mountain
			± 8	4	3	6	3	5	2	78	45	19	0.11			
35-ML-181	4	14635	71	24	192	34	58	176	33	376	194	189	0.82	48.7	72.9	Indian Creek Buttes A
			± 7	4	4	6	3	5	2	78	45	18	0.11			
35-ML-181	5	14536	67	12	133	36	42	236	21	760	186	502	0.75	47.3	33.1	Sourdough Mountain
			± 7	4	3	6	3	5	2	79	45	19	0.11			
35-ML-181	6	11880	169	22	100	103	69	385	18	981	353	1355	2.33	63.8	73.6	Unknown 1
			± 8	4	3	6	3	5	2	80	45	19	0.11			
35-ML-181	7	7158	60	22	184	27	53	169	32	551	278	140	1.30	48.1	75.3	Indian Creek Buttes A
			± 6	3	3	6	3	5	2	78	45	18	0.11			
35-ML-181	8	7749	51	18	143	36	40	216	22	903	212	463	0.92	48.2	33.3	Sourdough Mountain
			± 7	4	3	6	3	5	2	79	45	18	0.11			
35-ML-181	9	–	94	30	246	10	68	107	48	387	189	23	0.43	28.6	40.4	Barren Valley
			± 7	4	4	6	3	5	2	78	45	18	0.11			
35-ML-181	10	14599	79	19	132	32	35	212	25	934	327	417	0.98	30.6	34.1	Sourdough Mountain
			± 6	3	3	6	3	5	2	79	45	18	0.11			
35-ML-181	12	14611	39	13	112	29	27	173	16	424	132	417	0.49	51.5	41.1	Unknown 2
			± 7	4	3	6	3	5	2	78	45	19	0.11			
35-ML-181	14	14521	59	24	177	28	49	162	34	NM	NM	NM	NM	53.3	71.8	Indian Creek Buttes A *
			± 8	4	4	6	3	5	2	NM	NM	NM	NM			
35-ML-181	15	14117	48	17	207	30	32	106	10	NM	NM	NM	NM	73.2	73.4	Owyhee *
			± 8	4	4	6	3	5	2	NM	NM	NM	NM			
35-ML-181	16	13100	64	29	98	147	26	88	13	NM	NM	NM	NM	21.1	51.5	Venator *
			± 9	5	4	6	3	5	2	NM	NM	NM	NM			
35-ML-181	18	7786A	46	18	132	35	36	233	20	956	240	549	1.10	49.2	37.2	Sourdough Mountain
			± 6	4	3	6	3	5	2	79	45	18	0.11			
35-ML-181	20	7783	65	21	106	157	28	98	16	395	403	805	0.76	19.3	64.6	Venator
			± 7	4	3	6	3	5	2	78	45	19	0.11			
35-ML-181	22	14399	95	27	103	21	55	381	24	507	232	752	0.80	38.0	52.6	Wildcat Creek
			± 8	4	3	6	3	5	2	78	45	20	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: Birch Creek Site (35-ML-181), Malheur County, Oregon [NWROSL 2000-53]

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
35-ML-181	23	14480	38	19	110	30	33	178	18	474	149	411	0.59	50.9	42.8	Unknown 2
			± 7	4	3	6	3	5	2	78	45	19	0.11			
35-ML-181	24	14452	74	20	143	33	37	236	24	918	217	503	0.82	42.0	29.4	Sourdough Mountain
			± 6	4	3	6	3	5	2	79	45	19	0.11			
35-ML-181	25	14461	47	22	133	33	38	203	22	NM	NM	NM	NM	54.4	37.1	Sourdough Mountain *
			± 9	4	4	6	3	5	2	NM	NM	NM	NM			
35-ML-181	27	14449	66	23	174	31	54	168	30	547	174	NM	0.74	50.5	45.3	Indian Creek Buttes A
			± 7	4	3	6	3	5	2	78	45	NM	0.11			
35-ML-181	28	7859	76	20	109	158	28	103	11	534	500	924	0.86	17.0	53.0	Venator
			± 6	3	3	6	3	5	2	79	45	19	0.11			
35-ML-181	29	14456	210	44	212	7	95	516	36	783	208	38	1.42	73.8	57.4	Bretz Mine
			± 10	4	4	6	3	6	2	78	45	18	0.11			
35-ML-181	30	7801	56	17	136	35	40	237	22	977	226	575	0.88	42.6	29.4	Sourdough Mountain
			± 7	4	3	6	3	5	2	79	45	18	0.11			
35-ML-181	31	14478	89	17	111	24	64	433	31	1050	438	765	1.65	36.2	49.5	Coyote Wells
			± 7	4	3	6	3	5	2	80	45	18	0.11			
35-ML-181	33	15599	80	14	144	34	36	223	24	1022	379	451	1.11	29.3	35.1	Sourdough Mountain
			± 6	4	3	6	3	5	2	79	45	18	0.11			
35-ML-181	34	12355	67	19	134	34	39	241	22	847	203	539	0.91	50.4	35.2	Sourdough Mountain
			± 6	4	3	6	3	5	2	79	45	18	0.11			
35-ML-181	35	5991	81	21	113	139	29	93	11	378	551	879	0.88	15.6	76.8	Venator
			± 6	3	3	6	3	5	2	79	45	19	0.11			
35-ML-181	36	6062	73	25	182	31	51	169	35	318	187	172	0.79	49.2	83.5	Indian Creek Buttes A
			± 7	4	3	6	3	5	2	78	45	18	0.11			
35-ML-181	37	15219	69	21	135	35	42	295	25	791	203	501	0.91	50.2	37.7	Unknown 3
			± 6	3	3	6	3	5	2	79	45	18	0.11			
35-ML-181	38	6764	80	32	273	8	74	115	49	353	312	15	0.85	28.6	80.4	Barren Valley
			± 6	3	4	6	3	5	2	78	45	18	0.11			
35-ML-181	39	8040	92	21	112	21	61	434	32	1407	470	805	1.91	38.5	42.3	Coyote Wells
			± 6	3	3	6	3	5	2	80	45	18	0.11			
35-ML-181	40	7448	81	19	140	32	39	214	21	912	299	446	0.95	33.1	34.0	Sourdough Mountain
			± 6	3	3	6	3	5	2	79	45	18	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: Birch Creek Site (35-ML-181), Malheur County, Oregon [NWROSL 2000-53]

