RAW MATERIAL SOURCES AND THE PREHISTORIC CHIPPED-STONE ASSEMBLAGE OF THE BIRCH CREEK SITE (35ML181), SOUTHEASTERN OREGON

By

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To the Faculty of Washington State University:

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Abstract

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In this thesis I explore the relationship between lithic technology and raw material economy at the Birch Creek Site (35ML181), southeastern Oregon. Located in the Owyhee Uplands, this site includes a stratigraphic sequence of three pithouse floors and fill episodes dated within a period of approximately 4400 B.P. to 2400 B.P. This corresponds with reoccupation of archaeological sites within the northern Great Basin.

Abundant local chert is the staple resource in the lithic economy at 35ML181. Technology focuses on the production of bifaces and expedient flake tools produced from minimally prepared cores. Debitage indicates that both chert and obsidian underwent similar reduction sequences to produce tools. Obsidian was often transported in the form of cortical nodules or cortical flakes and favored for hafted bifaces. Consistent relative frequencies of obsidian to chert throughout the cultural strata indicates little change in raw material supply or demand.

Non-destructive x-ray fluorescence of 108 obsidian samples determines exploited source locations. Analysis reveals that most obsidian came to Birch Creek from eleven identified geologic sources situated within forty km of 35ML181. Change in distance-to-source through time is not evident. Two important localities suggest that prehistoric folks journeyed north to collect volcanic glass. Greater frequency of Sourdough Mountain obsidian suggests common travels along the Owyhee River produced more material than other sources less distant to the Birch Creek Site. A greater amount of cortical obsidian debitage within younger stratum indicates that trips during this period returned with unfinished Sourdough Mountain material.

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Dedication

This thesis is dedicated to my parents, whom I love dearly.

CHAPTER 1

INTRODUCTION

THE BIRCH CREEK SITE (35ML181), SOUTHEASTERN OREGON

In this thesis I analyze the chipped-stone assemblage from the Birch Creek Site (35ML181). My goal is to understand and describe the prehistoric organization of lithic technology as it relates to obsidian and chert sources in the Owyhee Uplands of southeastern Oregon. I compare local and distant source material variability expressed through stone tools and debitage (waste material) measurements.

Site 35ML181 permits study of raw material economy in the northern Great Basin because deposits hold a stratigraphic sequence of cultural remains. It is one of few stratified archaeological sites associated with radiocarbon dates in its vicinity. Five dated samples fit within a time period ranging from approximately 4400 B.P. (before present) to 2400 B.P. – the Great Basin's Middle Archaic. Spatial separation of local and distant raw materials allows their products and byproducts to be measured and compared and one to infer behaviors associated with the organization of lithic technology.

The Birch Creek Site (35ML181), Malheur County, southeastern Oregon, lies approximately 50 km northwest of the town of Jordan Valley (Figure 1.1) along a portion of the middle Owyhee River canyon that belongs to the Owyhee Uplands. The site developed on an alluvial terrace formed upon a bar that situates along the river bend. House depressions and surface scatters of chipped stone artifacts and ground stone identify this site.

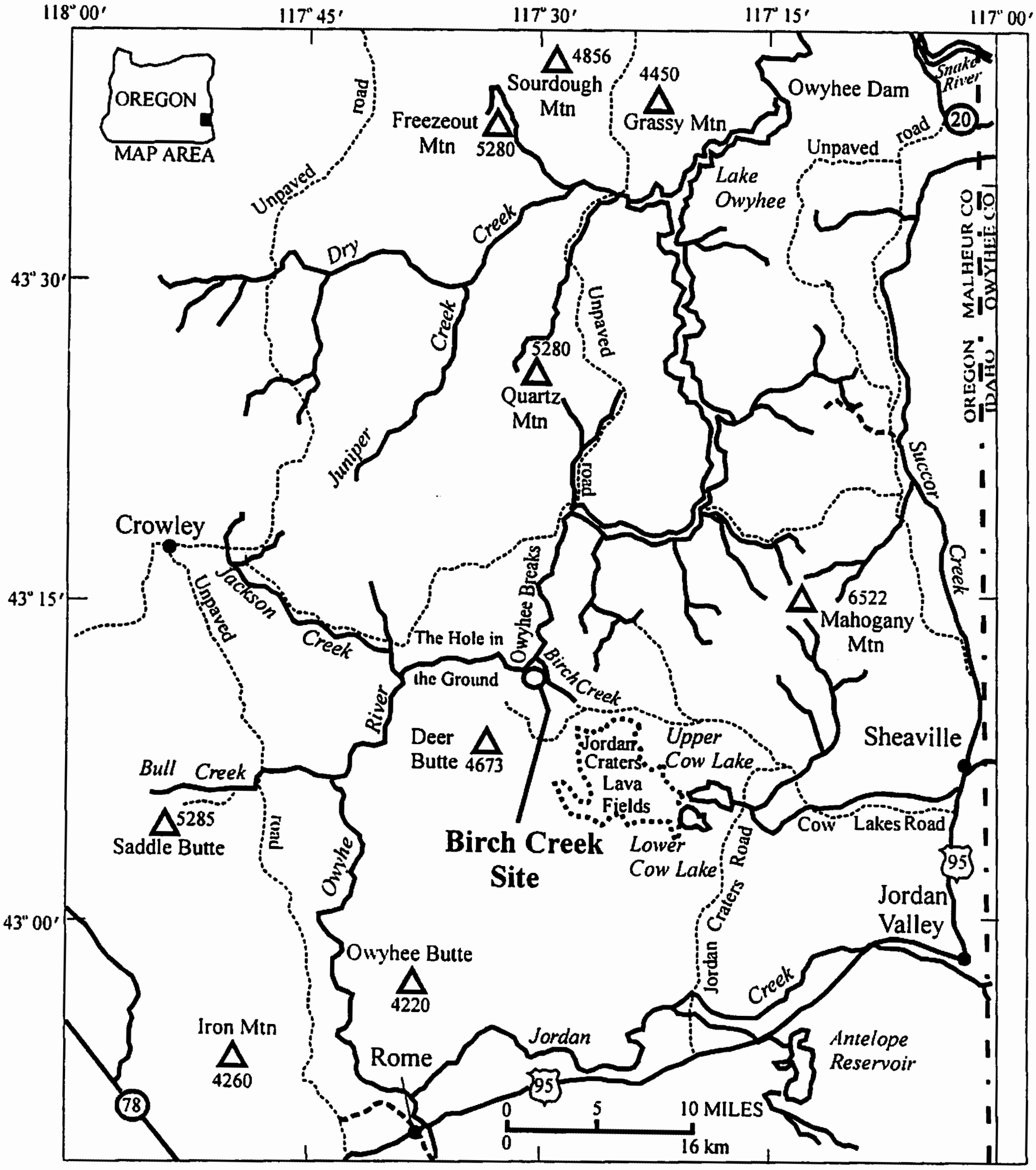

Figure 1.1 Location Map of the Birch Creek Site (Adapted from Vander Muelen et al. 1990).

Excavation conducted in 1998 and 1999 by students and staff of Washington State University revealed a stratified pithouse feature containing three intact living surfaces above a primary deposition of Mazama tephra. This stratified pithouse was labeled Housepit 1 of Feature 2. I analyze the chipped-stone artifacts from this occupation sequence.

Environment

Bureau of Land Management reports describe The Owyhee Uplands Plateau (USDI 1992:20; 1999). It is a desert environment through which the Owyhee River incises a canyon from 150 m to 330 m deep through basaltic and rhyolitic rock. Annual rainfall in the Owyhee basin ranges from 17 cm to 86 cm with no long-term trends. Annual temperatures often vary from +100° to –30° Fahrenheit (55° to –11° C).

Climate

Grayson (1993) and Mehringer (1986; 1996) furnish curent summaries and bibliographies of environment studies within the northern Great Basin. Mehringer (1985:185) describes a fossil pollen record often generalized into three trends, but cautions that doing so masks indications of "short, sharp climatic episodes." Following this simplified overview, an apparent warming trend replaces a period of greater effective moisture in place prior to 8000 B.P. This is evidenced by sediment cores taken from Fish Lake and Wildhorse Lake (located in a sagebrush and alpine steppe on the Steens Mountains of southeastern Oregon). From 7000 to 4000 B.P., lakes shrink in size and expanding shadscale and sagebrush communities invade forests and grasslands. This trend of prolonged but variable higher temperatures and reduced snow pack slows to an end from approximately 5400 B.P. to 4000 B.P. (Mehringer 1996:33). More effective moisture is available to the interior Northwest after this time.

Although enough precipitation occasionally transformed dry basins, this was more commonly seen between 4000 and 2000 B.P. than from 7000 to 5000 B.P. (Mehringer and Cannon 1990: 321; Mehringer and Wigand 1986). Analysis of plant remains from woodrat middens from Diamond Craters suggests that sagebrush steppe and juniper woodland increase under cooler, more mesic conditions after 5000 B.P. (Mehringer 1985:180-181). Wigand (1987:427) also notes the expansion of sagebrush into the shadscale desert surrounding Diamond Pond from approximately 5400 B.P to 4000 B.P. This marks the onset of more effective moisture and expansion of juniper grasslands begins after 4000 B.P. to 2000 B.P. This corresponds with deep late Holocene ponds (Mehringer 1986) and perhaps intensive human occupation of northern Great Basin marsh and lake locations (Wigand 1987). Benson et al. (1991:189) also note changes from shallow and desiccated ponds in Walker Lake (northeastern California and west central Nevada) to relatively high lake levels between 4800 B.P. and 2700 B.P.

Feature 2 of the Birch Creek Site contains minimally three periods of occupation bracketed between 4400 B.P. and 2400 B.P. A trend of more effective moisture than before approximately 5000 B.P. may influence house pit floors construction along the Owyhee River during this time. However, given that general climatic trends include sharp oscillations (Mehringer 1985), periodic drought could also attract prehistoric folks to live on the river. Members of the 1999 Washington State University field school observed modern woodrat middens within two km of the Morrison Ranch during an archaeological survey. Intensive survey for older specimens has not been conducted in the site environs. Combined with an examination of pollen extracted from sediment cores from the nearest condusive source (Cow Lakes is approximately 20 km southeast of the site), analysis of ancient local woodrat middens may determine if general climatic patterns apply to this area.

Biota

The present-day Owyhee Upland ecosystem lies within the Intermountain Sagebrush Province/Sagebrush steppe Ecosystem (USDI 1992:16). Generally, plateau tops and upper slopes are covered with sagebrush (Artemisia tridentata wyomingensis), rye grass (Elymus condensatus), bluebunch wheatgrass (Agropyron spicatum), and bitterbrush (Purshia tridentata). Juniper (Juniperus utahensis) flourishes in niches where water is more readily available. Grasses, rushes, and sedges comprise most riparian vegetation. Sagebrush and the modern invasive cheatgrass (Bromus tectorum) presently dominate the canyon (Pullen 1976:8).

The Owyhee River once supported runs of anadromous fish. Plew (1986) describes remains from Nahas Cave, which is located on a secondary tributary of the Owyhee River in southwestern Idaho. They included salmon (possibly chinook salmon Oncorhynchus tschawytscha) and steelhead (Oncorhynchus mykiss) bones excavated from deposits dating from approximately 5000 B.P. into the late prehistoric. Other native fish species include chiselmouth (Acrochelius alutaceus), squawfish (Ptychocheilus oregonensis), suckers (Catostomidea), and possible sculpins (Cottidae). Crayfish (Cambarus astacus) and freshwater mussels (Margaritifera fakata) are also common along stretches of this river (USDI 1984; 1992; Hanes 1988:3).

Regional Geology

The best material for knapping is that which can be "cracked in a reliable and predictable manner; such stones are brittle, homogeneous, and isotropic" (Andrefsky 1998:23). Hamblin and Howard (1971) outline properties of physical geology and the genesis of useful tool stone. Luedtke (1992) provides information on the genesis of chert. Pettijohn (1975) discusses the nature and formation of sedimentary rocks.

Patrick Plumley's (1986) geologic study has been supplemented by more recent geologic and mineral resource survey of the Owyhee Breaks area (Vander Meulen et al. 1990). Cummins et al. (2000) discuss regional distribution of lithic material. Lyons et al. (2001) also provides a description of relevant geologic features and identify chemical source and artifacts through ultraviolet fluorescence and trace-elements.

The Birch Creek Site is located within the Owyhee Plateau, which extends over southeastern Oregon, southwestern Idaho, and northern Nevada. The Owyhee Plateau includes the Oregon-Idaho graben (a depressed segment of the earth's crust bounded minimally on two sides by faults), which is part of a rift system that "extends 1,100 km from southern Nevada to southeastern Washington" (Cummings et al. 2000: 669). Figure 1.2 depicts the graben and nearby fault zones, along with major geological features surrounding the Birch Creek Site. Sediment from this graben is largely fluvial and contains intrabasinal obsidian and rhyolite clasts. Corcoran et al. (1962), Kittleman (1973), and Kittleman et al. (1965, 1967) describe major geological localities containing knappable materials within (and nearby) this formation.

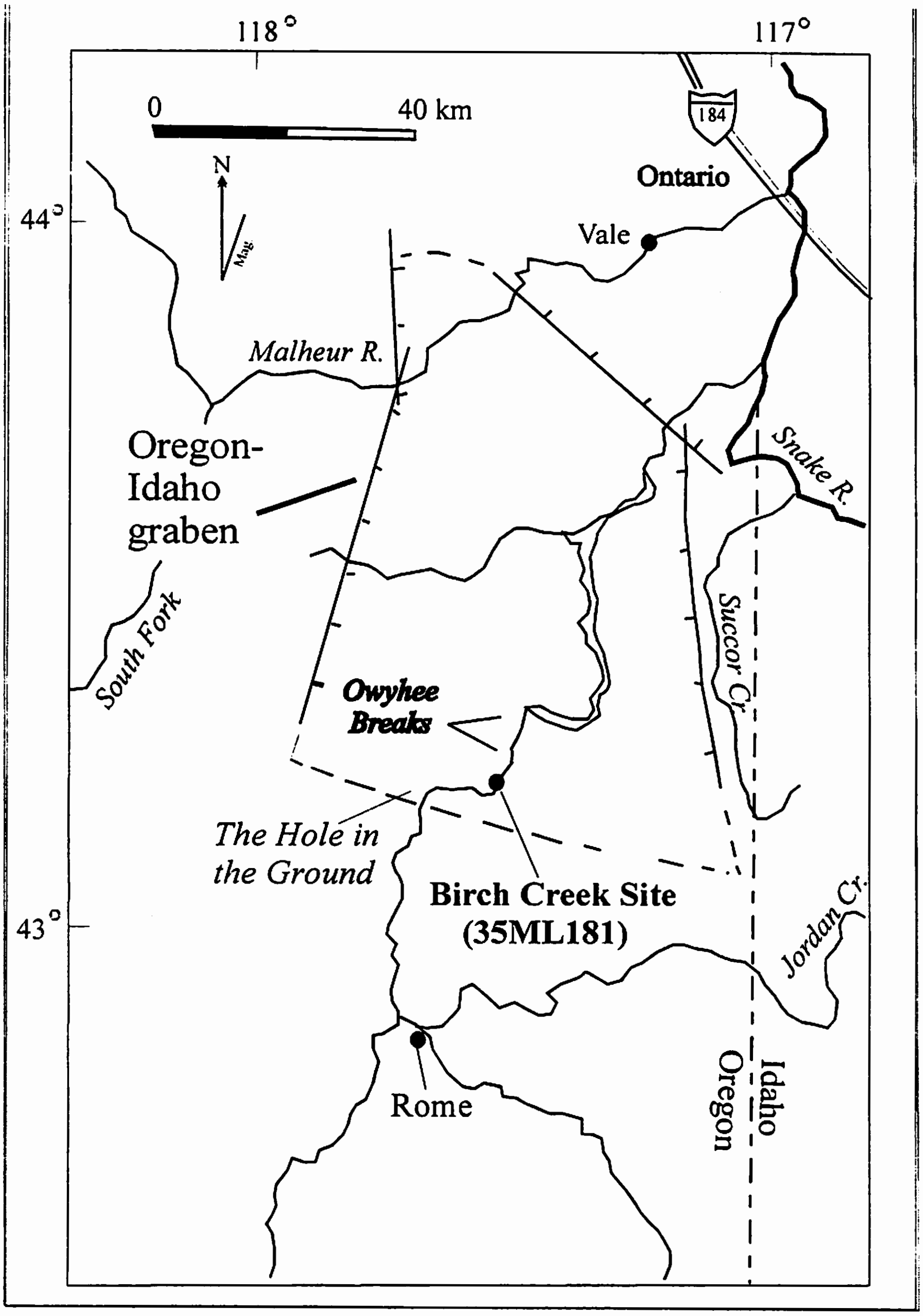

Figure 1.2 Location of Major Geological Features near the Birch Creek Site (Adapted from Lyons et al. 2001).

Local silicified sediments and precipitates suitable for knapping come in a great variety and quantity (Plumley 1986). One source for such material is The Hole in the Ground. Mechanical and chemical weathering sluice away less resistant material, leaving behind hard chert nodules that make their way downstream to the Owyhee River. Excavators of the Birch Creek Site have observed nodules in the streambed and shoreline adjacent to the site. I forded the Owyhee River to search a gravel bar approximately 180 m upstream from the Morrison Ranch and approximately two km downstream from 35ML181. I filled a backpack with knappable material in less than one hour. The Birch Creek Site locates immediately upstream of exposures along the Owyhee Breaks, another geologic feature (Plumley 1986) and potential source for chert.

Nearest identified sources of knappable-sized obsidian lie within 30 km to 35 km northwest of the Birch Creek Site (Craig Skinner, personal communication; William Lyons, personal communication). If obsidian enters upstream from the site, it is pulverized too quickly to be useful.

Previous Research

The first published archaeological investigations of the Owyhee Uplands come from two 1929 excavations along the Snake River in southwestern and South-central Idaho. These include Louis Schelback's excavation of Cave #1 (Schelback 1967) and Charlton Laird's work at Pence-Duering Cave (Gruhn 1961b). Luther Cressman (1937) noted the presence of archaeological sites near the Owyhee River. He describes rock art found adjacent to the shoreline of the Owyhee River at The Hole in the Ground. This geologic feature is roughly eight km west of site 35ML181 (Figure 1.2). Loring and Loring (1983:284-285) also visited The Hole in the Ground location and reported a site with numerous petroglyphs etched on 24 scattered boulders. To my knowledge, no excavation has been conducted at this feature.

Reg Pullin (1976) conducted perhaps the most systematic survey of riverine locales along the Owyhee. His listing presents the initial description of the Birch Creek Site. Other local surveys include Greenspan and Baxter (1980), Hauck (1978), Marti (1981), and Walton (1986a, 1986b).

Few investigations include stratigraphic associations to form local chronological sequences. Excavations at Dirty Shame Rockshelter (Aikens et al. 1977) and Nahas Cave (Plew 1986) are two important exceptions. Dirty Shame Rockshelter (DSR) is located approximately 62 km south of the Birch Creek Site (Figure 1.3) along Antelope Creek (a tributary of the Owyhee River) in an area known as the Three Forks (named for the juncture of the North Fork, Middle Fork, and main stem of the Owyhee River). Nahas Cave is eighty km southwest of the Birch Creek Site. These stratified deposits hold artifact assemblages of stone, bone, and fiber.