Site	Specimen No.	Catalog No.	Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	$Fe_2O_3^T$	Fe:Mn	Fe:Ti	Geochemical Source
			Trace Element Concentrations											Ratios		
35-ML-181	41	7112	80	18	138	37	38	231	24	1035	315	503	1.11	36.0	34.5	Sourdough Mountain
			± 6	3	3	6	3	5	2	79	45	18	0.11			
35-ML-181	42	6822	40	15	133	32	38	212	20	806	229	397	1.04	49.1	41.7	Sourdough Mountain
			± 6	3	3	6	3	5	2	79	45	18	0.11			
35-ML-181	43	5813	104	22	124	23	67	459	31	1099	412	839	1.60	37.6	45.9	Coyote Wells
			± 6	3	3	6	3	5	2	80	45	19	0.11			
35-ML-181	44	17865	74	23	113	164	28	100	14	518	522	922	1.01	18.8	63.5	Venator
			± 6	3	3	6	3	5	2	79	45	19	0.11			
35-ML-181	45	6871	65	20	148	33	38	219	22	935	255	464	1.04	43.5	36.1	Sourdough Mountain
			± 6	3	3	6	3	5	2	79	45	18	0.11			
35-ML-181	46	14544	92	17	122	31	40	209	17	390	110	401	0.29	43.8	29.1	Sourdough Mountain
			± 9	5	4	6	3	5	2	78	45	20	0.11			
35-ML-181	47	12296	87	25	206	9	52	91	35	169	172	14	0.43	31.9	93.2	Unknown 4
			± 7	4	4	6	3	5	2	77	45	19	0.11			
35-ML-181	48	14601	156	25	117	24	59	428	27	706	450	800	1.06	23.2	48.7	Coyote Wells
			± 8	4	3	6	3	5	2	79	45	18	0.11			
35-ML-181	49	CS-22-10	42	21	130	32	37	203	19	602	166	404	0.75	54.7	41.9	Sourdough Mountain
			± 7	4	3	6	3	5	2	78	45	19	0.11			
35-ML-181	50	CS-24-10	54	17	141	35	39	218	23	1007	255	434	1.13	46.8	36.2	Sourdough Mountain
			± 6	4	3	6	3	5	2	79	45	18	0.11			
35-ML-181	51	9223	138	25	112	31	70	480	33	1145	490	1113	1.73	33.5	47.4	Coyote Wells East
			± 7	4	3	6	3	5	2	80	45	21	0.11			
35-ML-181	52	14599	115	23	116	23	63	433	34	1085	429	781	1.36	30.8	39.8	Coyote Wells
			± 7	4	3	6	3	5	2	80	45	20	0.11			
35-ML-181	53	7741	134	37	278	9	74	116	50	381	289	7	0.48	18.7	44.6	Barren Valley
			± 8	4	4	6	3	5	2	78	45	22	0.11			
35-ML-181	54	CS-14-11	84	22	106	157	26	97	11	710	378	900	0.76	20.7	35.7	Venator
			± 7	4	3	6	3	5	2	79	45	19	0.11			
35-ML-181	56	CS-14-11	62	24	84	126	23	79	7	NM	NM	NM	NM	19.5	70.0	Venator *
			± 8	4	3	6	3	5	2	NM	NM	NM	NM			
35-ML-181	58	14149	98	38	298	8	75	120	49	193	253	21	0.60	26.6	109.0	Barren Valley
			± 7	4	4	6	3	5	2	77	45	19	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: Birch Creek Site (35-ML-181), Malheur County, Oregon [NWROSL 2000-53]

	Specimen		Trace Element Concentrations											Ratios		
Site	No.	Catalog No.	Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	$Fe_2O_3^T$	Fe:Mn	Fe:Ti	Geochemical Source
35-ML-181	59	14620	51	21	132	34	38	227	23	913	246	550	1.15	49.4	40.3	Sourdough Mountain
			± 6	3	3	6	3	5	2	79	45	18	0.11			
35-ML-181	60	7615	58	26	112	173	29	106	12	521	423	890	0.99	23.3	62.2	Venator
			± 7	4	3	6	3	5	2	79	45	20	0.11			
35-ML-181	66	14613	71	24	94	141	22	91	10	NM	NM	NM	NM	21.9	40.6	Venator *
			± 8	5	4	6	3	5	2	NM	NM	NM	NM			
35-ML-181	67	6664	50	18	136	31	39	212	22	835	207	458	0.93	50.4	36.5	Sourdough Mountain
			± 6	3	3	6	3	5	2	79	45	18	0.11			
35-ML-181	68	6791	55	14	139	31	36	213	24	697	167	462	0.66	48.3	32.2	Sourdough Mountain
			± 7	4	3	6	3	5	2	78	45	18	0.11			
35-ML-181	69	7498	70	36	185	20	46	65	36	435	511	26	0.36	7.8	30.5	Timber Butte
			± 6	3	3	6	3	5	2	78	45	18	0.11			
35-ML-181	71	6775	67	16	139	36	38	217	22	989	290	454	1.06	37.8	34.6	Sourdough Mountain
			± 6	3	3	6	3	5	2	79	45	18	0.11			
35-ML-181	72	4869	55	22	140	32	38	216	22	1112	240	443	1.27	55.9	36.3	Sourdough Mountain
			± 6	3	3	6	3	5	2	79	45	18	0.11			
35-ML-181	73	13298	38	20	141	36	36	218	22	948	246	438	1.14	49.2	38.7	Sourdough Mountain
			± 6	3	3	6	3	5	2	79	45	18	0.11			
35-ML-181	74	14387	71	21	134	30	38	211	23	820	177	469	0.82	54.2	32.9	Sourdough Mountain
			± 6	3	3	6	3	5	2	79	45	18	0.11			
35-ML-181	75	7618	113	26	127	25	62	448	32	1191	498	822	1.82	34.5	47.7	Coyote Wells
			± 6	3	3	6	3	5	2	80	45	19	0.11			
35-ML-181	76	13298	115	18	108	24	59	424	33	1027	377	796	1.44	37.6	44.5	Coyote Wells
			± 7	4	3	6	3	5	2	79	45	19	0.11			
35-ML-181	77	8367	79	14	135	34	37	211	22	983	321	405	1.15	36.3	37.5	Sourdough Mountain
			± 6	4	3	6	3	5	2	79	45	18	0.11			
35-ML-181	78	14618	121	22	104	133	31	92	12	262	490	851	0.59	12.4	77.7	Venator
			± 8	4	3	6	3	5	2	78	45	19	0.11			
35-ML-181	79	15375	52	23	209	29	26	106	13	NM	NM	NM	NM	66.2	66.4	Owyhee *
			± 7	4	4	6	3	5	2	NM	NM	NM	NM			
35-ML-181	80	7552	58	20	132	33	36	209	21	910	213	420	1.00	51.6	35.6	Sourdough Mountain
			± 6	3	3	6	3	5	2	79	45	18	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: Birch Creek Site (35-ML-181), Malheur County, Oregon [NWROSL 2000-53]