Hanes (1988:142) notes a wide range of lithic reduction activities at DSR, probably associated with biface reduction. As a campsite of repeated occupation, it also portrays a simple, utilitarian flake tool industry. Dirty Shame Rockshelter is also of particular interest because it is the closest stratified site to the Birch Creek Site and contains perishable materials absent at the latter location (Adovasio et al. 1977; Andrews et al. 1986).

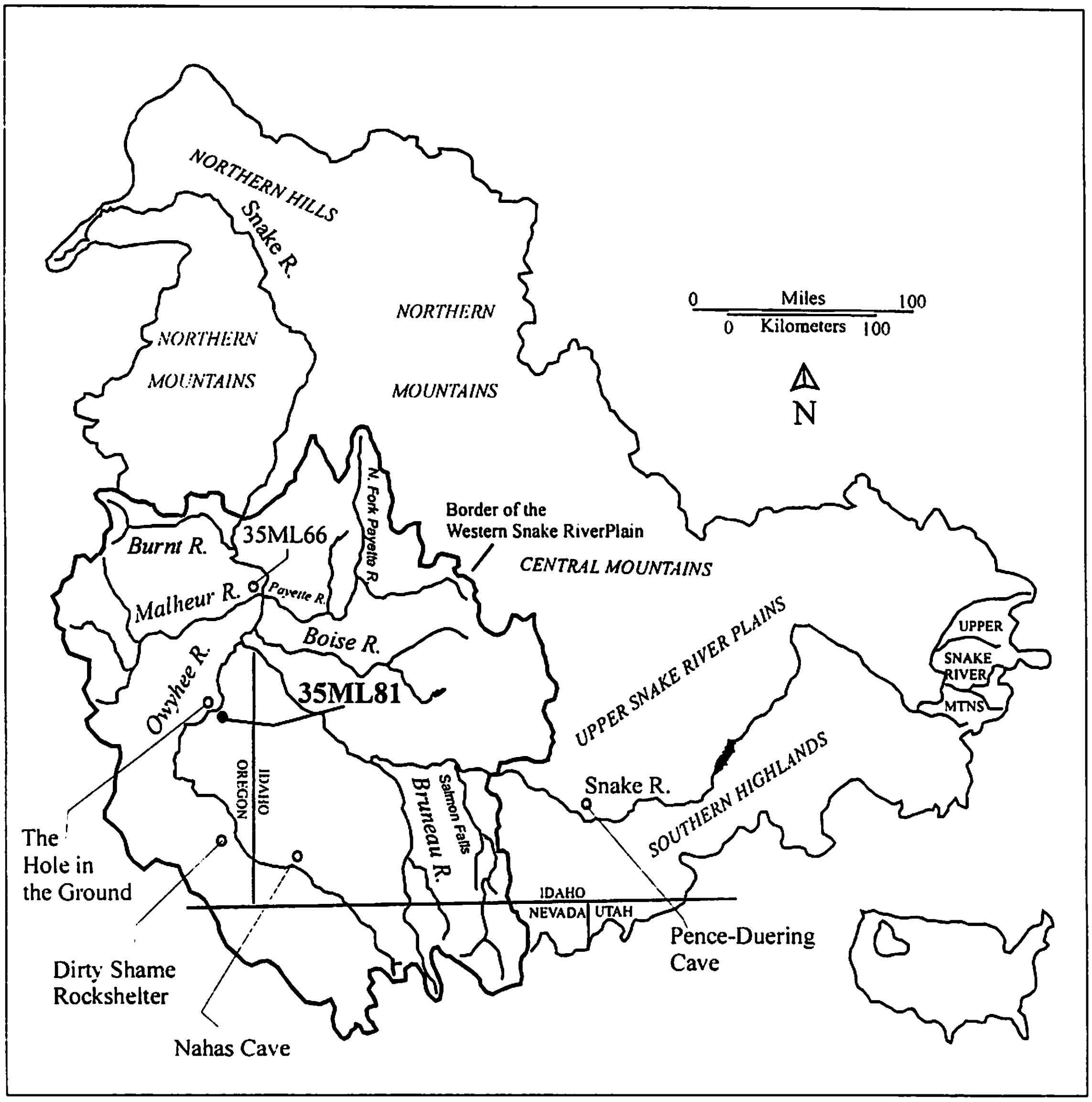

Figure 1.3 Regional Map with Selected Archaeological Sites (Adapted from Reid 1991).

The 1972 investigation of 35ML66 (no site name) at the Moore Ranch is located just west of the fork of the Malheur River and Snake River, approximately 100 km north of the Birch Creek Site. This excavation revealed a single-component, open campsite. Most of the 37 recovered projectiles belong to the Elko series (McNeil 1978) and these identify the site with the Early Archaic (11,000 B.P. (before present) to 7000 B.P.) based on projectile point chronology.

Elko points are widely recognized in the Great Basin and were recovered from the Birch Creek Site. Wilde (1985:191) observed Elko series points associated with hearth remains dated to 3425 B.P. from Honcho Cave in the Alvord Valley. A pre-Mazama component of Localilty 1 at Skull Creek Dunes yielded Windust, Elko, and Humboldt projectiles (Wilde 1985:263). Bettinger and Eerkens' (1999:231-233) comment on difficulties in separating Elko and Rosegate points apart after 1350 B.P. within California and Nevada assemblages, which suggests that the utility of these long- lived projectile as a chronological marker might limit to inferring maximum ages for undated components.

Wegener (1998:77) summarizes change in biface technology between Middle and Late Achaic components and provides evidence for bow-and-arrow technology at Skull Creek Dunes in the Catlow Valley (located west of the Steens Mountains in southeastern Oregon). His analysis concluded that smaller debitage marked tool maintenance after introduction of the arrow to the area. Rose Spring arrow points date approximately to 1800 B.P. in the Steens Mountain region and have been recovered from House Feature 6 of Dirty Shame Rockshelter as early as 2545 B.P.

Other than excavation of the Birch Creek Site, the most contemporary regional archaeological investigations are surface surveys. Daniel Meatte (1990) surveyed the Western Snake River Basin and Charles Luttrell (2000) surveyed cultural resources around the Lake Owyhee Reservoir. Andrefsky and Presler (2000) recently reviewed the regional archaeological literature.

Regional Prehistory

Prehistory of the Owyhee Uplands fits into a mold to conform to assumptions about northern Great Basin cultural notions. This is probably to the detriment of understanding a more complex history because the mix of Columbia Plateau, Great Basin, and Plains culture traits is not clearly understood. Steward (1938) and Lohse and Sprague (1998:11) both comment on the subjectivity in defining this "transitional" region. Pithouses and reliance on anadromous fish associate with a Plateau lifestyle, but are found within adjacent regions (Green 1982; Schelback 1967). Leonhardy and Rice (1970) developed a chronological sequence for the southern Plateau, but it doesn't acknowledge the presence of Great Basin affiliated features like projectile styles and wickiups.

Rather than choose a single chronology, I present three approaches that represent cultural sequences of closest proximity to the Birch Creek Site (Table 1.1). These include the Upper Humboldt Valley (Elston and Katzer 1990) and Southern Plateau (Leonhardy and Rice 1978) systems, as well as a synthesis of Great Basin projectile point typologies. The basis for chronologically identifying projectiles includes work by Heizer and others (Heizer and Baumhoff 1961; Heizer and Clewlow 1968; Hezier and Hester 1978), Holmer (1986), and Thomas' (1970) quantitative approach.

Fagan (1995) and Jennings (1986:115) have both constructed models centered on a Pre-Archaic/Archaic sequence linked to regional projectile point series. Upland prehistory may begin approximately 11,000 B.P. through 8000 B.P but evidence of occupation during this time is not found in the Owyhee Uplands itself. According to

Table 1.1 Owyhee Upland Chronology.

	Upper Humboldt Valley (Elston and Katzer)		Southern Plateau (Leonhardy and Rice)			Great Basin Projectiles (Heizer & Hester; Holmer)	
Dates (B.P.)	Diagnostic Artifacts	Component	Diagnostic Artifacts	Period	Phase	Diagnostic Artifacts	Phase
							Historic
50			European	Ethno-	Numipu	European	Northern
81	Shoshoni	Eagle Rock	Trade Goods	graphic		Trade Goods	Paiute &
250	Pottery						Shoshone
			Small		Piqunin	Desert	Late
350			Corner-Notch			Side-Notch	Archaic
			& Side-Notch			Cottonwood	"Numic"
550			Points	Snake River		Points	
600	Rosegate	Maggie			Harder		
1,000	Points	Creek	Snake-River				
1,250	Elko, Pinto,	James	Corner-Notch			Rose Spring	Late-
	Gypsum &	Creek	Points			Eastgate	Middle
	Humboldt					Points	Archaic
2,000	Points						
2,800	Pinto	South Fork					
3,000	Humboldt		"Crude"		Tucannon	Elko	Middle
	& Gatecliff		Snake-River	Initial Snake River		Gatecliff	Archaic
4,000	Points		Corner-Notch			Humboldt	
4,050	Northern	No Name	Points			Points	
	Side-Notch						
5,000	& Elko					Northern	Early
	Points					Side-Notch	Archaic
6,000			Cold-Springs		Cascade	Points	
			Side Notch		(late)		
	Mazama	*Tephra*	*(c.a. 6850 B.P.)*				
7,000	?	?	Cascade		Cascade	Stemmed	Initial
			Points	Pioneer	(early)	&	Archaic
8,000	Stemmed	Dry Gulch				Haskett	
	Points					Points	
9,000	Great Basin		Windust		Windust		
			Points				
10,000						Crescents	
						Fluted	Paleo-
11,000						Points	Indian

Adapted from Elston and Katzer (1990); Hezier and Hester (1978); Holmer (1986); Leonhardy and Rice (1978).

Hanes (1988:6), the Great Basin Archaic in southeastern Oregon probably relates to a fading bison population and was well established between 8000 B.P. and 7000 B.P.

Major models of prehistoric human occupation in the northern Great Basin include Jenning's (1957) Desert Culture and Bedwell's (1970) Western Pluvial Lakes Tradition. Based on excavations at Danger Cave, Jennings predicts a material culture based on portability and a subsistence model "wherever life is hard, and full exploitation of the environment is required for survival" (Jennings 1957:284). Bedwell (1970) suggests a mostly uniform adaptation to a lacustrine environment. His model implies intensified use of marsh resources based on associations between artifacts and the shorelines of pluvial lakes in early prehistory.

The appearance of pithouses along the Snake River and its major tributaries approximately 6000 B.P. marks the Initial Snake River Period (Green 1982; Leonhardy and Rice 1978) within the Southern Plateau. Pithouse villages along the Snake River and its major tributaries suggest a difference in mobility by 4500 B.P. and help identify the later Southern Snake River Period. By 1500 B.P., frequencies of Elko points decline as compared to smaller Rosespring and Eastgate projectiles. This may indicate the increased influence of bow-and-arrow technology. Along with pithouse villages, bone splinter awls and polished, incised bone tubes at upland sites now resemble Plateau assemblages (Plew 1986).

The "Numic" expansion of Shoshone and Northern Pauite into the northern Great Basin may have occurred between 1000 B.P. and 800 B.P. Linguistic evidence demonstrates that during this time the Pauite expanded from a homeland in the southwestern desert, but there is debate on almost everything about the Numa (Madsen and Rhode 1994). Shoshone style pottery and Great Basin basketry mark the Expansion Phase (Andrews 1986; Gruhn 1961a). Dwellings that continue along the Snake River and its tributaries include pit houses as well as pole-and-thatch wikiups (Aikens et al. 1977).

The local chronological sequence surrounding the Birch Creek Site begins with the Early Archaic Period and ends with the Ethnographic Period. Excluding the Windust Phase/Paleoindian Period, all of these chronological units are represented in the stratified excavations at Nahas Cave and Dirty Shame Rockshelter.

Ethnographic and Historic Periods

Pullen's (1976:6) ethnographic summary notes that The *Tagu'* Tika band of Shoshone may have occupied the middle Owyhee River canyon and basins near Jordan Creek. The name comes from the people's reliance upon bulbs found along streams and meadows. Paiute bands also found in the Owyhee region settled near the Owyhee and Malheur rivers (Stewart 1938, 1939). Northern Pauite and Shoshone populations shared loosely defined territories (Fowler and Lijeblad 1986:436; Stewart 1941), which probably accounts for similar names subscribed to different bands. Julian Steward's (1938) ethnography offers perhaps the most formalized representation of group identity and territorial boundaries.

Ethnographic descriptions include house structure designs. The Shoshone constructed conical pole shelters covered with grass or brush. They built and recycled pit structures along major watercourses, but no evidence remains for semi-subterranean lodges (Lowie 1909:184; Steward 1943). Northern Paiute sheltered in small wickiups that consisted of grass, reeds, or brush matting attached to a pole frame. These round floor remnants (Steward 1941) would be modest compared to the deposits uncovered at the Birch Creek Site.

Historic Period

The historic period of the Owyhee River is often violent and filled with adventure. Reg Pullen (1976:5) and Charles Luttrell (2000) provide brief descriptions, but Mike Hanley's (1973) *Owyhee Trails* reveals a much grander story. Earliest known non-indigenous explorations by fur traders (ca. 1809?) leads to further territorial penetration (ca. 1825) by geographic surveyors and missionaries (Luttrell 2000:2.8). Waves of miners and farmers followed suit by 1842. Conflicts with Native Americans grew in frequency and scale as traffic on the Oregon Trail increased. This resulted in wars that led to native "resettlement" on reservations before the close of the century.

Farmers and ranchers along the middle portion of the Owyhee River grew in numbers large enough to open a post office by 1898 (Landis 1969:80). Located near the south end of the present day Owyhee Reservoir, the "Watson" post office became a small but important town of 37 residents by 1911. Subsequent agricultural development led to development of the Owyhee Dam. This required endangered settlers to relocate and the Watson post office closed in 1936 (Luttrell 2000:2.8).

The Birch Creek Ranch (Morrison Ranch) within two river miles of the Birch Creek Site remains the closest of three historic ranches (the other two are The Hole in the Ground and Pinnacle ranches) still standing in the site area. I include one further point of general interest, taken from Reg Pullen (1976:5)

"Peter Skene Ogden, who led a contingent of Hudson Bay trappers into the region in 1819, named the Owyhee River. Two Hawaiians were sent to trap on a tributary of the Snake where Ogden was camped. They were killed by Indians, so Ogden named the tributary for them. The Hawaii River has since been corrupted into the Owyhee River."

SITE DESCRIPTION

A surface scatter of artifacts continues approximately 60 m upland from the Owyhee River's edge and 200 m along the shoreline. A 70-m long backhoe trench supplemented block excavation of 45 m^2 test units during the 1998 summer field season (Figure 1.4; note that the original site datum North-South 0, East-West 0 was converted to North 1000, East 1000). The backhoe trench excavated a 2-m path in an east-to-west direction from the river beach and revealed two separate prehistoric pithouses. A second excavation block surrounded the housepit feature nearest the river and was labeled Housepit 1 of Feature 2 (Figure 1.5).

The 1999 field season continued excavation of Feature 2. This work included fifteen adjacent 1x1 meter squares (N24W1 through N24W15) opened five m north of the 1998 backhoe trench. A perpendicular hand-dug trench (N19W6 through N23W6) connected these two trenches to stratigraphically define the top portion of the pithouse sequence and orient further excavation.

Andrefsky and Presler's (2000) preliminary site report includes an artifact analysis. Excavation reveals a total of 219,687 items from 35ML181. Chipped stone

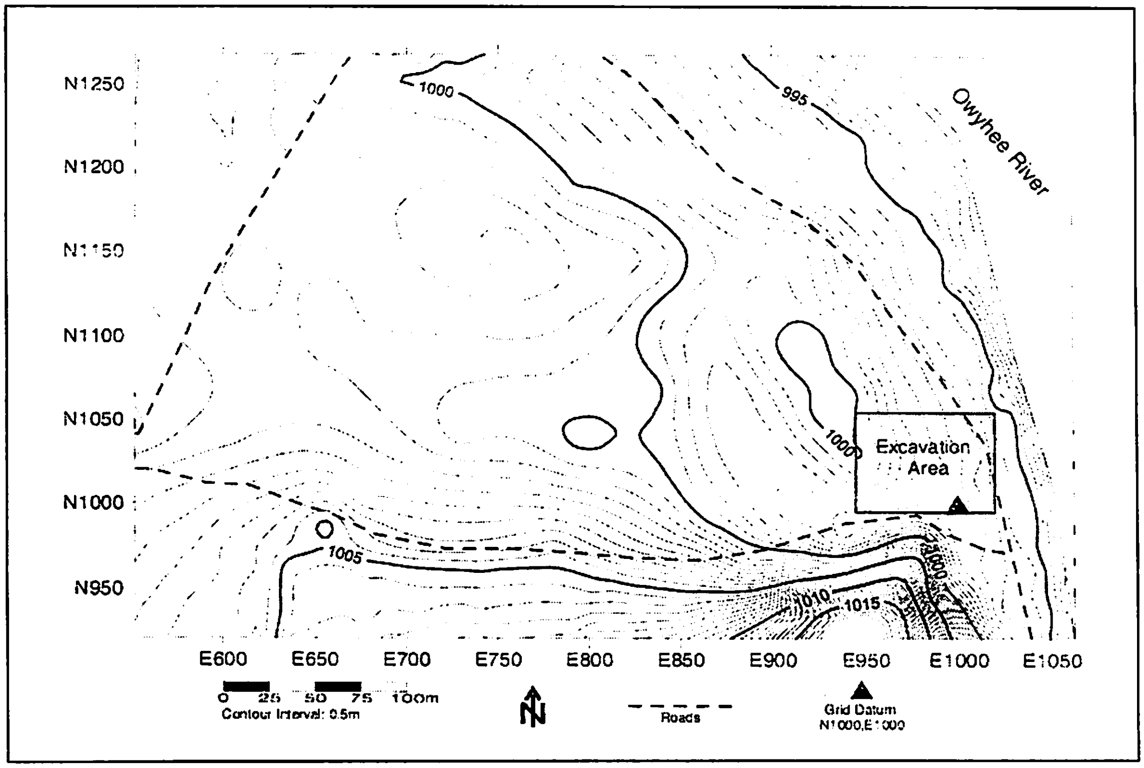

Figure 1.4 Topographic Map of the Birch Creek Site Excavation Area.

artifacts accounts for most of the material (99%), which is mainly in the form of debitage (98%). Most of these specimens are chert (84%), but obsidian (16%) is also represented. Specimen recovery also includes faunal remains (bone and shell) and charcoal (Andrefsky and Presler 2000:51). Table 1.2 lists major specimen and tool categories.