	Specimen		Trace Element Concentrations											Ratios		
Site	No.	Catalog No.	Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	$Fe_2O_3^T$	Fe:Mn	Fe:Ti	Geochemical Source
35-ML-181	81	7552	79	18	97	20	48	357	26	741	288	636	1.01	36.7	44.4	Wildcat Creek
			± 7	4	3	6	3	5	2	79	45	20	0.11			
35-ML-181	82	14452	70	20	131	35	36	232	23	1079	315	511	1.17	37.9	34.8	Sourdough Mountain
			± 6	3	3	6	3	5	2	79	45	18	0.11			
35-ML-181	83	14660	101	33	271	10	72	118	49	293	342	17	0.71	21.7	82.1	Barren Valley
			± 7	3	4	6	3	5	2	77	45	18	0.11			
35-ML-181	84	7550	48	21	161	29	51	152	25	354	187	168	0.71	44.4	67.8	Indian Creek Buttes A
			± 7	4	3	6	3	5	2	78	45	18	0.11			
35-ML-181	85	13061	57	20	149	37	37	222	25	834	198	443	0.91	51.9	35.6	Sourdough Mountain
			± 6	4	3	6	3	5	2	79	45	18	0.11			
35-ML-181	86	13017	62	29	96	175	29	84	10	NM	NM	NM	NM	15.7	129.9	Gregory Creek *
			± 8	4	3	6	3	5	2	NM	NM	NM	NM			
35-ML-181	87	13017A	57	19	163	40	36	229	20	755	171	379	0.72	50.2	31.8	Sourdough Mountain
			± 8	4	4	6	3	5	2	78	45	19	0.11			
35-ML-181	88	13017B	37	21	136	40	38	225	25	668	177	403	0.77	51.3	38.2	Sourdough Mountain
			± 7	4	3	6	3	5	2	79	45	20	0.11			
35-ML-181	89	13017C	49	26	149	34	39	210	22	NM	NM	NM	NM	48.7	37.8	Sourdough Mountain *
			± 8	4	4	6	3	5	2	NM	NM	NM	NM			
35-ML-181	90	13017D	22	14	104	28	29	171	16	461	127	354	0.50	55.3	38.1	Unknown 2
			± 9	4	3	6	3	5	2	78	45	19	0.11			
35-ML-181	91	13153	41	20	134	35	37	239	22	695	176	474	0.76	51.1	36.5	Sourdough Mountain
			± 8	4	3	6	3	5	2	79	45	18	0.11			
35-ML-181	92	13018	85	20	96	173	29	88	11	318	525	2154	0.77	14.6	81.3	Gregory Creek
			± 7	4	3	6	3	5	2	80	45	25	0.11			
35-ML-181	93	13018A	54	23	189	32	57	165	35	319	175	151	0.73	50.0	77.7	Indian Creek Buttes A
			± 8	4	4	6	3	5	2	78	45	19	0.11			
35-ML-181	96	15087	139	18	108	15	77	502	33	1049	608	601	2.12	32.1	62.7	Skull Springs
			± 8	4	3	6	3	5	2	79	45	19	0.11			
35-ML-181	97	13152	57	23	147	36	38	222	21	867	190	421	0.90	54.1	34.0	Sourdough Mountain
			± 6	4	3	6	3	5	2	79	45	19	0.11			
35-ML-181	98	13152B	45	18	143	36	36	219	23	600	175	409	0.71	48.3	39.8	Sourdough Mountain
			± 7	4	3	6	3	5	2	78	45	18	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: Birch Creek Site (35-ML-181), Malheur County, Oregon [NWROSL 2000-53]

	Specimen		Trace Element Concentrations											Ratios		
Site	No.	Catalog No.	Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	$Fe_2O_3^T$	Fe:Mn	Fe:Ti	Geochemical Source
35-ML-181	99	13153	71	25	94	167	25	86	9	403	365	2012	0.52	15.3	45.1	Gregory Creek
			± 7	4	3	6	3	5	2	79	45	26	0.11			
35-ML-181	100	13153A	51	19	144	33	35	201	18	NM	NM	NM	NM	55.0	44.3	Sourdough Mountain *
			± 8	4	4	6	3	5	2	NM	NM	NM	NM			
35-ML-181	101	CS-17-11	62	8	28	18	13	58	6	680	96	210	0.35	62.7	19.0	Unknown 5 (GGOV)
			± 6	4	3	6	3	5	2	78	45	18	0.11			
35-ML-181	102	CS-17-10	37	21	124	33	37	209	19	NM	NM	NM	NM	47.4	31.8	Sourdough Mountain *
			± 9	4	4	6	3	5	2	NM	NM	NM	NM			
35-ML-181	103	14709	105	20	126	22	62	453	30	840	337	597	1.28	38.1	48.7	Coyote Wells
			± 8	4	3	6	3	5	2	79	45	20	0.11			
35-ML-181	105	14968	50	23	214	45	31	134	13	586	138	525	0.94	85.7	52.5	Owyhee?
			± 6	3	3	6	3	5	2	79	45	18	0.11			
35-ML-181	107	14649	122	23	145	131	30	329	15	1748	392	990	1.62	40.1	29.1	Dry Creek Canyon (GGOV)
			± 7	4	3	6	3	5	2	81	45	19	0.11			
35-ML-181	108	15051	39	20	129	34	37	225	21	756	198	459	0.95	53.9	41.0	Sourdough Mountain
			± 7	4	3	6	3	5	2	79	45	19	0.11			
35-ML-181	109	8039	59	22	137	118	33	315	19	1715	278	979	1.57	57.6	28.8	Dry Creek Canyon (GGOV)
			± 7	4	3	6	3	5	2	81	45	19	0.11			
35-ML-181	110	6794	113	29	282	10	74	116	48	310	340	11	0.90	27.2	96.0	Barren Valley
			± 6	3	4	6	3	5	2	78	45	19	0.11			
35-ML-181	111	9082	53	21	105	161	26	103	12	599	614	917	1.26	19.5	67.6	Venator
			± 6	3	3	6	3	5	2	79	45	18	0.11			
35-ML-181	112	15046	76	19	133	32	35	213	18	987	284	487	1.07	39.3	35.1	Sourdough Mountain
			± 6	3	3	6	3	5	2	79	45	18	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: Birch Creek Site (35-ML-181), Malheur County, Oregon [NWROSL 2002-16]

	Specimen		Trace Element Concentrations											Ratios		
Site	No.	Catalog No.	Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	$Fe2O3^T$	Fe:Mn	Fe:Ti	Geochemical Source
35-ML-181	1	1065	64	20	103	132	30	92	15	753	484	838	1.00	20.0	43.5	Venator
			± 7	3	3	6	2	6	2	76	46	28	0.11			
35-ML-181	2	3641	72	30	220	26	29	110	13	488	188	142	0.94	55.7	63.5	Owyhee
			± 6	3	3	6	2	6	2	75	46	28	0.11			
35-ML-181	3	5559	112	16	114	21	60	431	30	1358	540	795	1.99	34.0	46.1	Coyote Wells
			± 7	3	3	6	2	6	2	77	46	28	0.11			
35-ML-181	4	6276	68	19	106	134	28	93	13	333	611	923	0.94	14.7	93.2	Venator
			± 6	3	3	6	2	6	2	75	46	28	0.11			
35-ML-181	5	7009	108	19	122	21	64	449	34	1468	523	828	1.99	35.1	42.7	Coyote Wells
			± 7	3	3	6	2	6	2	77	46	28	0.11			
35-ML-181	6	7173	57	19	110	131	29	98	13	691	566	882	1.20	20.0	56.1	Venator
			± 6	3	3	6	2	6	2	76	46	28	0.11			
35-ML-181	7	11687	57	16	138	31	40	217	26	1113	310	417	1.47	46.8	42.2	Sourdough Mountain
			± 6	3	3	6	2	6	2	76	46	28	0.11			
35-ML-181	8	12343	96	30	273	11	72	120	51	266	288	19	0.80	29.1	101.2	Barren Valley
			± 7	3	4	6	2	6	2	74	46	27	0.11			
35-ML-181	9	12405	44	19	142	35	39	241	25	1095	351	529	1.25	35.1	37.0	Sourdough Mountain
			± 6	3	3	6	2	6	2	76	46	28	0.11			
35-ML-181	10	12700	58	25	102	150	29	97	15	918	518	929	1.17	21.5	41.3	Venator
			± 6	3	3	6	2	6	2	76	46	28	0.11			
35-ML-181	11	12765	66	22	107	138	31	96	14	283	535	869	0.77	14.2	92.1	Venator
			± 7	3	3	6	2	6	2	75	46	28	0.11			
35-ML-181	12	12937	42	26	220	26	32	113	13	601	173	168	1.11	72.2	60.3	Owyhee
			± 6	3	3	6	2	6	2	75	46	27	0.11			
35-ML-181	13	13656	97	18	121	23	62	448	37	1171	419	794	1.72	38.8	46.5	Coyote Wells
			± 7	4	3	6	2	6	2	77	46	28	0.11			
35-ML-181	14	15663	53	24	179	32	53	169	30	441	229	158	1.12	51.3	82.4	Indian Creek Buttes A
			± 7	3	3	6	2	6	2	75	46	28	0.11			
35-ML-181	15	15908	168	23	117	10	76	504	34	1284	796	572	2.74	30.6	66.5	Skull Springs
			± 7	3	3	6	2	6	2	77	46	28	0.11			
35-ML-181	16	17228	80	23	238	8	62	104	42	174	228	29	0.56	28.0	113.5	Barren Valley
			± 7	4	4	6	2	6	2	74	46	28	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.