Feature 2 Site Stratigraphy and Radiocarbon Dates

The Birch Creek Site sets on a sequence of three alluvial terraces. The two house pit features on the second terrace overlie a primary layer of Mazama tephra (Walker 2001). Mazama tephra dates to 6850 ^{14}C B.P. Feature 2 on the intermediate terrace

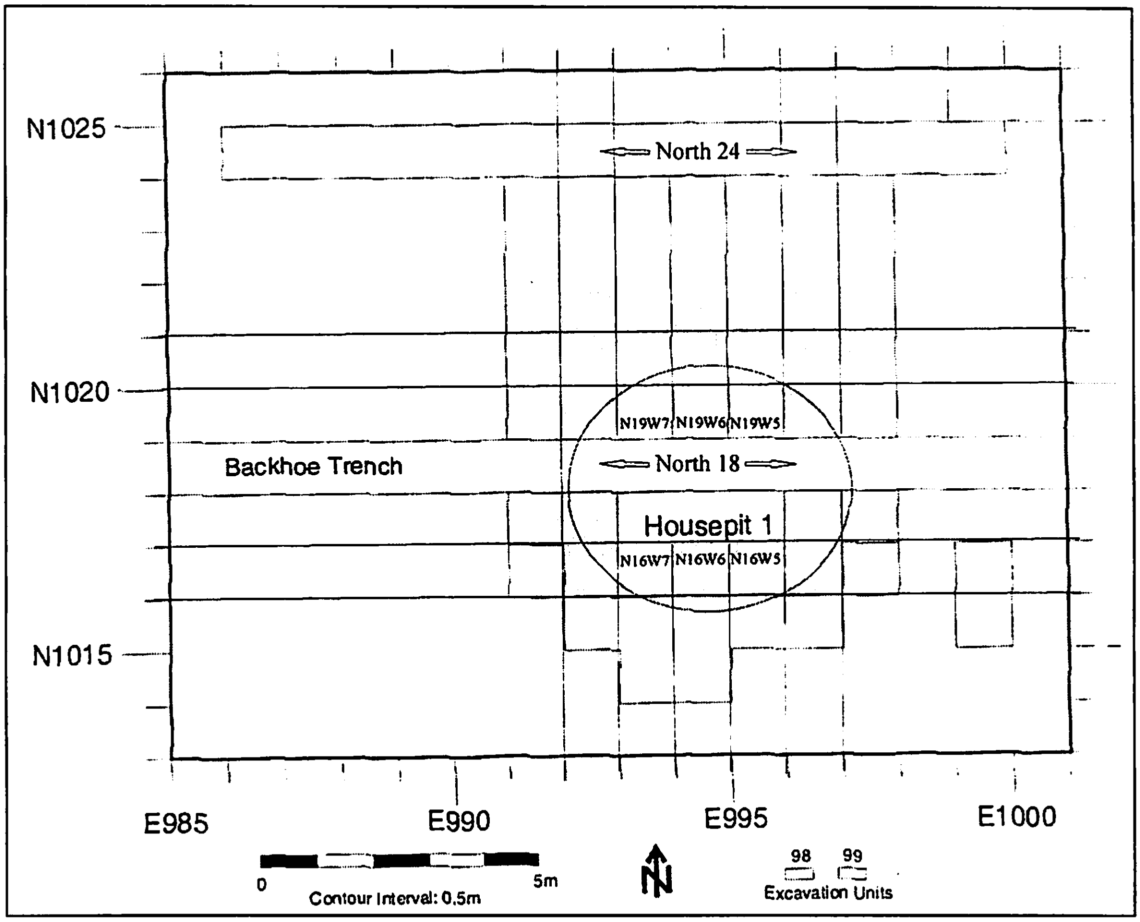

Figure 1.5 Map of Feature 2 Pithouse Excavation Units (Adapted From Andrefsky and Presler 2000).

(Terrace 2) consists of four living surfaces interleaved with four fills. I interpret fills as trash dumping, structure collapse, and sediment deposition born by wind and water. I designate these cultural strata as contacts A (youngest) through D (oldest) and fills A through D (in the same chronological order). Profiles drawn of the housepit stratigraphy were taken from the north and south walls of the 1998 backhoe trench. Figure 1.6 represents the south wall profile and illustrates the sequence of housepit floor and fill episodes.

Table 1.2 Total Artifact Frequency Percentages (Adapted from Andrefsky and Presler 2000).

Artifact Type	Count	% of Total	Proportion (%)
Points	101	0.03	0.06
Point Tips	67	0.02	0.04
Drills	19	0.00	0.01
Bifaces and Preforms	254	0.07	0.16
Scrapers	33	0.01	0.02
Cores	277	0.07	0.18
Cobble Cores	37	0.01	0.02
Retouched Flakes	773	0.20	0.49
Retouched Cobble Spalls	13	0.00	0.01
Total Chipped Stone Tools	1,574	0.41	1.00
Pestle	5	0.00	0.03
Mortar	13	0.00	0.09
Hammerstone	27	0.01	0.19
Other Groundstone	100	0.03	0.69
Total Groundstone	145	0.04	1.00
Historic Metal	14	0.00	0.54
Other Historic Material	12	0.00	0.46
Total Historic Material	26	0.01	1.00
Shell Ornament	1	0.00	0.01
Shell Fragments	795	0.21	0.99
Total Shell	796	0.21	1.00
Bone Awl/Needle	11	0.00	0.01
Bone Bead	11	0.00	0.01
Fish Remains	179	0.05	0.14
Mammal Remains	800	0.21	0.63
Other Bones	276	0.07	0.22
Total Bones	1,277	0.33	1.00
Total	3,818	1.00	

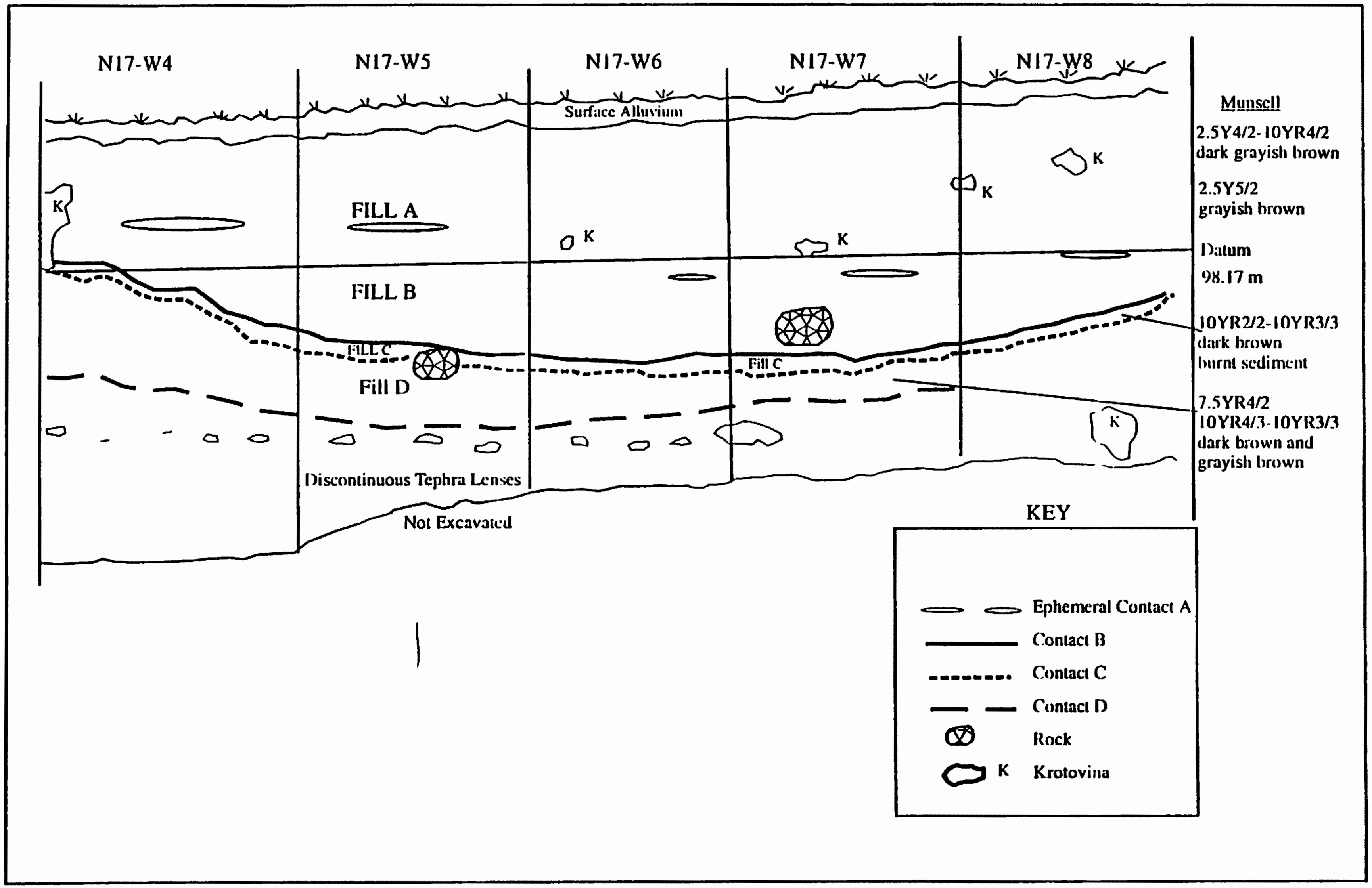

Figure 1.6 Backhoe trench south wall profile (adapted from Andresky and Presler 2000).

Radiocarbon Dates

Beta Analytic Incorporated analyzed five radiocarbon specimens selected from Feature 2 (Figure 1.7). Table 1.3 displays the sampled cultural strata and associated age determinations. Recovered from the bottom contact (Contact D), the oldest sample dates to 4480 ± 70 B.P. Funding limitations constrained radio carbon dating to five strategically chosen samples, which left the cultural strata between Contact D and Contact B undated. Plans are to date these episodes after further excavation of these levels. Two carbonized wood fragments recovered from the top surface of Contact B returned comparable ages (2420 ± 70 B.P and 2410 ± 60 B.P.). A sample collected *en masse* from directly below the bottom of Contact B came from the north half of the Feature 2 excavation. This specimen dated to 2760 ± 110 B.P.

Age of the stratigraphically "youngest" charcoal sample suggests possible mixing. Recovered from the bottom of Contact A near the south perimeter of the feature, it gave a date of 2620 ± 40 B.P. I calibrated all dates using the University of Washington Calib© program (ver. 4.3) and discuss the results' influence on my research design in Chapter 2.

Contact D is the oldest occupational surface reached by excavation to date. Artifacts deep in the backhoe trench wall show an intact component below this contact, which may represent activity in the region before the use of pithouse structures. I saw artifacts in the wall below Mazama tephra. Thus, occupation of this river bar predates the Mazama eruption of 6850 ^{14}C B.P.

Evidence for house pits on the Columbia Plateau does not date confidently to earlier than 5,500 years ago (Lohse and Sammons-Lohse 1986). However, Alpowa,

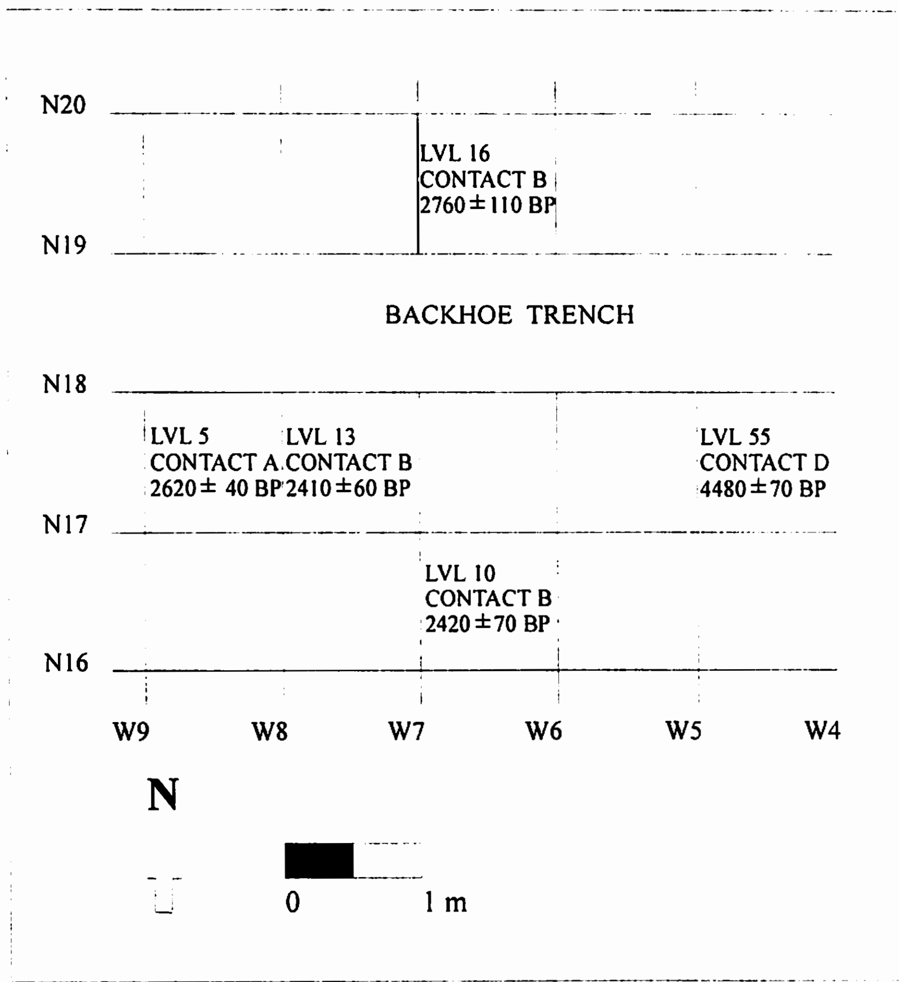

Figure 1.7 Planview of Excavation Units Showing the Location of Radiocarbon Dates.

Hatiuhpuh, and Hatwai sites all possess pithouses with radiocarbon dates potentially ranging from 6400 B.P. to 3800 B.P. (Ames et al. 1998). Pithouse may also appear before this time in the Great Basin (Aikens 1993).

The Birch Creek site may lack settlement in recent historic periods. Prehistoric pottery and small projectile points have yet to be recovered. Small points are often associated with the bow and arrow toolkit. This technology may arrive to the Columbia Plateau and northern Great Basin by 2,500 years ago (Andrefsky and Presler 2000).

Despite ensuing popularity, the archaeological record of Birch Creek Site does not include evidence for this innovation.

Table 1.3 Radiocarbon Dates From Feature 2 of the Birch Creek Site.

Beta Analytic Specimen #	Unit	Lvl	Stratum	Measured Radiocarbon Age
Beta-145557	N17-W8	5	Above Contact A	2620 ± 40 B.P
Beta-130363	N17-W7	13	Above Contact B	2430 ± 60 B.P.
Beta-130362	N16-W6	10	Above Contact B	2460 ± 70 B.P.
Beta-144771	N19-W6	16	Below Contact B	2760 ± 110 B.P.
Beta-142362	N17-W4	55	Above Contact D	4480 ± 70 B.P.

CHAPTER 2

RESEARCH DESIGN

This paper initiates investigation of mobility and raw material economy as it relates to pithouse occupation along the middle Owyhee River region during the end of the Middle Archaic and early Late Archaic. Chemical trace-element signatures from obsidian artifacts in discreet chronological units allow for a tentative measure of group travel patterns. Morphological differences among specimens from identified sources provide evidence for raw material selection and its physical state when arriving at the Birch Creek Site.

After establishing variation in raw material economy, this study examines the extent to which treatment of local and non-local lithic resources differ from one another. I explore the connection between tools and raw material types. Since tools represent only a small fraction of the behaviors associated with lithic technology, I also look for corroboration within the debitage population.

SAMPLING FROM FEATURE 2

The Feature 2 pithouse is an appropriate choice to sample from because it is a stratified and dated sequence. Sandy sediments make distinction between some fill episodes and contacts unclear. Thus, I reject ambiguous or mixed unit levels. Table 2.1 defines my data set and Table 2.2 displays the total number of excavation levels that comprise each cultural stratum and its percentage of the sample's excavation volume.

Table 2.1 Excavation Units and Levels Comprising Sample from Feature 2.

			Cultural Stratum			
UNIT	Fill AB	Contact B	Fill C	Contact C	Fill D	Contact D
N16-W5	Lv. 4-10	Lv. 11-12	//	//	//	//
N16-W6	Lv. 4-10	Lv. 11	//	//	//	//
N16-W7	Lv. 5-9	Lv. 10-11	//	//	//	//
N16-W8	Lv. 4-8	X	//	//	//	//
N17-W4	Lv. 5-12	Lv. 13	NA	NA	Lv. 50-52	Lv. 53
N17-W5	Lv. 4-7 Lv. 4B-7B Lv. 8-11	Lv. 12-13	NA	Lv. 21-22	Lv. 23-26	//
N17-W6	Lv. 4-8 Lv. 8B, 9-11	Lv. 12-13, 28	NA	NA	Lv. 38-39	//
N17-W7	Lv. 4-8 Lv. 8B-9B	Lv. 10-14, 29	Lv. 30-36	Lv. 37-42	Lv. 43-51	X
N17-W8	Lv. 4-5, 7-9	Lv. 10-11	Lv. 29-34	//	//	//
N19-W5	Lv. 4-13	NA	Lv. 22	Lv. 23-25	Lv. 26-30	//
N19-W6	Lv. 6-10, 12-14	Lv. 15-19	Lv. 20-21	Lv. 22-23, 26	Lv. 24-25, 27-42	//
N19-W7	Lv. 5-14	Lv. 15, 16A, 17-18	Lv. 21-23	Lv. 24-25	//	//

X = Not Present, // = Not Excavated to Depth, NA = Association Unclear, Not Included in Sample.

Table 2.2 Excavation Amount Within the Feature 2 Sample.

	Excavation Levels	
	# of Levels	% Volume
Stratum	n	%
Fill AB	93	46
Contact B	28	13
Fill C	20	8
Contact C	16	8
Fill D	41	25
Contact D	1	0
Total	199	100

Note: Not All Levels Excavated to 5 cm Depth.

Results of Radiocarbon Calibration (Using Calib©)

The University of Washington Radiocarbon Calibration Program (hereafter Calib©) determines that samples Beta-130362 (Contact B) and Beta-130363 (Contact B) are from the same population ($\alpha = .05$). Calib© also determines that the combination of Beta-145557 (Contact A) and Beta-144771 (Contact B), as well as Beta-145557 and Beta-130362, are from the same population. However, these sets of dated samples cannot be combined altogether as one population with this same level of confidence (Figure 2.1). This indicates possible contamination from Contact B into the fill above it.