Table A-1. Results of XRF Studies: Birch Creek Site (35-ML-181), Malheur County, Oregon [NWROSL 2002-16]

	Specimen		Trace Element Concentrations											Ratios		
Site	No.	Catalog No.	Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	$Fe_2O_3^T$	Fe:Mn	Fe:Ti	Geochemical Source
35-ML-181	17	17525	111	26	260	7	66	118	51	730	360	11	0.87	24.3	39.4	Unknown 6
			± 7	3	4	6	2	6	2	75	46	27	0.11			
35-ML-181	18	18368	55	16	129	32	39	211	23	822	217	422	0.94	46.7	37.7	Sourdough Mountain
			± 6	3	3	6	2	6	2	76	46	28	0.11			
35-ML-181	19	18369	55	23	184	59	28	158	11	985	143	982	0.91	76.4	30.5	Sourdough Mountain Unknown A
			± 7	4	3	6	2	6	2	76	46	28	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: Birch Creek Site (35-ML-181), Malheur County, Oregon

	Specimen		Trace Element Concentrations											Ratios		
Site	No.	Catalog No.	Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	$Fe2O3^T$	Fe:Mn	Fe:Ti	Geochemical Source
35-ML-181	1	2062	162	45	252	8	96	230	47	468	170	58	1.45	94.3	99.1	Unknown 7
			± 8	5	4	9	3	7	2	75	46	32	0.11			
35-ML-181	2	6696	54	25	154	36	40	222	24	892	217	432	0.97	45.2	35.6	Sourdough Mountain
			± 7	4	4	9	3	7	1	76	41	31	0.11			
35-ML-181	3	7008	47	22	141	33	38	213	22	965	243	451	1.20	48.6	40.1	Sourdough Mountain
			± 7	4	4	9	3	7	1	76	41	31	0.11			
35-ML-181	4	7742	40	21	150	34	37	219	23	916	356	479	1.08	29.3	38.5	Sourdough Mountain
			± 7	4	4	9	3	7	1	76	41	31	0.11			
35-ML-181	5	8524	38	21	156	36	39	221	21	846	211	448	1.02	49.2	39.4	Sourdough Mountain
			± 7	4	4	9	3	7	1	76	41	31	0.11			
35-ML-181	6	10936	41	19	138	33	40	234	23	1147	400	569	1.37	32.2	38.3	Sourdough Mountain
			± 7	4	4	9	3	7	1	77	41	31	0.11			
35-ML-181	7	13248	63	23	185	31	54	167	33	531	265	191	1.27	46.6	76.5	Indian Creek Buttes Variety A
			± 7	4	4	9	3	7	1	75	41	31	0.11			
35-ML-181	8	13598	146	22	87	105	67	353	16	1207	586	1401	2.95	45.1	76.1	Eldorado
			± 8	4	4	9	3	7	1	78	41	31	0.11			
35-ML-181	9	14054	65	32	245	29	62	369	46	1505	191	575	1.96	101.5	41.0	Unknown 8
			± 7	4	4	9	3	7	1	78	41	31	0.11			
35-ML-181	10	15047	46	19	174	31	50	165	30	547	375	192	1.23	31.1	72.1	Indian Creek Buttes Variety A
			± 7	4	4	9	3	7	1	75	41	31	0.11			
35-ML-181	11	15730	39	25	210	30	27	110	11	510	184	224	1.09	60.6	69.0	Owyhee
			± 7	4	4	9	3	7	1	75	41	31	0.11			
35-ML-181	12	18207	37	18	139	31	35	209	22	1130	300	470	1.37	44.0	39.0	Sourdough Mountain
			± 7	4	4	9	3	7	1	76	41	31	0.11			
35-ML-181	13	18875	87	21	117	20	60	433	30	1089	409	782	1.59	36.2	46.4	Coyote Wells
			± 7	4	4	9	3	7	1	77	41	32	0.11			
35-ML-181	14	18876	44	19	154	34	39	224	24	707	152	406	0.69	50.1	33.0	Sourdough Mountain
			± 8	4	4	9	3	7	1	75	41	32	0.11			
35-ML-181	15	19413	96	20	99	31	65	450	33	1499	673	1178	2.31	30.8	48.4	Coyote Wells East
			± 8	4	4	9	3	7	1	78	41	31	0.11			
35-ML-181	16	19693	66	32	254	8	65	117	46	297	454	21	0.90	19.5	100.7	Barren Valley
			± 7	4	4	9	3	7	1	74	46	30	0.11			

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NA = Not available; ND = Not detected; NM = Not measured.; * = Small sample.