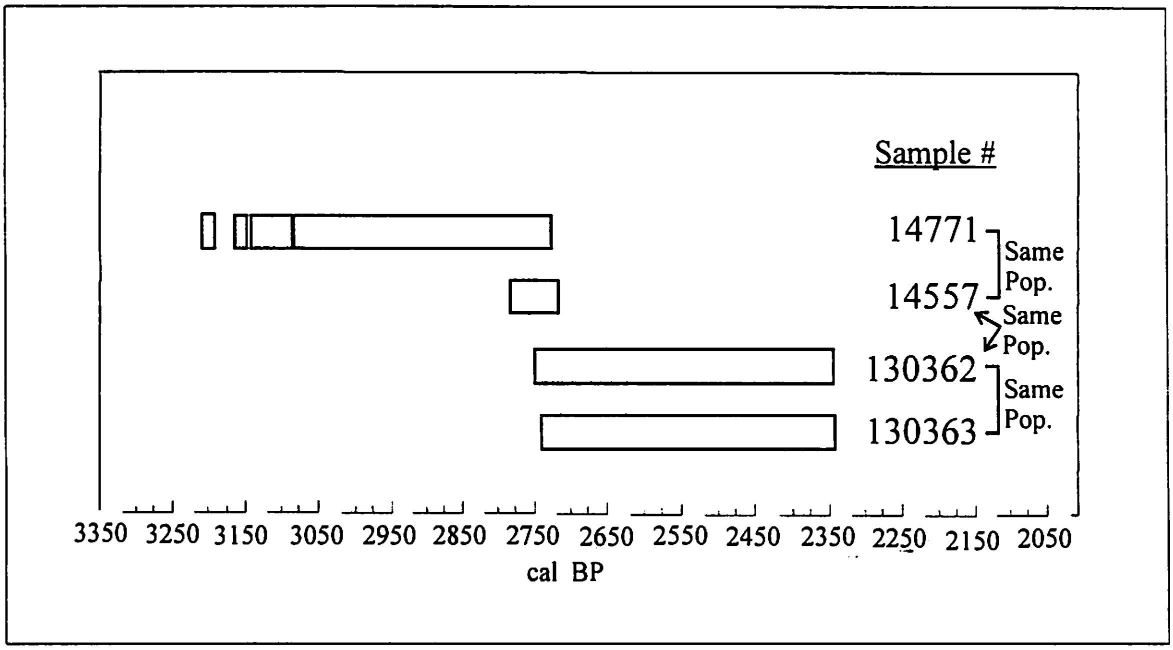

Figure 2.1 Results of Calibrating (Calib©) Radiocarbon Dates.

Five Identified Cultural Strata

I use the term *cultural stratum* (*strata)* when referring to individual contacts and fills without specifically naming them. Portions of the top strata in Feature 2 are likely the ephemeral remains of a living surface that was once occupied but mostly obliterated by repeated use of the site. I caution that one date from near the perimeter of Fill A probably does not represent the entire episode. Further radiocarbon testing throughout this fill sequence is required to develop a better understanding of this feature.

I compress Fill A and Contact A with Fill B into one cultural stratum (designated Fill AB). Because dates above and below Contact B are statistically different, I do not separate the younger strata chronologically. Calib© pools the age of Beta-130363 and Beta-130362 to 2443 B.P. The pooled age of Beta-145557 and Beta-144771 is 2637

B.P. I consider Fill AB and Contact B to represent one time range from approximately 2443 B.P. to 2637 B.P. (Figure 2.2).

The alternating sequence of contacts and fills below Fill AB are treated as distinct cultural episodes (Figure 2.3). These are labeled (from top to bottom) Contact B, Fill C, Contact C, and Fill D. Contact D was exposed but not excavated. As of yet, neither Contact C nor Fill C has been dated. All considered, the occupation of this portion of the site is within a period from approximately 7,000 years ago until about 2,400 years ago.

Classification of Raw Material

I recognize two general categories of raw material, chert and obsidian. *Chert* is defined as all silicified sedimentary stone or silicic chemical precipitates suitable for knapping into tools. I do not distinguish from among the various names given to chert-like stone, such as jasper or flint. Chert is considered as an immediately available, inexhaustible material and therefore artifact size and quantity is regulated by demand, not supply. Evidence to support this premise includes studies of local geology previously discussed and an analysis by Lyons et al. (2001) correlating chemical characterizations of chert artifacts sampled from 35ML181 and local river cobbles that I collected. I include silicified basalt in this category. A relatively high amount of S_iO_2 makes it difficult to consistently discriminate this material from dark-colored cherts common in the area.

Obsidian is the second major raw material type in my classification. By obsidian, I mean any volcanic glass or glassy vitrophyre. Previous source analyses suggest that obsidian originates from more distant localities than chert (Craig Skinner, personal communication; William Lyons personal communication). No recorded trace of obsidian has been found in river gravel or natural deposits close to the Birch Creek Site.

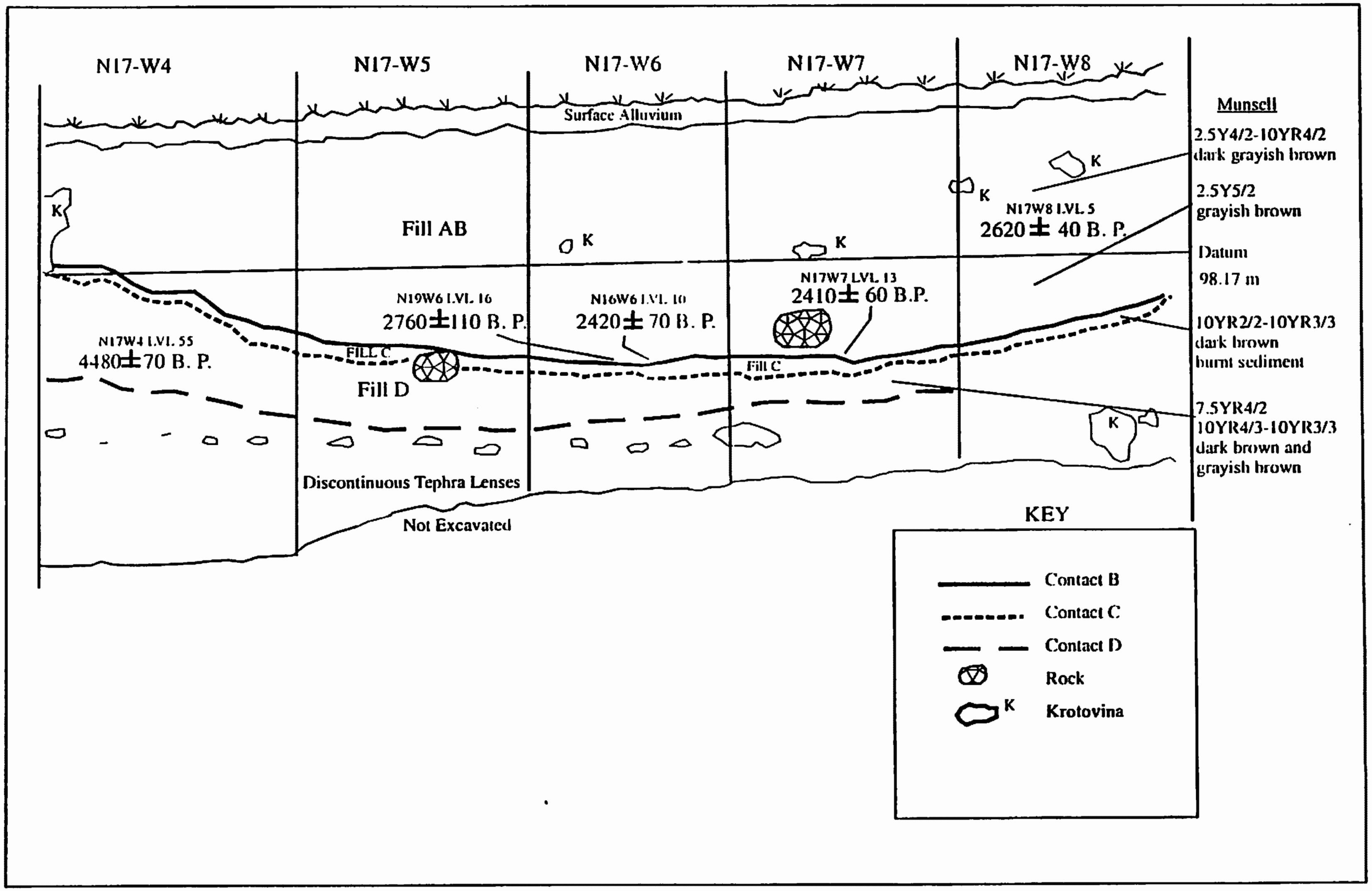

Figure 2.2 South wall profile including radiocarbon dates (adapted from Andrefsky and Presler 2000).

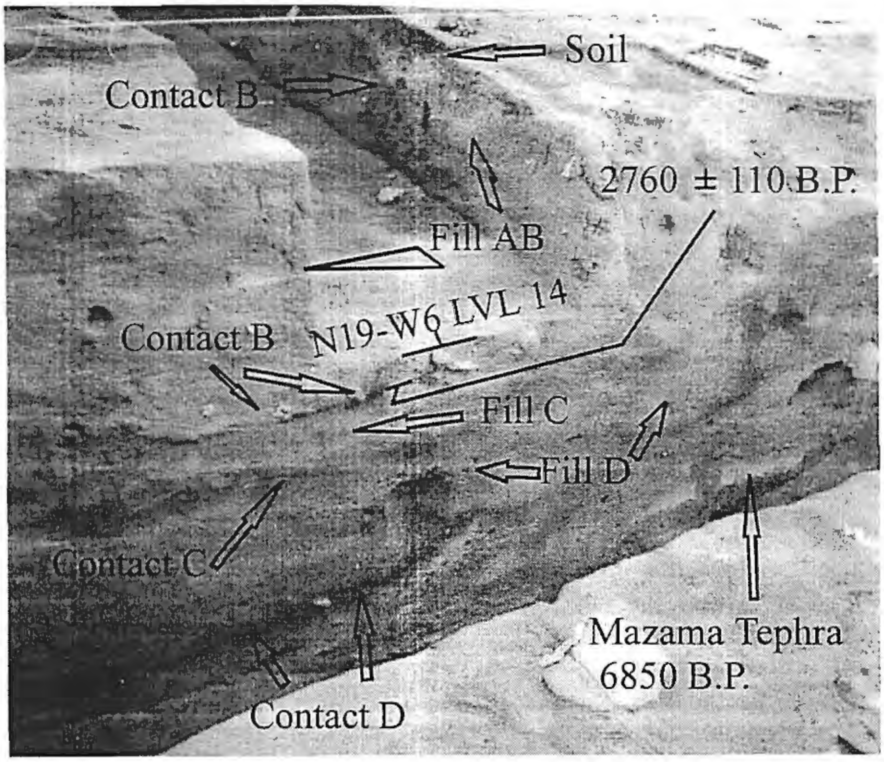

Figure 2.3 Stratigraphic Profile in North Wall of Backhoe Trench.

Artifact Sampling for Obsidian Source Analysis

Funding provided by Washington State University and a generous grant by Craig Skinner allowed for x-ray fluorescence analysis of 108 obsidian artifacts and hydration rind measurements of 15 artifacts. The samples were initially divided as evenly as possible across the five cultural strata. The sample from within each stratum balances between tools (generally finished products) and the largest debitage pieces. Cortical debitage was given priority but selection favored large non-cortical debitage over small debitage with less than 50% cortex on its surface. If a cultural stratum was exhausted of potential specimens, I distributed the remainder equally among the other strata.

ARTIFACT CLASSIFICATION

Classification of tools and debitage follows methods outlined in Andrefsky (1998). Major tool categories include hafted bifaces, non-hafted bifaces, scrapers, cores, flake tools, and non-flake tools. Debitage was divided into three major categories: proximal flakes (flakes possessing a platform, or a point of applied force), flake shatter (flakes possessing recognizable dorsal and ventral surfaces), and angular shatter (all other debitage). Figure 2.4 outlines a flow chart for artifact assignments. Examples of hafted biface and flake tool morphology are shown in Figure 2.5. Measurements and attributes selected for analysis also follow those outlined in Andrefsky (1998). Weight was measured to .1 g using a Mettler© digital scale.

Sampling

I analyzed all tools recovered from the Feature 2 sample. All debitage was first sorted by raw material type. Identified proximal flakes, flake shatter, and angular shatter were placed into separate groups. I counted and measured aggregate weight of each and every sorted debitage category per level of all Feature 2 excavation units. Size 3 through Size 1 debitage refers (in the same order) to ½" , ¼", and 1/8" screen-mesh categories. Small debitage that passed through 1/8" mesh (Size 0) was counted and discarded. In order to maintain consistency in the size-grading procedure, each mesh was agitated individually for ten seconds without flakes falling through the screen (or the screen was emptied). All members of each size-sorted debitage category were counted. I proportionally random sampled cortex and bifacial flakes from the size-graded debitage population. I discuss this sampling procedure where it is used (Chapter 4).

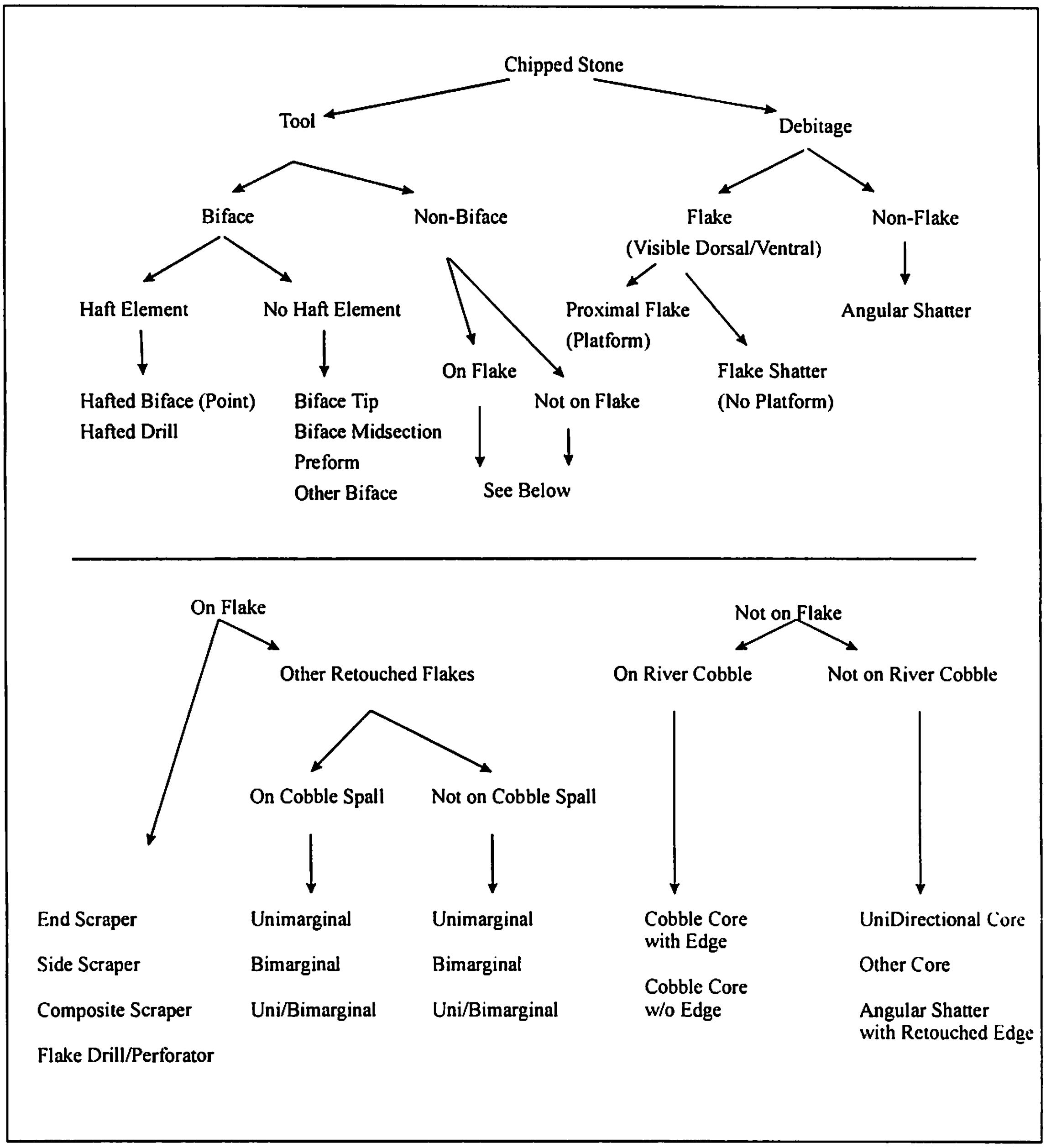

Figure 2.4 Tool and Debitage Classification Flow Chart (Adapted from Andrefsky and Presler 2000).

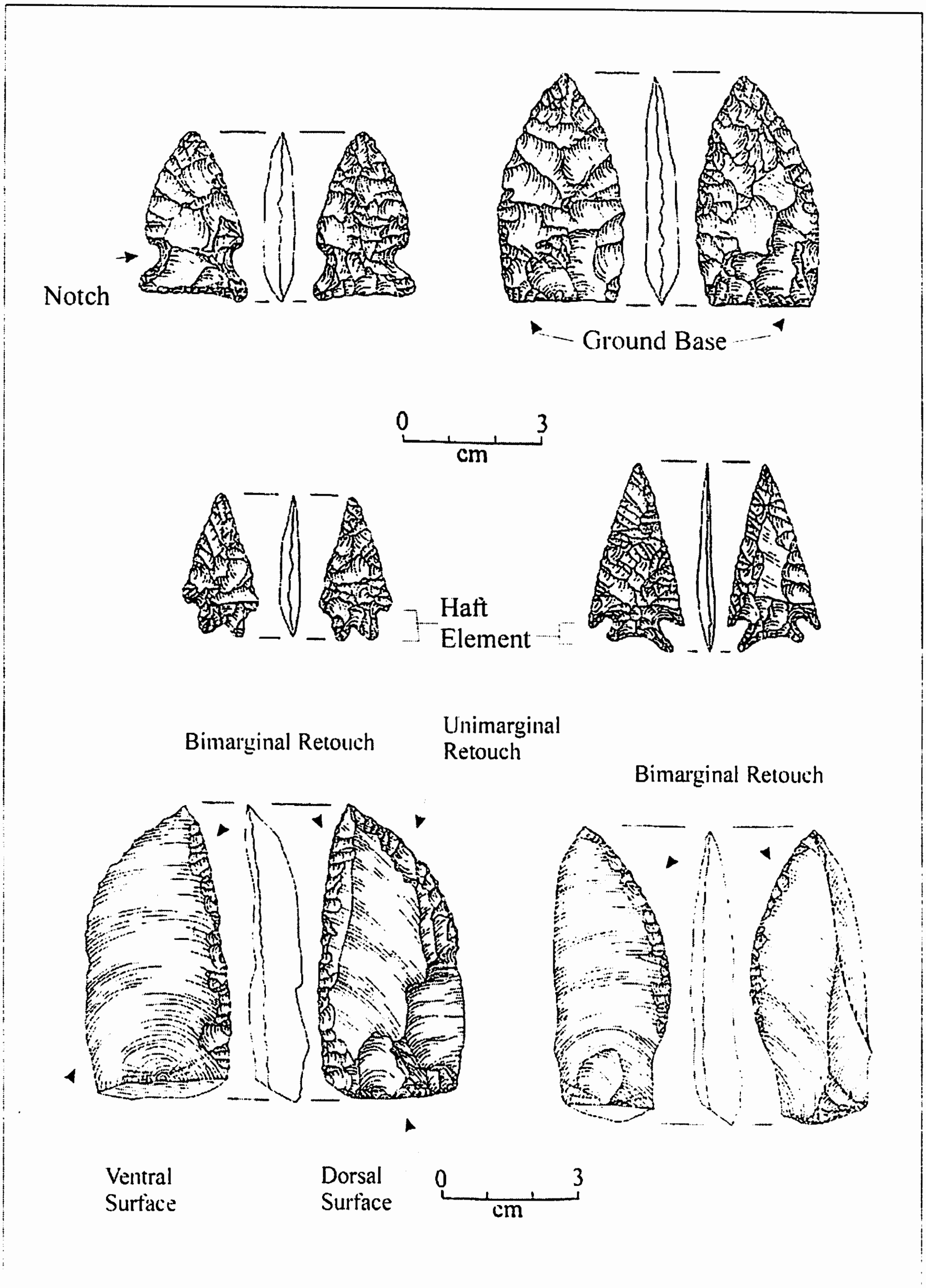

Table 2.5 Attributes for Classifying Flake Tools and Hafted Bifaces (Adapted from Andrefsky 1998).

CHAPTER 3

OBSIDIAN PROCUREMENT AT THE BIRCH CREEK SITE

Obsidian trace-elements potentially link material culture to the landscape (Jack and Carmichael 1969; Hughes 1984, 1986). Researchers have exploited obsidian to investigate trade (Ericson 1981) and other identifiable volcanics to explore territoriality (Weide 1974). Measured distance from artifact deposition to provenance has importance for modeling economic behavior and inferring exchange (Hess 1997; Hughes 1986, 1994; Renfrew 1977). Yet, criticisms warn against both the abuses of distance-decay models to infer trade (Basgall 1979) and the equation of obsidian chemical sources with geologic sources (Hughes 1998a). Both are particularly relevant when incomplete knowledge of an obsidian source's geologic distribution causes incorrect estimation of source distance.

Studies of human interaction with geologic sources are more powerful when variability is chronologically constrained. For example, Lyons et al. (2001) link changing obsidian sources to travel patterns by comparing relatively contemporaneous components in eastern Oregon. However, such research is rare in the vicinity of the Owyhee Uplands. The only association between raw material source and stratified deposits comes from Hanes' (1988) study of Dirty Shame Rockshelter. Unfortunately, results of this analysis is specific to one machine and not replicable (Hughes 1986).

X-ray Fluorescence Analysis

Craig Skinner's Northwest Research Obsidian Studies Laboratory submitted 108 obsidian artifacts to energy dispersive X-ray fluorescence (XRF) trace-element analysis (Appendix B). Trace-element values are compared to trace-element data collected from geologic source samples (Skinner 2000). Geologic source assignment is limited to the "known" universe and obsidian source distribution within the Owyhee Uplands is not fully understood. Lag deposits and obsidian flows overlap. Difficult access to the landscape favors investigation in some geologic areas over others. Nevertheless, continued research further refines the validity of inferences about prehistoric obsidian acquisition. Recent fieldwork has uncovered new sources of importance to this study (Lyons et al. 2001, Luttrell 2000). In turn, this study provides a measure of how much more needs to be done.

OBSIDIAN TRAVELS TO THE BIRCH CREEK SITE

The sample of 108 artifacts produced 11 identified sources and 14 unidentified sources (Table 3.1). Small sizes of individual samples make assignment difficult, and it is likely that most of the fourteen unidentified sources actually fall within the identified group (Craig Skinner, personal communication). The Sourdough Mountain source group, located approximately 38 km to the north of the Birch Creek Site, dominates the assemblage and accounts for at least 30% of all specimens. Removing the minor unknowns (mostly one specimen each) brings this percentage up to 35%. Unknowns 1 and 2 are from important sources. Combined, the two sources account for 22% of this sample, only 13% less than Sourdough Mountain.

Table 3.1 Frequency of Characterized Obsidian Sources.

	Obsidian Source	Distance (km)	#	%	% *
Major Unknowns	Unknown 1		9	8	10
	Unknown 2		11	10	12
Unknowns	Unknowns 3-14		17	16	
Venator Group	Venator	35	10	9	11
	Coyote Wells	37	6	6	7
	Wildcat Creek	31	3	3	3
	Dry Creek Canyon	32	2	3	2
	Skull Springs	32	2	2	2
	Black Bull Springs	37	1	1	1
Sourdough	Sourdough Mtn	38	32	30	35
Distant Group	Indian Creek Buttes A	48	8	7	9
	Gregory Creek	55	3	3	3
	Owyhee (Idaho)	76	3	3	3
	Timber Butte	122	1	1	1
	Total		108	101	100

Allow 1% Rounding Error; * Unknowns 3-14 Removed.

Distance and Location of Obsidian Sources

Keeping Hughes' (1998) caution in mind, I understand the pit falls inherent in inferring distance from sites to sources with undefined boundaries. I determine distance to provenance by measuring nearest distances for all sources. This assumes that populations drew from the nearest exposure of each of these locations.

Four groups divide the obsidian sample. The Major Unknowns group provides no measurable distances. Six sources located in a collective from approximately 31 to 37 km to the Birch Creek Site define the Venator group (Figure 3.1). Sourdough Mountain

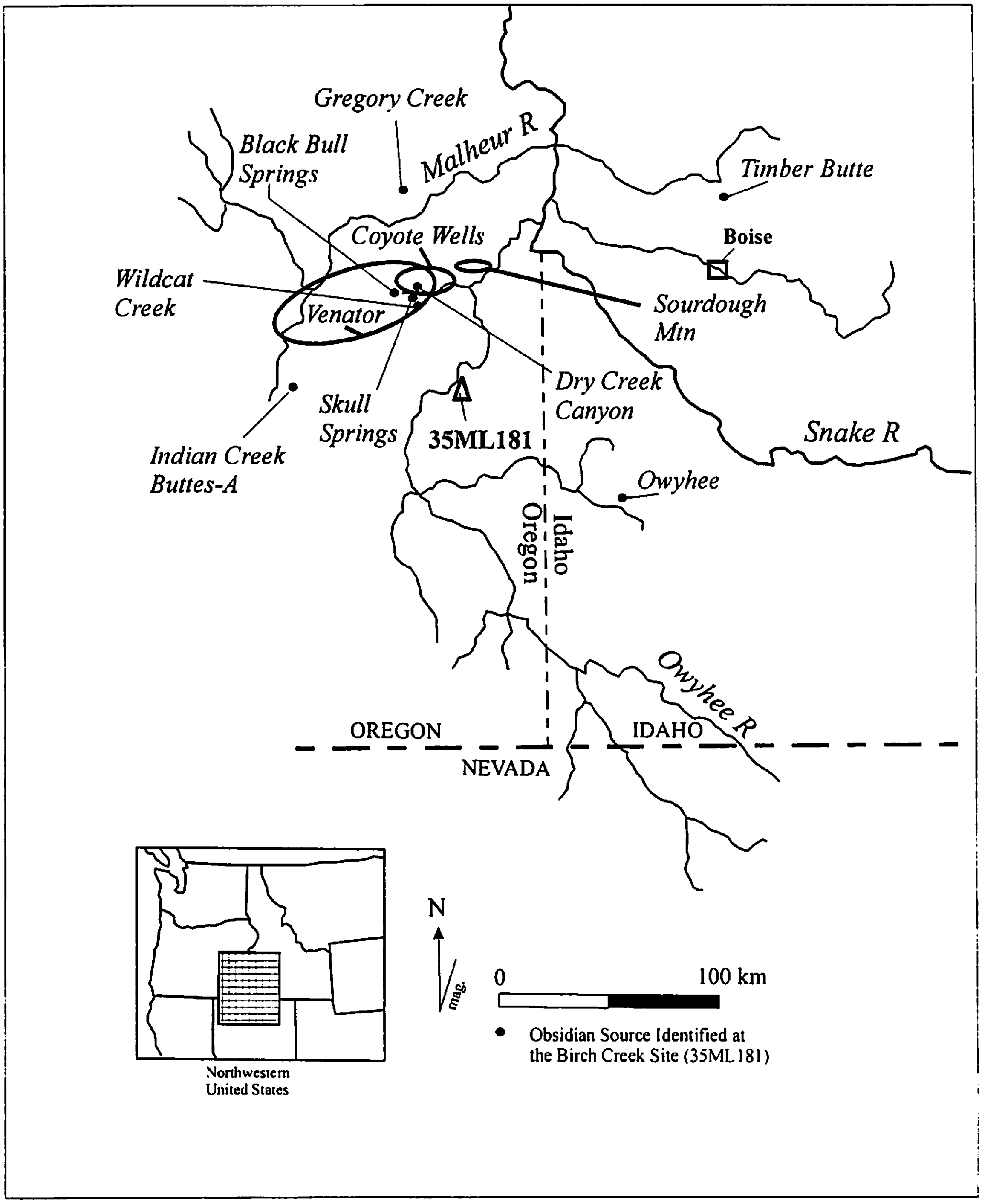

Figure 3.1 Identified Obsidian Sources at the Birch Creek Site (35ML181) (Adapted From Lyons et al. 2001).

becomes available from about 38 km to the north. All other sources cluster as a Distant group. These range minimally from 48 to 122 km away from the Birch Creek Site.

At a distance of 38 km, Sourdough Mountain accounts for 45% of 71 artifacts with provenance information. Sources combined within approximately 38 km account for 79% of all identified materials. While 21% can be attributed to furthest source localities, over half of these originate from the nearest one (Indian Creek Buttes-A). Sourdough Mountain and the Venator group are the two most important identified sources. Yet, the major unknown group should not be underestimated. Each member provides almost as much material as the Indian Creek Butte and Venator sources (not the entire Venator group).

CHRONOLOGY OF OBSIDIAN ACQUSITION

With the exception of Contact C, the Sourdough Mountain locale is the single most important source area for all cultural components in Feature 2 (Table 3.2). It comprises from 1/3 of sampled Contact C obsidian to almost 2/3 of Fill AB obsidian. While the intermittent activity within the Feature 2 assemblage occurs in a period from approximately 4400 B.P. to 2400 B.P., results are consistent with geochemical analysis of surface finds from Charles Luttrell's (2000) survey of the Owyhee Reservoir. Sourdough Mountain and Coyote Wells figure prominently in both collections. Samples of the Sourdough Mountain source (Lyons 2001) matched several previously analyzed by Richard Hughes (1995, 1997, 1998b).

Table 3.2 Distribution and Nearest Distance of Obsidian Sources by Strata.

			Fill AB		Contact B		Fill C		Contact C		Fill D	
	Source	(km)	n	%	n	%	n	%	n	%	n	%
Venator Group	Black Bull Springs	37	0	0	1	8	0	0	0	0	0	0
	Venator	35	2	9	1	8	1	8	4	40	2	13
	Coyote Wells	37	3	14	1	8	0	0	0	0	2	13
	Skull Springs	32	0	0	0	0	1	8	1	10	0	0
	Wildcat Creek	31	0	0	1	8	1	8	0	0	1	7
	Dry Creek Canyon	32	1	5	0	0	0	0	1	10	0	0
Sourdough	Sourdough Mtn	38	14	64	5	42	4	33	3	30	6	40
Distant Group	Indian Creek Buttes - A	47	1	5	2	17	1	8	1	10	3	20
	Owyhee (Idaho)	76	0	0	1	8	1	8	0	0	1	7
	Gregory Creek	55	0	0	0	0	3	25	0	0	0	0
	Timber Butte	122	1	5	0	0	0	0	0	0	0	0
	Total		22	102	12	99	12	98	10	100	15	100

Travel distances to collect obsidian represented by the cultural strata of Feature 2 do not seem to change appreciably through time. A Student's T-Test matrix suggests that there is no basis for rejecting H_0 (null hypothesis) that mean distances (weighted by sample counts) to obsidian sources remains relatively unchanged (Table 3.3).

Table 3.3 Student's T-Test Comparing Strata and Distance.

	Contact B	Fill C	Contact C	Fill D
Fill AB	$p < .905$	$p < .553$	$p < .42$	$p < .924$
Contact B		$p < .592$	$p < .206$	$p < .965$
Fill C			$p < .082$	$p < .527$
Contact C				$p < .185$

Cultural Component

	Component C	Component D
Component B	$p < .903$	$p < .956$
Component C		$p < .847$

Agreggating the cultural strata into larger chronological units increases sample size for more robust statistical inference. For example, Fill AB and Contact B can be aggregated into what I call Component B. This unit would date younger than strata below Contact B. I also combine Fill C and Contact C into one component (Component C). This unit would date relatively older than Component B above it and Fill D below it. I refer to Fill D as Component D to maintain consistency of table format.

Collapsing the strata into components does not change H_0 rejection. Figure 3.2 displays travel distance histograms along with smoothed distribution curves for each cultural component. All curves show a slight rise and then rapid falloff at distances greater than 40 km. Mean distance for all three components is approximately 42 km. The peak at 38-40 km shows the influence of Sourdough Mountain.

Material procured within 40 km exceeds that from all other sources, which agrees with expectations from distance decay (Renfrew 1977). However, in a strict sense, material available at closer distance to the Birch Creek Site is not exploited to the same degree as Sourdough Mountain. While a few km may not appear worth discussing, the Venator group consists of multiple sources and encompasses a larger territory (about three times greater, as far as is currently known). What's more, the Venator material makes large pieces without inclusions easily available (William Lyons, personal communication). Sourdough Mountain obsidian is typically found in smaller nodule size and would require more effort for a comparable return. Reasons for the apparent preference for Sourdough Mountain material are explored later in this chapter.

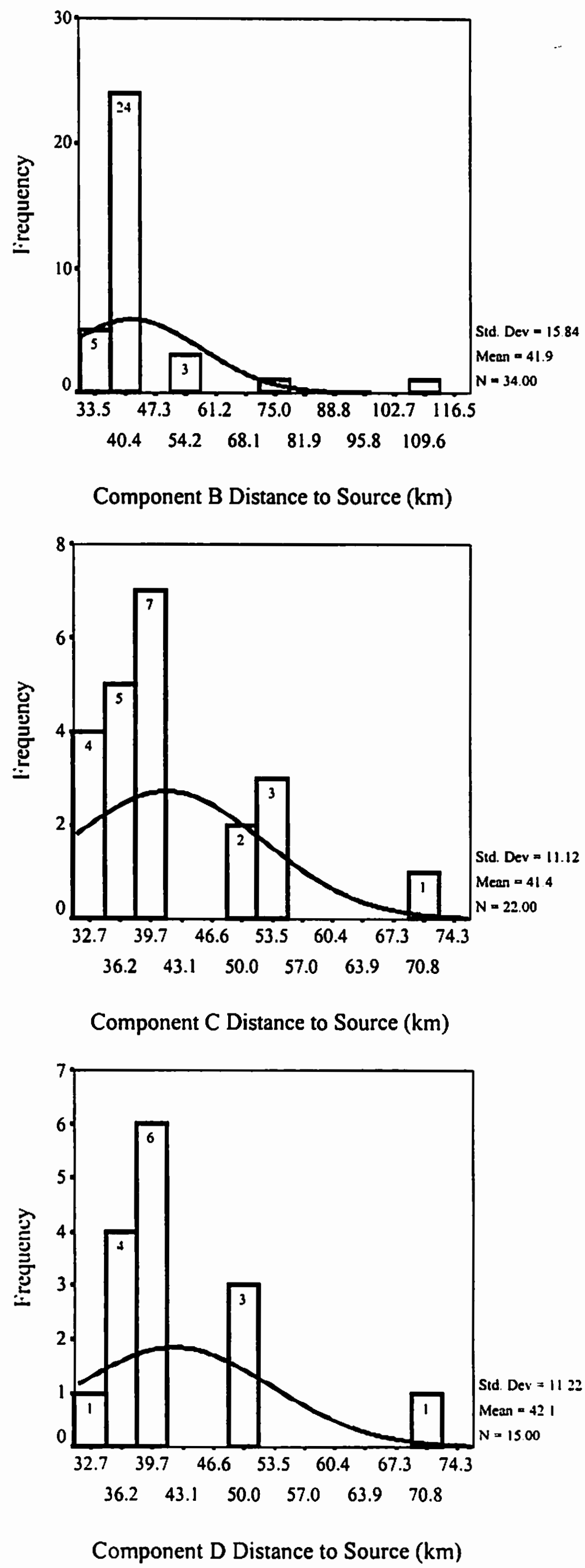

Figure 3.2 Distance to Obsidian Source Histograms.

Differential Exploitation of Obsidian Sources

Emphasis on the Sourdough Mountain source is most marked in the Fill AB stratum. This resource comprises 56% of the sample from this deposit (approximately 2650-2440 B.P.) if minor unknowns are excluded (Table 3.4). Mean distance-to-source appears to change little throughout the Feature 2 record, but the close proximity of some sources to each other may obscure patterning between individual sources and cultural strata.

I perform a cross tabulation of source and strata counts using SPSS© ver. 9.0.0 based on Table 3.4 results with minor unknowns removed. While a general chi-square suggests no significant association between sources and strata (see Table 3.5), 61 cells (93.8%) have expected counts less than 5. Rather than using the cross-tabulation to find intersections between source (row) and strata (column) variables contrary to H_0 (no significant variability), I explore standardized residuals (residuals divided by the standard error) to find values > 2.0 or < -2.0 (highlighted in tables). Results of this size or larger have less than 5% chance that there is no relationship between row and column variables.

Results

A comparison of individual obsidian sources suggests an interesting association between source and cultural strata only within Fill C and Contact C (Table 3.5). A Cross-tabulation of standardized residuals indicates an unusual abundance of Unknown 2 and Gregory Creek source material in Fill C, and unusual abundance of Venator obsidian in

Table 3.4 Distribution of Obsidian Sources in the Feature 2 Sample.

		Fill AB		Contact B		Fill C		Contact C		Fill D	
	Chemical Source	n	%	n	%	n	%	n	%	n	%
Major Unknowns	Unknown 1	2	7	2	10	2	9	2	11	1	5
	Unknown 2	1	4	2	10	7	32	0	0	1	5
	Unknown 3-14	2	7	5	24	1	5	6	33	3	15
Venator Group	Black Bull Springs	0	0	1	5	0	0	0	0	0	0
	Venator	2	7	1	5	1	5	4	22	2	10
	Coyote Wells	3	11	1	5	0	0	0	0	2	10
	Skull Springs	0	0	0	0	1	5	1	6	0	0
	Wildcat Creek	0	0	1	5	1	5	0	0	1	5
	Dry Creek Canyon	1	4	0	0	0	0	1	6	0	0
Sourdough	Sourdough Mtn	14	52	5	24	4	18	3	17	6	30
Distant Group	Indian Creek Buttes-A	1	4	2	10	1	5	1	6	3	15
	Owyhee	0	0	1	5	1	5	0	0	1	5
	Gregory Creek	0	0	0	0	3	14	0	0	0	0
	Timber Butte	1	4	0	0	0	0	0	0	0	0
	Total	27	100	21	103	22	103	18	101	20	100

Table 3.5 Cross-Tabulation of Obsidian Source Standardized Residuals.