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Table A-1. Results of XRF Studies: Birch Creek Site (35-ML-181), Malheur County, Oregon

Site	Specimen No.	Catalog No.	Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	$Fe_2O_3^T$	Fe:Mn	Fe:Ti	Geochemical Source
			Trace Element Concentrations											*Ratios*		
35-ML-181	17	19786	53	33	186	16	43	59	36	255	767	39	0.39	5.4	57.2	Timber Butte
			± 7	4	4	9	3	7	1	74	46	33	0.11			
35-ML-181	18	19818	137	19	108	16	73	470	34	1395	840	531	2.93	30.8	65.1	Skull Springs
			± 8	4	4	9	3	7	1	77	46	31	0.11			
35-ML-181	19	19949	140	24	109	13	73	485	32	1324	785	535	2.76	31.2	64.7	Skull Springs
			± 8	4	4	9	3	7	1	77	46	31	0.11			
35-ML-181	20	20282	62	31	194	17	45	64	36	249	615	40	0.37	6.5	55.4	Timber Butte
			± 7	4	4	9	3	7	1	74	46	33	0.11			
35-ML-181	21	20469	47	22	173	28	49	160	29	508	270	173	1.22	46.0	77.5	Indian Creek Buttes Variety A
			± 7	4	4	9	3	7	1	75	46	31	0.11			
35-ML-181	22	22372	55	19	105	123	30	91	14	341	547	891	0.84	14.9	82.1	Venator
			± 7	4	4	9	3	7	1	75	46	31	0.11			
35-ML-181	23	22384	44	19	138	34	37	270	20	890	213	515	1.07	53.9	39.2	Sourdough Mountain?
			± 7	4	4	9	3	7	1	76	46	31	0.11			
35-ML-181	24	22609	33	16	139	31	37	213	23	973	364	426	1.20	32.3	39.8	Sourdough Mountain
			± 7	4	4	9	3	7	1	76	46	31	0.11			
35-ML-181	25	22914	50	21	189	33	54	168	32	439	384	184	1.08	27.7	80.5	Indian Creek Buttes Variety A
			± 7	4	4	9	3	7	1	75	46	31	0.11			
35-ML-181	26	23240	61	30	94	165	26	85	12	178	460	2159	0.68	14.9	131.0	Gregory Creek
			± 7	4	4	9	3	7	1	76	46	33	0.11			
35-ML-181	27	23340	125	27	118	16	72	489	30	1128	691	631	2.43	31.6	67.2	Skull Springs
			± 8	4	4	9	3	7	1	77	46	31	0.11			
35-ML-181	28	23985	77	22	114	20	58	418	29	1140	482	821	1.80	34.7	49.8	Coyote Wells
			± 7	4	4	9	3	7	1	77	46	31	0.11			
35-ML-181	29	24116	41	27	236	30	31	111	13	511	176	136	0.96	62.1	62.2	Owyhee
			± 7	4	4	9	3	7	1	75	46	31	0.11			
35-ML-181	30	24618	54	33	247	9	67	106	45	310	343	11	0.98	28.6	103.5	Barren Valley
			± 7	4	4	9	3	7	1	74	46	30	0.11			
35-ML-181	1	19694	93	22	120	23	62	440	33	1226	524	746	1.74	27.8	47.4	Coyote Wells
			± 7	4	4	9	3	7	1	91	28	32	0.11			
35-ML-181	2	20222	133	23	108	14	71	471	29	1551	893	561	3.12	28.7	66.4	Skull Springs
			± 8	4	4	9	3	7	1	91	28	32	0.11			

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Northwest Research Obsidian Studies Laboratory

Table A-1. Results of XRF Studies: Birch Creek Site (35-ML-181), Malheur County, Oregon