			Stratum					
			Fill AB	Contact B	Fill C	Contact C	Fill D	Total
SOURCE	Unknown1	Count	2	2	2	2	1	9
		Std. Residual	-.3	.3	-.1	.7	-.5	
	Unknown2	Count	1	2	7	0	1	11
		Std. Residual	-1.2	.0	$\boxed{2.8}$	-1.2	-.7	
	Black Bull	Count	0	1	0	0	0	1
		Std. Residual	-.5	2.0	-.5	-.4	-.4	
	Venator	Count	2	1	1	4	2	10
		Std. Residual	-.5	-.6	-.9	$\boxed{2.3}$	.1	
	Coyote	Count	3	1	0	0	2	6
		Std. Residual	1.1	-.1	-1.2	-.9	.8	
	Skull	Count	0	0	1	1	0	2
		Std. Residual	-.7	-.6	.8	1.4	-.6	
	Wildcat	Count	0	1	1	0	1	3
		Std. Residual	-.9	.7	4	-.6	.6	
	Dry Creek	Count	1	0	0	1	0	2
		Std. Residual	.6	-.6	-.7	1.4	-.6	
	Sourdough	Count	14	5	4	3	6	32
		Std. Residual	1.8	-.3	-1.2	-.6	.0	
	ICB-A	Count	1	2	1	1	3	8
		Std. Residual	-.8	.5	-.6	-.1	1.2	
	Owyhee	Count	0	1	1	0	1	3
		Std. Residual	-.9	.7	.4	-.6	.6	
	Gregory	Count	0	0	3	0	0	3
		Std. Residual	-.9	-.7	$\boxed{2.8}$	-.6	-.7	
	Timber	Count	1	0	0	0	0	1
		Std. Residual	1.4	-.4	-.5	-.4	-.4	
Total		Count	25	16	21	12	17	91

$\chi^2 = 59.951$, $n = 91$, $df = 48$, $p = .115$

Contact C. The location of Unknown 2 remains a mystery. Gregory Creek's position north of the Malheur River suggests that activities captured in Fill C include a unique link to a relatively exotic source. However, when individual sources are aggregated into groups, there is no evidence of significant change in source represention through time (Table 3.6).

Table 3.6 Standardized Residuals of Obsidian Source Group by Strata.

			STRATUM					
			Fill AB	Contact B	Fill C	Contact C	Fill D	Total
SOURCE GROUP	Major Unknown	Count	3	4	9	2	2	20
		Std. Residual	-1.1	.3	2.0	-.4	-.9	
	Venator	Count	6	4	3	6	5	24
		Std. Residual	-.2	-.1	-1.1	1.6	.2	
	Sourdough	Count	14	5	4	3	6	32
		Std. Residual	1.8	-.3	-1.2	-.6	.0	
	Distant	Count	2	3	5	1	4	15
		Std. Residual	-1.0	.2	.8	-.7	.7	
Total		Count	25	16	21	12	17	91

$\chi^2 = 18.034$, $n = 91$, $df = 12$, $p = .115$; 41.7% cells have expected counts less than 5.

OBSIDIAN ECONOMY

I characterize the obsidian assemblage and attempt to discover what motivated obsidian acquisition from different source areas. Certain locales might be preferred for biface production. Others may have a propensity to produce more debitage or cortical waste flakes. I examine total count and individual weight of sampled bifaces, other tools (all combined due to small numbers), and debitage. Maximum individual weight, total average weight, and total count of bifaces, all other tools, and debitage are grouped by obsidian sources and provided in Table 3.7.

Bifaces

The sample selected for XRF analysis includes 31 bifaces. All four obsidian

Table 3.7 Frequency of Obsidian Artifact Type and Size (g) by Source.

Source		Biface Max (g)	Biface Ave (g)	Biface n	Other Tool Max (g)	Other Tool Ave (g)	Other Tool n	Debitage Max (g)	Debitage Ave (g)	Debitage n	Total n
Major Unknowns	Unknown 1	4.0	3.0	2	3.6	2.2	1	21.6	3.9	6	9
	Unknown 2	0.0	0.0	0	0.7	0.7	1	0.7	0.4	10	11
Unknowns	Unknown 3-14	4.1	1.4	4	15.7	8.4	2	4.1	0.7	11	17
Venator Group	Black Bull Springs	0.0	0.0	0	8.9	8.9	1	0.0	0.0	0	1
	Venator	23.0	9.9	3	0.0	0.0	0	1.4	0.7	7	10
	Coyote Wells	2.5	2.5	1	14.8	14.8	1	5.4	3.0	4	6
	Skull Springs	1.9	1.9	1	0.0	0.0	0	0.2	0.2	1	2
	Wildcat Creek	0.0	0.0	0	0.0	0.0	0	1.9	0.8	3	3
	Dry Creek Canyon	30.9	5.4	2	0.0	0.0	0	0.0	0.0	0	2
Sourdough	Sourdough Mtn	14.1	5.2	8	13.8	8.8	4	23.6	4.0	20	32
Distant Group	Indian Creek Buttes	2.9	1.5	6	4.6	4.6	1	0.3	0.3	1	8
	Owyhee	3.5	1.6	3	0.0	0.0	0	0.0	0.0	0	3
	Gregory Creek	0.0	0.0	0	0.0	0.0	0	0.8	0.4	3	3
	Timber Butte	1.9	1.9	1	0.0	0.0	0	0.0	0.0	0	1
	Total	88.8	34.3	31	62.1	48.4	11	60.0	14.4	66	108

source groups produce material for this tool type (I do not consider the minor unknowns). Interestingly, distant sources are responsible for 32% of the biface sample. Segregating this small population by cultural strata produces low or absent counts, yet general trends are worth exploring. For example, Indian Creek Buttes-A accounts for only one less biface than the entire Venator group and two less than Sourdough Mountain. This is remarkable, given the high quality of the Venator group obsidian and the relative distance of ICB-A.

I search for patterning among obsidian source and artifact typology using standardized residuals in the same manner as described on page 44. While a general chi-square test suggests a significant association between obsidian source and artifact type (Table 3.8), 34 cells (87.2%) have expected counts less than 5.

A comparison of standardized residuals suggests that most obsidian sources distribute evenly across represented artifact types (bifaces, other tools, and debitage). Evidence to associate specific sources to certain artifact forms (such as bifaces) occurs in three cases. A comparison of standardized residuals among sampled obsidian artifact types suggests interesting variability ($\alpha = .05$) caused by 6 projectiles from Indian Creek Buttes-A and 3 projectiles from the Owyhee source. While a non-bifacial tool recovered from Black Bull Springs produces the greatest single residual (2.9) in this table, this source is represented by only one artifact.

When individual obsidian sources aggregate into more generalized source groups, a significant association is found only between distant sources and bifaces (Table 3.9). Whether through exchange or manufactured off-site, it is not unexpected that artifacts from more distant locations would arrive to the Birch Creek Site in a finished form.

Table 3.8 Standardized Residuals of Obsidian Artifact Types by Source.

			TYPE			
			Biface	Other Tool	Debitage	Total
SOURCE	Unknown1	Count	2	1	6	9
		Std. Residual	-.4	.1	.2	
	Unknown2	Count	0	1	10	11
		Std. Residual	-1.8	-.1	1.3	
	Black Bull	Count	0	1	0	1
		Std. Residual	-.5	$\boxed{2.9}$	-.8	
	Venator	Count	3	0	7	10
		Std. Residual	.0	-1.0	.4	
	Coyote	Count	1	1	4	6
		Std. Residual	-.6	.5	.2	
	Skull	Count	1	0	1	2
		Std. Residual	.5	-.4	-.2	
	Wildcat	Count	0	0	3	3
		Std. Residual	-.9	-.5	.9	
	Dry Creek	Count	2	0	0	2
		Std. Residual	1.8	-.4	-1.1	
	Sourdough	Count	8	4	20	32
		Std. Residual	-.5	.5	.1	
	ICBA	Count	6	1	1	8
		Std. Residual	$\boxed{2.4}$	.2	-1.7	
	Owyhee	Count	3	0	0	3
		Std. Residual	$\boxed{2.2}$	-.5	-1.3	
	Gregory	Count	0	0	3	3
		Std. Residual	-.9	-.5	.9	
	Timber	Count	1	0	0	1
		Std. Residual	1.3	-.3	-.8	
Total		Count	27	9	55	91

$\chi^2 = 43.888$, $n = 91$, $df = 24$, $p = .008$

Table 3.9 Standardized Residuals of Obsidian Artifact Types by Source Group.

			ARTIFACT			
			Biface	Other Tool	Debitage	Total
SOURCE GROUP	Major Unknown	Count	2	2	16	20
		Std. Residual	-1.6	.0	1.1	
	Venator	Count	7	2	15	24
		Std. Residual	.0	-.2	.1	
	Sourdough	Count	8	4	20	32
		Std. Residual	-.5	.5	.1	
	Distant	Count	10	1	4	15
		Std. Residual	2.6	-.4	-1.7	
Total		Count	27	9	55	91

$\chi^2 = 14.338$, n = 91, df = 6, p = .026; 41.7% cells have expected values less than 5.

Cortical Debitage

Differential frequencies of cortex assigned to particular obsidian sources may best indicate the initial state of raw material transport to the Birch Creek Site. Cortex is generally rare on obsidian recovered from 35ML181 and this sample is biased towards cortical pieces. However, I assume that there is equal representation among the sources and that frequency of cortex among these pieces reflects transport of cortical obsidian to the Birch Creek Site. It is therefore interesting to find that 56% of 39 cortical pieces indicate Sourdough Mountain as their source. The Major Unknowns group accounts for 28%. No cortex was present on Distant source material, while 10% sources to the Venator group.

Table 3.10 provides the frequency of cortex distribution by source area. It is arranged in an ordinal scale from 0 (representing no cortex) to four. The maximum dorsal cortex value is three. Complete dorsal cortex in addition to a cortical platform provides the greatest possible value of four. Otherwise, platform cortex increases the ordinal class by one value.

Table 3.10 Cortex Distribution by Obsidian Source Group.

	Cortex Amount					
	0%	< 50%	50-75%	> 75%	100%	
Source Group	n (%)	n (%)	n (%)	n (%)	n (%)	Total
Major Unknowns	9 (45)	9 (45)	0 (0)	1 (5)	1 (5)	20 (100)
Venator Group	17 (74)	3 (13)	3 (13)	0 (0)	0 (0)	23 (100)
Sourdough Mountain	10 (31)	11 (34)	9 (28)	2 (6)	0 (0)	32 (100)
Distant Group	15 (100)	0 (0)	0 (0)	0 (0)	0 (0)	15 (100)

When weight is considered, the Venator group comprises 28% of the 171.5 grams that make up the cortical population of the sample. The weight of cortical obsidian from Sourdough Mountain is 66%, or 112.6 grams. Although Major Unknowns produce some of the cortical flakes with total surface coverage, the population itself is not large by weight (7%). Whether considered by simple count or by weight, Sourdough Mountain is the predominate source of cortical obsidian. This is true despite the fact that it is not the largest, nor the nearest source group to the Birch Creek Site.

Why Sourdough Mountain?

I want to produce an explanation for selection of raw material sources at the Birch Creek Site. Prehistoric occupants relied upon Sourdough Mountain to furnish about 1/3 of their obsidian needs. This source is one of the three most exploited source areas. Two of these lie to the north and northwest in a nearest-to-source range of 30-40 km. The location of the two major sources remains unresolved. Given the size, presence of cortex, and frequency within tool and debitage classes, these locations are likely within a similar distance to the Birch Creek Site as the Venator and Sourdough source areas.

Variability among obsidian sources is remarkably limited. Figure 3.4 displays other major obsidian source groups in the surrounding environs. While heavily exploited in northern Great Basin prehistory (see Hanes 1988 for one example), the Birch Creek sample has not produced these resources.

All three important source areas found in the record of 35ML181 produced tools and debitage. Little difference is found in mean weight of specimens, but maximum size of samples may suggest that the Venator group is capable of producing larger bifaces and the Sourdough group produces the largest debitage (see Table 3.7). There is no question that the Sourdough group produces more cortex. Easy access to large pieces of inclusion-free obsidian from the Venator group may have targeted this locality for obsidian tool stone (William Lyons, personal communication). If this is the case, why is Sourdough Mountain producing more obsidian?

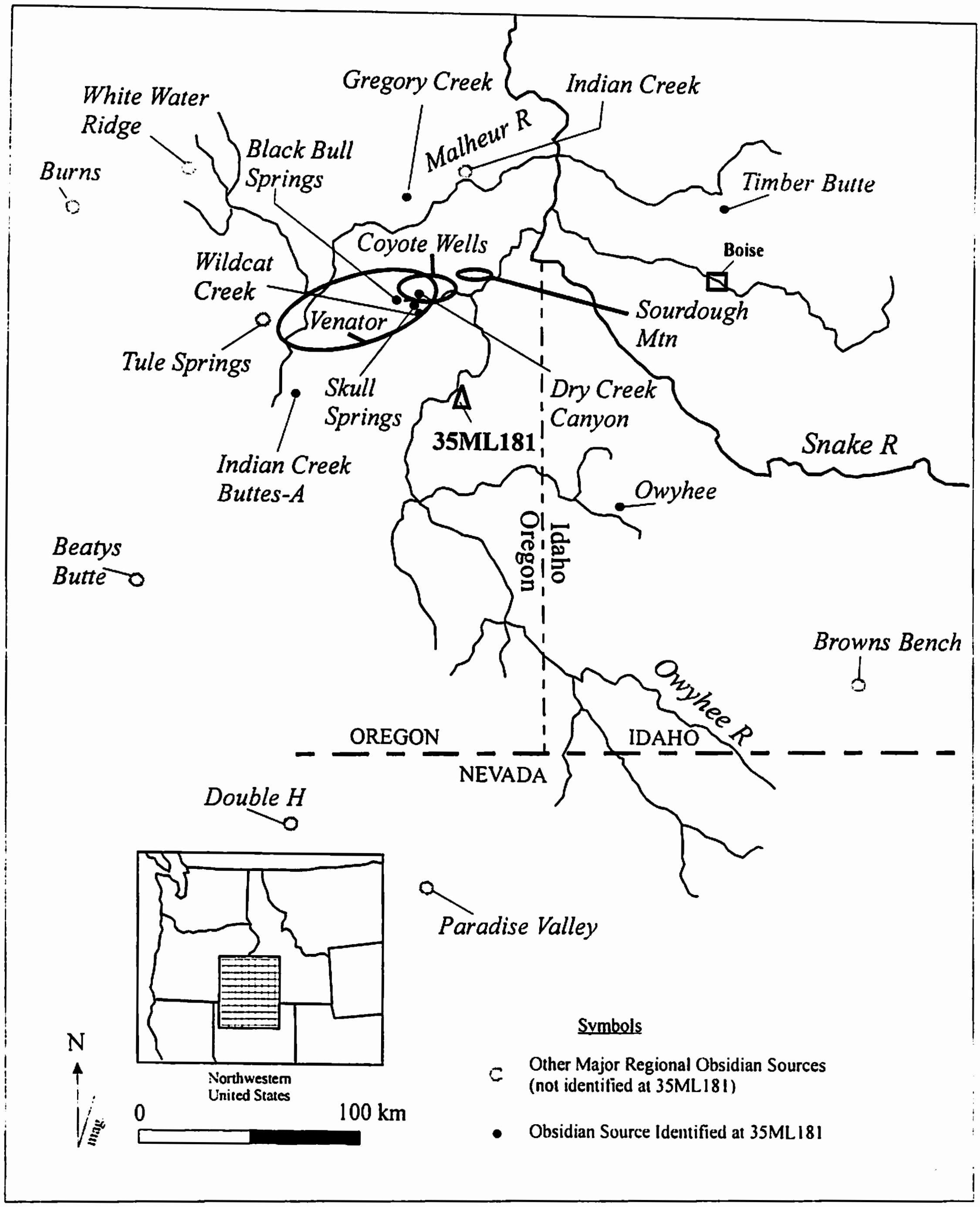

Figure 3.3 Identified and Major Regional Obsidian Sources.

One explanation is Sourdough Mountain's location. Among identified sources, it remains the closest to the Owyhee River. Accessibility is probably not an explanation as both the Venator and Sourdough Mountain areas are within an easy walk. Journeys past Sourdough Mountain provide the logical means of accessing either the Malheur River or the Snake River. Travels northwest past the Venator group would not likely afford such a connection (Figure 3.4). Differential obsidian acquisition may not be simply a matter of raw material accessibility at the Birch Creek Site. Instead, it may reflect variability in travel patterns.

Differences in cortex between the Venator group and Sourdough Mountain may suggest that more intentional shaping (and therefore, more cortex removal) may be preformed on the Venator material before arrival to the Birch Creek Site. This would occur whether obsidian was the reason for travels to this region, or whether simply more time was spent within the vicinity for other reasons. Though always common in the sample, Sourdough Mountain is most abundant in the younger stratum.

The Significance of the Birch Creek Site in the Owyhee Uplands

Obsidian source material obtained "at distance" from 35ML181 is somewhat a misnomer. The pattern of obsidian displacement associated with the Birch Creek Site contrasts sharply with Dirty Shame Rockshelter (DSR). Hanes (1988:148-149) notes that this upland campsite holds obsidian from sources as far away as 246 km. Among 100 samples from DSR, 56% produce distance ranges of 100 km or greater. One interesting similarity between the two sites is the comparable frequency of obsidian projectiles (hafted bifaces) procured from relatively great distances. At DSR, about 20% of the sampled projectiles were produced from sources at the extremity of observed ranges.

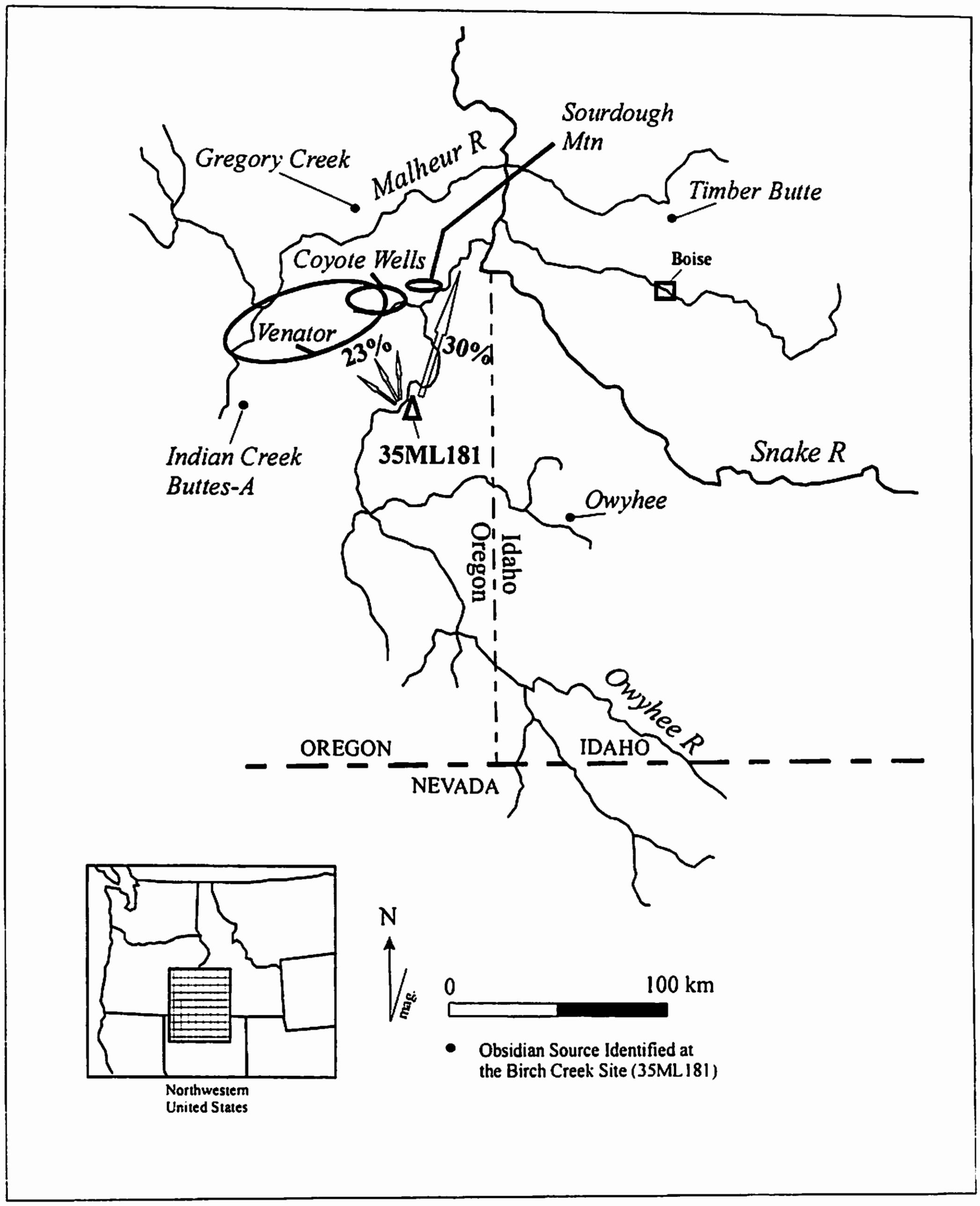

Figure 3.4 Frequency of Sourdough and Venator Group Obsidian Displacement (Adapted from Lyons et al. 2001).

Bifaces from the *distant* group make up about 30% of the Birch Creek sample.

Obsidian represented in seven cultural zones of Dirty Shame Rockshelter date from the Early Archaic (9500 – 6800 B.P.) and Late Archaic (2700-400 B.P.) periods and suggest little change in obsidian source frequencies (Hanes 1988:148). The Birch Creek

Site fits the gap within this 3,200-year cultural "hiatus" at DSR (5900 B.P.) with a record dating from 4400 B.P. to 2400 B.P. A transition to wetter conditions replaces a period of marked aridity during this time in southeastern Oregon (Mehringer 1985:174).

Reoccupation or more intensive occupation of sites in the northern Great Basin begins about 4000 B.P. Hanes (1988:167) summarizes evidence for site use after this time and I choose several examples to illustrate this pattern. Intensive use of Hidden Cave occurs between 4000-3600 B.P. (Thomas 1985:369) and at Kramer Cave from 3900-3600 B.P. (Hattori 1982:121). Accumulation of bone, shell, and lithic materials at Nahas Cave first begins at 4500 B.P. (Plew 1986). A long hiatus at Wilson Butte Cave in central Idaho ends approximately 2,940 B.P. (Webster 1978:28). The period from 5000-3000 B.P. also sees pithouse construction and villages developing in the lower Snake River region at Hatwai (Ames et al. 1981:143) and Alpowa (Brauner 1976). Leonhardy and Rice (1970:14) note increased pithouse village clusters and intensified fishing and root collection.

Distances to obsidian sources from the Birch Creek Site suggest much smaller ranges than at DSR, and most obsidian procurement within a few days journey. The majority of these sources lie to the north, which might indicate the direction of travel corridors during site use in the Feature 2 sample. As opposed to the other identified sources, Sourdough Mountain lies in a direction that provides easiest access to the Malheur or Snake rivers.

CHAPTER FOUR

TOOL AND DEBITAGE ANALYSIS

Results of obsidian sourcing suggest that prehistoric occupants relied mostly on material from close to home during their stay at the Birch Creek Site. Although an important aspect of their economy, obsidian remains but a minor component of this lithic assemblage at 35ML181. Three major obsidian source areas within short travel distance produce both tools and debitage but further analysis is required to determine the context within which obsidian plays its part. For example, chert is readily available in inexhaustible supply. How important is obsidian and why procure this material at all? I examine variability in lithic technology to differentiate the use of obsidian and chert. Patterns recognized in this assemblage may corroborate evidence from the obsidian source analysis. For example, a proportional increase in obsidian within Fill AB may correspond with the greater frequency of cortical obsidian observed in Chapter Three.

Replication studies have increased the understanding of processes to shape and finish stone tools (Bordes and Crabtree 1969; Crabtree 1982; Flenniken 1985; 1986). Studies of tool function and design supplement information about how tools were made (Frison 1991; Goodyear 1974; Harold 1993; Heizer and Hester 1978). Factors influencing material conservation (Bamforth 1988; Parry and Kelly 1987) include researches into the organization of technology surrounding raw material availability (Ammerman and Andrefsky 1982; Andrefsky 1991, 1994b).

Tools provide information about products of lithic reduction before discard. Comparing frequencies of tool types can help determine the range and intensity of site activities. Debitage provides additional information, particularly about early reduction and how much tool shaping occured on site.

Methods of Debitage Analysis

I blend several approaches to debitage analysis. I class debitage using what Andrefsky (2001:7) describes as a *free-standing* typology and combine this with other characteristics such as weight and cortex. I do not use cortex alone to infer a reduction sequence. I prefer to combine size characteristics with cortex proportions to determine "early" and "late" reduction between obsidian and chert. Replicability makes freestanding typologies useful for debitage analysis (see Sullivan and Rozen 1985:758). The ability to determine and standardize the minimum number of impact episodes through recognizable proximal flakes is among its greatest assets.

I rely on aggregate analysis as an efficient means of characterizing populations. Size is often inherent to aggregate analyses (Ahler and Van Nest 1985; Ammerman and Andrefsky 1982; Stahle and Dunn 1982) and my method stratifies sample populations based on screen size (Ahler 1989; Stahle and Dunn 1982). Mixed assemblages are not easily discriminated, but I do not use size grade to produce reduction curves. Instead, I constrain my reliance on size grades to stratify the sample population and supplement other attributes for more effective descriptions of chert and obsidian variability.

Identification of bifacial flakes provides one method for recognizing byproducts from a specific technological process. Comparisons of bifacial flake frequencies (Raab et al.1979) helps determine variability in biface chert and obsidian reduction on site.

THE FEATURE 2 ARTIFACT ASSEMBLAGE

Artifacts from the Feature 2 assemblage at the Birch Creek Site include 391 tools and 42,068 pieces of debitage (Table 4.1). Chert makes up 75% of these tools and 84% of all debitage. Larger, more numerous chert pieces confirm that this material is the staple lithic resource. Chert tools comprise over 99% of almost 20 kg in tool weight and 93% of an almost equal amount in debitage weight.

Table 4.1 Relative Percentage of Obsidian to Chert.

	Count				Weight (g)			
	Tools		Debitage		Tools		Debitage	
	n	(%)	n	(%)	n	(%)	n	(%)
Obsidian	98	(25)	6,611	(16)	1,650.3	(1)	1,375.2	(7)
Chert	293	(75)	35,457	(84)	18,136.4	(99)	18,916.9	(93)

Diachronic Frequency of Chert and Obsidian

Although tool and debitage recovery includes all cultural strata, analysis suggests the greatest manufacture of tools and associated byproducts within the younger component (Fill AB and Contact B). Obsidian tool weight is proportionally highest in Fill C, but tool count and weight is greatest in the younger strata. The proportion of obsidian to chert tools count is also at its highest amount (Table 4.2). Chert consistently produces the greatest tool weight and relative percentages of chert to obsidian range from 92% to 99%. An unusually large core (9.2 kg) helps produce the unusually high result (13, 149.0 g) in Fill AB (I discuss the importance of cores later in this analysis). However, even when this core is removed, Contact B then possesses the greatest tool weight (Table 4.3).

Table 4.2 Relative Frequency of Tools by Strata.

	Obsidian		Chert	
	n	(%)	n	(%)
Fill AB	63	(29)	155	(71)
Contact B	18	(27)	49	(73)
Fill C	2	(25)	6	(75)
Contact C	3	(10)	27	(90)
Fill D	12	(18)	56	(82)
Totals	98		293	

Tool Production

The Feature 2 sample reveals not only tools but also tool production. Greater quantities of debitage relative to tools occurs in both obsidian and chert throughout all cultural strata (Table 4.4). The amount of obsidian relative to chert averages at 16% and does not fluctuate radically within the occupation and fill sequence. Differences lay not only in relative proportions but as greater chert and obsidian quantity in the younger fill.

Table 4.3 Relative Proportion of Tool Weight by Stratum.

	Fill AB	Contact B	Fill C	Contact C	Fill D
Obsidian					
weight (g)	165.3	41.7	2.5	31.7	33.9
%	1	2	9	4	2
Chert					
weight (g)	13,149.0	2,397.0	25.5	733.0	1,831.9
%	99	98	92	96	98
Total (g)	13,314.3	2,438.7	28.0	764.7	1,865.8
Total (%)	100	100	100	100	100

Table 4.4 Frequency of Debitage by Cultural Strata.

	Total	Fill AB	Contact B	Fill C	Contact C	Fill D
Obsidian						
cnt	6,611	3,917	945	524	258	967
%	16	16	15	22	9	14
Chert						
cnt	35,457	19,852	5,159	1,868	2,773	5,805
%	84	84	85	78	91	86
Total cnt	42,068	23,769	6,104	2,392	3,031	6,772
Total %	100	100	100	100	100	100

Table 4.5 Debitage Weight by Cultural Strata.

		Total	Fill AB	Contact B	Fill C	Contact C	Fill D
Obsidian							
	cnt	1,374.9	1,174.2	95.2	37.4	13.5	54.6
	%	7	9	3	6	1	2
Chert							
	cnt	18,916.9	11,705.4	2,897.2	642.1	1,139.4	2,532.8
	%	93	91	97	94	99	98
	Total cnt	20,292.1	12,879.6	2,992.4	679.5	1,152.9	2,587.4
	Total %	100	100	100	100	100	100

This is perhaps most clearly seen in the amount and relative proportion of obsidian to chert debitage (Table 4.5). Not only is there relatively more obsidian in the younger strata, but the amount in weight (g) is also several magnitudes larger.

TOOLS

Choice of a raw material for certain tool types may indicates change in preference or circumstances that favor selection for particular stones (e.g. Andrefsky 1994a). Availability determines only one aspect of material choice. Ease and time of working is just as important. I have shown that there was little change in raw material proportions and I infer no change in supply meeting demand. Variation within proportions of tool forms may help determine what the demand was for.

Feature 2 recovery includes 98 obsidian tools (25%) and 293 (75%) chert tools. I identified 17 tool types within the assemblage following the classification outlined in Andrefsky and Presler (2000). Categories with relative frequencies of > 10 percent include multidirectional cores, unimarginal flakes, and bifaces. The single most common type (40%) among these is the unimarginal flake (Table 4.6). Obsidian makes its greatest contributions in biface categories.

Table 4.6 Frequency of Tool Types in the Feature 2 Sample.

		All Tools		Obsidian		Chert	
Tool Class	Tool Type	n	%	n	%	n	%
	Cobble Core w/o Edge	1	0	0	0	1	0
Core	Multi-Directional Core	40	10	2	2	38	13
Tools	Other Core with Edge	6	2	1	1	5	2
	Uni-Directional Core	2	1	0	0	2	1
	Unimarginal Flake	156	40	29	30	127	43
	Uni/Bi-Marginal Flake	9	2	1	1	8	3
	Angular with Edge	25	6	0	0	25	9
Flake	Bi-Marginal Flake	16	4	2	2	14	5
Tools	Side Scraper	2	1	0	0	2	1
	Composite Scraper	3	1	0	0	3	1
	Endscraper	2	1	0	0	2	1
(Hafted)	Hafted Biface	37	9	26	27	11	4
	Bifacial Drill	2	1	0	0	2	1
Bifaces	Other Biface	81	21	33	34	48	16
	Preform	1	0	0	0	1	0
	Biface Midsection	2	1	1	1	1	0
	Biface Tip	6	2	3	3	3	1
	Total	391	102	98	101	293	101

Allow 2% Rounding Error.

Discussion is simplified with fewer distinctions among tools. I refer to such groups as tool classes. All core types form one tool class. Retouched edges on non-bifacial tools designate the flake tool class. Bifaces possess retouch that extends past the median on both faces of an artifact. Hafted bifaces are separated from all other bifaces based only on the presence of an identifiable haft element (refer to Figure 2.5).

Bifaces

Obsidian is clearly preferred for making hafted bifaces (70% percent of all hafted bifaces and 41% of all non-hafted bifaces). However, although obsidian dominates this category, 32% of obsidian was also used for flake tools. It is obvious that not all transported obsidian is in finished form. Obsidian may be intended for hafted biface production but its initial state of transport produces material of a size useful for other tool types.

It is difficult to fully determine from this analysis if non-bifacial tools identify to some sources more than others. Only 11 of 108 sourced obsidian artifacts are non-bifacial tools (refer to Table 3.7). While Sourdough Mountain produced almost half of these (4 artifacts), all source areas produced non-bifacial tools. Neither is there great discrepancy in either maximum individual tool weight or average non-bifacial tool weight. For example, the maximum non-bifacial tool weight from Sourdough Mountain is 13.8 g. This contrasts with a maximum individual weight of 14.8 g from the Venator group.

While obsidian dominates the hafted biface category, this does not undervalue chert as a resource for manufacturing bifaces. Chert produces 60% of all non-hafted bifaces recovered from Feature 2. Variability between chert and obsidian bifaces may underscore different purposes for these tools. Another possibility is that chert was transported and hafted elsewhere.

The presence of intact and broken bifaces on location suggest a full cycle of biface manufacture, maintenance, and replacement of discards. This occurs in all cultural components with biface artifact counts greater than five specimens. The ratio of intact-to-broken specimens is slightly higher in chert as compared to obsidian, but variability among the components is considerable (Table 4.7). Ratios most closely match each other in Component D. For example, 1 intact obsidian biface (11%) out of 9 specimens compares with 1 intact specimen (8%) out of 12 chert bifaces.

Table 4.7 Ratio of Intact to Broken Bifaces.

INTACT : BROKEN		Comp B	Comp C	Comp D	Total
Obsidian					
	Ratio	4 : 46	0 : 3	1 : 8	5 : 57
	% Intact	8%	0%	11%	9%
Chert					
	Ratio	6 : 40	2 : 4	1 : 11	9 : 55
	% Intact	13%	33%	8%	14%

Other Tools

Other than bifaces, the lithic industry of the Birch Creek Site is based on expedient flake tools derived from multi-directional or "rotated" cores. These types have been associated with increased sedentism (Parry and Kelly 1987). Patterson (1987:51-53) links amorphous cores to the predominance of utilized flake technology in North America. Pithouse floors, local chert availability, and the relatively short distances to obsidian sources provides a context with which to study the role of biface and expedient core technology.

A complete lack of evidence for bipolar core strategies (Goodyear 1993; Hayden 1980; Shott 1989) practiced on obsidian within Feature 2 suggests that residents did not resort to extreme measures for conserving a restricted resource. No direct evidence for haft elements on tools other than bifaces confirms a generally expedient flake tool industry. This is of considerable importance because non-bifacial obsidian appears to be treated no differently than chert at the Birch Creek Site.

Artifact recovery from the Feature 2 assemblage includes only two uni-directional cores (both chert). I recognized no other indications for carefully prepared cores or a blade industry (Crabtree 1968; 1982). Residents of the Birch Creek Site preferred biface production over blade production.

<u>Cores</u>

Change in the frequency of obsidian in cobble form versus finished tools would suggest different strategies for transporting this material to the Birch Creek Site. However, substantial core reduction is only apparent in the chert tool population. Forty-six cores comprise 16% of the total chert tool assemblage within the sample. Their significance is established in total tool weight (Table 4.8). Almost 15 kg comprises 81% of all chert tool weight, making this the single largest category. This includes one exceptionally large core recovered from Fill AB (9.2 kg). This specimen demonstrates that chert cores need neither be reduced for transport to Feature 2 nor fully reduced before discard (Figure 4.1).

Table 4.8 Total Weight of Obsidian and Chert Tool Class.

	Obsidian		Chert		Obsidian	Chert
Tool Class	g	%	g	%	%	%
Core Tools	32.5	12	14,740.5	81 (73)	1	99
Flake Tools	78.3	28	2,358.0	13 (19)	3	97
Hafted Bifaces	47.7	17	101.4	1 (< 1)	32	68
All Other Bifaces	116.6	42	936.5	5 (8)	11	89
Total	275.1	99	18,136.4	101		

Note: Percentages in Parenthesis Reflect Changes if Largest Core is Removed.
Allow 1% Rounding Error.

Over two kg of chert tool weight is in the form of flake tools, which suggests that many chert cores probably reduce into this form. Obsidian cores are more scarce (only three were recovered. One possibility is that obsidian does not arrive often in core form. Another possibility is that they reduced completely into debitage. The presence of rare cores and non-bifacial flake tools within all cultural strata except Fill C at least suggests non-bifacial conversion of obsidian cores similar to what is seen with chert (Table 4.9).