	Specimen		Trace Element Concentrations											Ratios		
Site	No.	Catalog No.	Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	$Fe2O3^T$	Fe:Mn	Fe:Ti	Geochemical Source
35-ML-181	3	20233	48	21	77	143	23	83	12	453	594	2284	1.12	16.2	81.1	Gregory Creek
			± 7	4	4	9	3	7	1	91	28	33	0.11			
35-ML-181	4	20429	42	20	80	148	23	80	12	NM	NM	NM	NM	17.0	79.0	Gregory Creek *
			± 7	4	4	9	3	7	1	NM	NM	35	NM			
35-ML-181	5	21705	36	24	100	126	26	88	15	447	626	929	1.16	15.9	84.7	Venator
			± 7	4	4	9	3	7	1	89	28	32	0.11			
35-ML-181	6	22021	62	21	107	18	59	411	30	NM	NM	NM	NM	34.6	43.9	Coyote Wells *
			± 8	4	4	9	3	7	1	NM	NM	32	NM			
35-ML-181	7	22130	119	16	101	29	63	439	29	1563	694	1165	2.44	29.1	51.9	Coyote Wells East
			± 7	4	4	9	3	7	1	92	28	32	0.11			
35-ML-181	8	22304	62	19	104	21	55	408	31	1215	408	882	1.71	35.3	47.1	Coyote Wells
			± 8	4	4	9	3	7	1	91	28	32	0.11			
35-ML-181	9	22350	49	20	74	143	25	73	12	385	547	2378	0.89	14.2	75.9	Gregory Creek
			± 7	4	4	9	3	7	1	90	28	34	0.11			
35-ML-181	10	22477	43	22	71	137	24	72	14	730	504	2385	1.20	20.4	55.0	Gregory Creek
			± 7	4	4	9	3	7	1	91	28	34	0.11			
35-ML-181	11	22944	34	19	146	33	40	216	20	1188	301	481	1.25	35.5	35.6	Sourdough Mountain
			± 7	4	4	9	3	7	1	90	28	32	0.11			
35-ML-181	12	23274	50	16	136	33	39	224	21	NM	NM	NM	NM	48.2	40.8	Sourdough Mountain *
			± 7	4	4	9	3	7	1	NM	NM	32	NM			
35-ML-181	13	23662	73	23	110	22	59	420	28	NM	NM	NM	NM	37.5	46.4	Coyote Wells *
			± 7	4	4	9	3	7	1	NM	NM	33	NM			
35-ML-181	14	23716	26	26	207	49	26	132	9	NM	NM	NM	NM	69.9	45.6	Owyhee *
			± 8	4	4	9	3	7	1	NM	NM	32	NM			
35-ML-181	15	23756	48	15	96	126	25	92	14	482	563	897	1.07	16.3	72.9	Venator
			± 7	4	4	9	3	7	1	89	28	32	0.11			
35-ML-181	16	23807	73	20	106	19	62	414	34	1475	509	847	2.07	33.8	46.7	Coyote Wells
			± 8	5	4	9	3	7	1	92	28	32	0.11			
35-ML-181	17	23809	57	45	205	21	41	59	36	NM	NM	NM	NM	7.1	49.1	Timber Butte *
			± 8	4	4	9	3	7	1	NM	NM	39	NM			
35-ML-181	18	23859	53	20	173	23	52	157	31	465	356	126	1.23	29.6	86.3	Indian Creek Buttes Variety A
			± 8	4	4	9	3	7	1	88	28	32	0.11			

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Northwest Research Obsidian Studies Laboratory

Table A-1. Results of XRF Studies: Birch Creek Site (35-ML-181), Malheur County, 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
35-ML-181	19	23920	66	27	179	16	43	56	35	NM	NM	NM	NM	7.0	77.8	Timber Butte *
			± 7	4	4	9	3	7	1	NM	NM	33	NM			
35-ML-181	20	23926	50	26	160	40	38	223	22	NM	NM	NM	NM	48.5	42.5	Sourdough Mountain *
			± 10	5	4	9	3	7	2	NM	NM	34	NM			
35-ML-181	21	23930	56	19	137	34	37	234	22	1254	285	578	1.39	41.6	37.4	Sourdough Mountain
			± 7	4	4	9	3	7	1	90	27	32	0.11			
35-ML-181	22	23998	87	19	121	22	58	439	33	1174	413	808	1.68	34.2	47.8	Coyote Wells
			± 7	4	4	9	3	7	1	91	28	34	0.11			
35-ML-181	23	24154	89	23	123	23	62	442	34	1498	557	854	2.17	32.4	48.3	Coyote Wells
			± 7	4	4	9	3	7	1	92	28	33	0.11			
35-ML-181	24	24165	79	22	241	9	68	110	43	287	366	2	1.06	24.9	116.5	Barren Valley
			± 7	4	4	9	3	7	1	88	28	31	0.11			
35-ML-181	25	24397	81	22	118	21	59	431	30	NM	NM	NM	NM	35.2	48.8	Coyote Wells *
			± 8	4	4	9	3	7	1	NM	NM	34	NM			
35-ML-181	26	24945	76	22	106	19	57	418	30	1379	480	828	1.93	33.6	46.7	Coyote Wells
			± 7	4	4	9	3	7	1	91	28	32	0.11			
35-ML-181	27	24957	88	21	115	23	62	435	29	1426	514	837	2.05	33.2	47.9	Coyote Wells
			± 7	4	4	9	3	7	1	91	28	33	0.11			
35-ML-181	28	25006	62	28	273	10	69	121	50	347	332	39	1.04	27.1	96.6	Barren Valley
			± 7	4	4	9	3	7	1	88	28	37	0.11			
35-ML-181	29	25007	42	19	110	160	27	101	12	512	652	952	1.27	16.5	81.1	Venator
			± 7	4	4	9	3	7	1	89	28	33	0.11			
35-ML-181	30	25076	48	14	129	35	37	205	20	NM	NM	NM	NM	37.7	38.2	Sourdough Mountain *
			± 7	4	4	9	3	7	1	NM	NM	33	NM			
NA	RGM-1	RGM-1	23	27	151	103	28	219	8	1724	276	808	1.95	59.4	37.9	RGM-1 Reference Standard
			± 8	4	4	9	3	7	1	92	28	32	0.11			

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