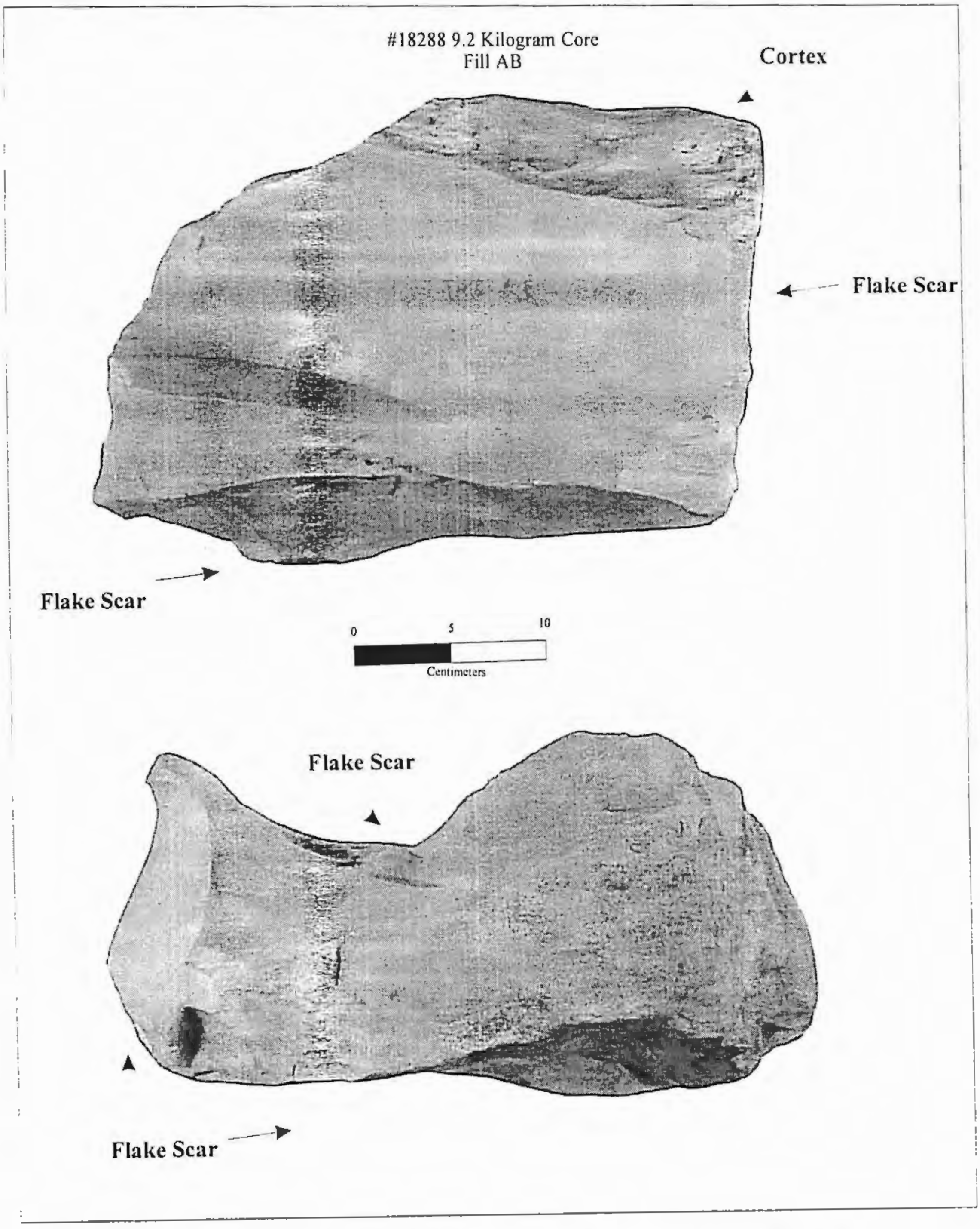

Figure 4.1 9.2 kg Chert Cobble Core Recovered from Fill AB.

Table 4.9 Frequency of Chert and Obsidian Tools By Strata.

	Total		Fill AB		Contact B		Fill C		Contact C		Fill D	
	Obsid	Chert	Obsid	Chert	Obsid	Chert	Obsid	Chert	Obsid	Chert	Obsid	Chert
Tool Class	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Core Tools	3 (6)	46 (94)	2 (8)	24 (92)	0 (0)	7 (100)	0 (0)	0 (0)	0 (0)	5 (100)	1 (9)	10 (91)
Flake Tools	32 (15)	181 (85)	22 (18)	99 (82)	7 (21)	26 (79)	0 (0)	5 (100)	1 (6)	17 (94)	2 (6)	34 (94)
Hafted Bifaces	26 (70)	11 (30)	15 (83)	3 (17)	3 (60)	2 (40)	1 (50)	1 (50)	0 (0)	0 (0)	7 (58)	5 (42)
All Other Bifaces	37 (40)	55 (60)	24 (45)	29 (55)	8 (36)	14 (64)	1 (100)	0 (0)	2 (29)	5 (71)	2 (22)	7 (78)

Debitage

Knowing that chert core reduction occurs in large quantity on site allows for comparing a "constant" raw material source (chert) against an assumed variable (obsidian). Based on the tool population, I expect that chert debitage reflects an industry based largely on minimally prepared core conversion into expedient flake tools and bifaces. Inferences about the initial state of obsidian transported to the Birch Creek Site and its subsequent reduction depend on how closely obsidian debitage size-grade and cortex profiles match the chert example. Comparable proportions within size-grades suggest that both materials begin and end their reduction sequences similarly, only that the scale for obsidian quantity is reduced. Otherwise, two different strategies for chert and obsidian must be proposed.

<u>Size-Graded Debitage</u>

Size-grading the debitage population and eliminating Size 0 (< 1/8") artifacts produces a sample of 40,384 pieces. The presence of obsidian in all sizes (Figure 4.10) indicates that either bifaces were reduced while they were still large, or that large unworked pieces arrived to the site. Similar proportions within each size-grade for both obsidian and chert debitage indicate that these materials probably reduced through comparable trajectories. For example, obsidian was not only pressure flaked from small pre-formed bifaces. Otherwise, large-sized debitage would not be in proportions similar to what is seen in the chert population.

Small debitage stands out as being 23% more frequent in obsidian than chert. Relative proportions (Table 4.11) of obsidian to chert also indicate the preponderance of

Table 4.10 Frequency of Size-Graded Debitage.

	Obsidian		Chert	
	n	%	n	%
Size 1	5,005	82	20,349	59
Size 2	998	16	11,155	33
Size 3	112	2	2,765	8
Total	6,115	100	34,269	101

Note: Totals Differ From Previous Tables Since Size 0 is Excluded.

Table 4.11 Relative Frequency of Size-Graded Debitage.

		Size 1	Size 2	Size 3
Obsidian				
	n	5,005	998	112
	%	20%	8%	4%
Chert				
	n	20,349	11,155	2,765
	%	80%	92%	96%
	total n	25,354	12,153	2,877
	total %	100%	100%	100%

Note: Totals Differ From Previous Tables Since Size 0 is Excluded.

Size 1 material. However, large objective pieces create small flakes as easily as small objective pieces and this only indicates that activities produced more smaller debris relative to chert. These could result from very different processes, such as core preparation, flake tool retouch, or generating finely worked bifaces.

There is little difference in the assortment of size-graded debitage across cultural episodes, which suggests little change in reduction sequences on either material (Table 4.12). This includes the greater frequency of small obsidian debitage (Size 1), which is general throughout the sequence. This may relate to the relatively large numbers of obsidian hafted bifaces (more detailed work) and unrefined (less detailed work) chert flake tools. Size-grading suggests that obsidian and chert tools both reduced from large starting pieces and apparently went through similar processes. Unfortunately, size-grade alone may not identify large obsidian flakes produced from transported bifaces versus simple cores.

The size of obsidian debitage may relate to the source from which it was derived (Table 3.7). Whether measured by maximum individual artifact weight or average weight, two sources produce considerably larger specimens than others. The Sourdough Mountain debitage sample produces artifacts with weights as large as 23.6 g. Unknown 1 also produces a relatively large maximum individual debitage size (21.6 g.). This is approximately four times larger than the next largest specimen (Coyote Wells). Therefore, Sourdough Mountain not only produces relatively more cortical pieces, but the greatest maximum and average debitage weight values as well.

Proximal Flakes

I define proximal flakes as lithic byproducts possessing recognizable ventral and

Table 4.12 Frequency of Size-Graded Debitage by Cultural Strata.

	Fill AB		Contact B		Fill C		Contact C		Fill D	
	n	%	n	%	n	%	n	%	n	%
Obsidian										
Size 1	2,886	78	684	82	388	86	218	92	831	94
Size 2	733	20	137	16	58	13	18	8	52	6
Size 3	87	2	18	2	4	1	0	0	3	0
Total	3,706	100	839	100	450	100	236	100	886	101
Chert										
Size 1	10,990	57	2,952	59	1,219	70	1,797	68	3,391	62
Size 2	6,713	35	1,640	33	441	25	667	25	1,694	31
Size 3	1,668	9	412	8	91	5	167	6	427	8
Total	19,371	101	5,004	100	1,751	100	2,631	99	5,512	101

Note: Allow 1% Rounding Error.

Row Percentages

	Fill AB		Contact B		Fill C		Contact C		Fill D	
	Obsidian	Chert	Obsidian	Chert	Obsidian	Chert	Obsidian	Chert	Obsidian	Chert
Size 1	21%	79%	19%	81%	24%	76%	11%	89%	20%	80%
Size 2	10%	90%	8%	92%	12%	88%	3%	97%	3%	97%
Size 3	5%	95%	4%	96%	4%	96%	0%	100%	1%	99%

dorsal surfaces in addition to platforms (points of applied force) (Andrefsky 1998). Size-graded debitage cannot accurately measure the actual frequency or "intensity" of work involved in reducing a particular stone into a desired product. Each flaking episode (either percussion or pressure initiated) can produce many or singular pieces of debris. The advantage of identifying proximal flakes lies in their capture of actual flake-producing events (Andrefsky 1998:81-82). The ratio of proximal flake to flake production is typically 1:1.

Results

Obsidian produces more proximal flakes and accounts for more of its debitage weight than chert (Table 4.13). Small proximal flake debitage is most frequent in both materials, but more so with obsidian. Greater frequency of small proximal flakes of obsidian than chert is common to all strata. This may not only result from chert conversion into expedient flakes, which might explain the lower relative frequencies of small flakes. Instead, the production of hafted bifaces may produce greater quantities of small obsidian proximal debitage through the form of bifacial edge flakes.

Table 4.13 Frequency of Proximal Flakes by Raw Material Type.

	OBSIDIAN		CHERT		OBSIDIAN		CHERT	
	Count		Count		Weight (g)		Weight (g)	
Class	n	%	n	%	n	%	n	%
Proximal	3,112	47	10,369	29	847.2	62	8,963.3	47
Other	3,499	53	25,088	71	527.7	38	9,953.6	53
Total	6,611	100	35,457	100	1,374.9	100	18,916.9	100

Bifacial Edge Flakes

Bifacial edge flakes (BEFs) provide perhaps the most direct evidence of bifacial reduction available. I recognize two forms of BEFs, which I designate as Type I and Type II. Type I BEFs are identified by possessing complex platforms along with multiple dorsal flake scars that originate from the direction of the platform. In addition, at least one flake scar must emanate from an angle perpendicular to the platform or greater. Less conservative Type II BEFs do not require flake scars from an angle perpendicular to the platform or greater (Figure 4.4). These types do not inherently distinguish from bimarginal (the same margin retouched on both faces) and bifacial retouch (flake scars on both faces extend past the tool median) and both occur in the archaeological record of the Birch Creek Site.

The proximal flake population was proportionally random sampled by size-grade. 50% of Size 1 obsidian and 100% of other size-grades were identified as BEF (I or II) or non-BEF flakes. The same method was applied to the larger chert population, but with a smaller sample. I sampled and analyzed 5% of Size 1 and 2 proximal flakes and 10% of Size 3 proximals. Because proportions are not the same across all grades, comparable data comparisons do not include cross comparisons of size-grades. I calculate a minimum and maximum estimation of biface reduction by multiplying Type I and Type II flakes by the relative percentage of bifaces to bimarginal flakes.

<u>Results</u>

All cultural components produce obsidian and chert BEFs within all size-grades. BEF trimming is not restricted to small-sized bifacial tools. While reduction of obsidian

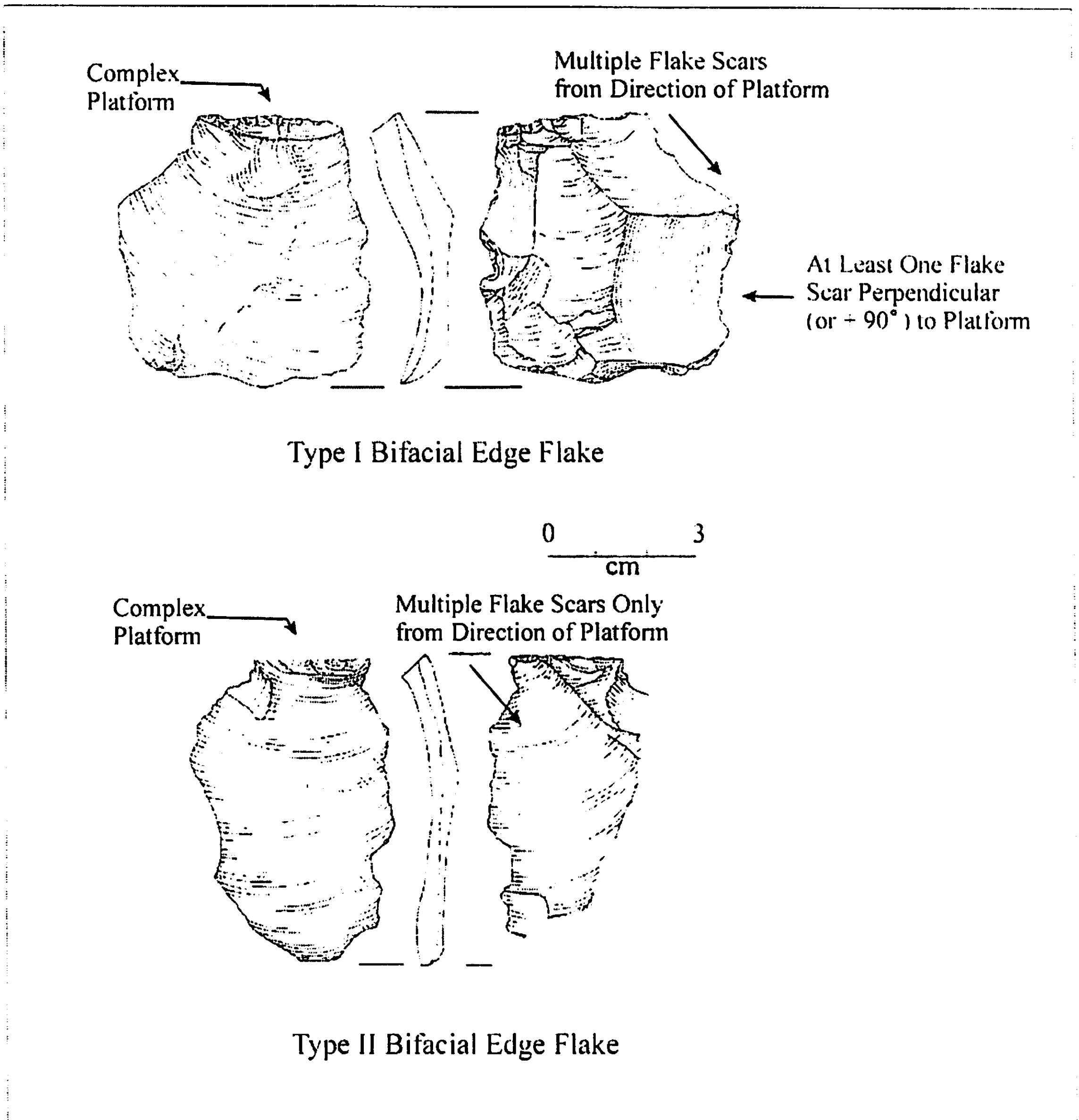

Figure 4.2 Examples of Type I and Type II Bifacial Edge Flakes (Adapted From Andrefsky 1998).

bifaces from off site offers one explanation, the evidence is not unequivocal. Another possibility is that obsidian is transformed into large bifaces on site and survives to be further reduced later in its use life. Regardless, obsidian useful for larger bifacial manufacture was not limited to specific cultural units.

Obsidian produces proportionally more BEFs. Again, this is not limited to small-sized debitage, but holds true for all size grades and across all cultural components. Greater variability in minimum and maximum values within the chert population undoubtedly relates to more frequent bimarginal flake tools created from this material. The disparity between chert and obsidian BEF values is great enough to produce no overlapping figures in Table 4.14.

Taken at face value, debitage attributable to biface reduction may minimally account for 50% to 80% of all flake-producing events on obsidian. Percentages rarely exceed 40% on chert. On average, proportionally twice as much of this activity occurs on obsidian as on chert in Component B. This average ratio is closer to three times greater for obsidian in Component C and two times greater for obsidian in Component D. How closely do BEF estimates match bifacial tool discard on site? Bifaces comprise 66% of the obsidian tool population and 33% of the chert population (Table 4.6). This suggests a fairly close match and that, at least in the case of the Birch Creek Site, this methodology surrounding bifacial debitage would accurately depict the influence of bifacial technology without representation by the tool assemblage.

Closely matching bifacial tool and debitage proportions suggests that many of the bifaces produced at Feature 2 probably also returned to the Birch Creek Site. It might be

Table 4.14 Minimum and Maximum Bifacial Edge Flake Values by Component.

	Component B				Component C				Component D			
	Obsidian		Chert		Obsidian		Chert		Obsidian		Chert	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Size 1	64%	66%	30%	36%	65%	65%	28%	39%	66%	69%	21%	28%
Size 2	63%	65%	43%	49%	52%	52%	16%	23%	82%	86%	26%	35%
Size 3	53%	55%	27%	32%	66%	66%	12%	17%	63%	67%	32%	42%

% of Bimarginal Tools and Bifaces by Component

	Component B		Component C		Component D	
	Obsidian	Chert	Obsidian	Chert	Obsidian	Chert
Bimarginal	5%	21%	0%	36%	5%	31%
Biface	95%	79%	100%	64%	95%	69%
Total	100%	100%	100%	100%	100%	100%

that most manufactured bifaces from this sample do not end up as lost items or discards out on forays. Instead, the majority of these tools returned for maintenance or replacement.

Large obsidian biface manufacture and reduction occurred within all strata. This forms my impression that the greater obsidian debitage weight and count within the younger strata (noted earlier in this chapter) is not related to a shift in technology. In other words, increasing amounts of debitage later in time does not necessarily connect to a change away from producing bifaces, or that bifaces substantially changed in a way as to create different debitage size profiles.

Unrestricted sizes of BEFs in both raw material types confirm the possibility for large obsidian biface transport to the Birch Creek Site. I look for variation of cortex distributions on debitage to help determine if large obsidian bifaces or cortical flakes provided the main form of objective pieces transported to this location.

Cortex

I assume that proportions of cortex on size-graded chert debitage result from local core reduction. This provides a means of comparing obsidian debitage to infer the initial state of obsidian transport. I measure cortex using an ordinal scale (see Andrefsky 1998) on all obsidian debitage except Size 1 debris from Fill AB. The great quantity of this material required me to random sample 50%. Doubling the identified specimens within each cortex category in this size grade provides comparable frequencies to the rest of the population. I sampled the chert population (20%) in the same fashion.

Table 4.15 displays the frequency of chert and obsidian cortex within three ordinal categories ranging from 0% to 100% dorsal cortex. This is arranged for all cultural strata. Profiles indicate the prevalence of large-sized debitage within cortical chert groups. Size 3 debitage often accounts for over 50% of sampled chert within them. This contrasts with obsidian profiles in which Size 3 debitage rarely exceeds 18% of any cortical class and is often not represented.

Given that chert is a raw material "constant," it is not surprising that variability in the cortex profile rarely differs more than 10% for any category. Cortex fluctuates more widely in the obsidian assemblage and frequencies reflect a very different profile to that of chert. Large obsidian cortical debitage does not exceed 20% and most often makes up less than 10% of cortical categories.

The state of most obsidian transported to 35ML181 occurred in the form of tested or perhaps partially prepared cortical flakes. I base this on the appearance of cortex throughout the spectrum of obsidian size grades. Yet, cortical obsidian differs in proportion to chert. This indicates a strategy different than transporting large cortical cobbles to the site.

I have not fully determined the extent to which obsidian biface preforms may have been transported to the Birch Creek Site, but do not rule out the possibility. I suggest that this occurred more rarely than with cortical flakes, given that cultural components produce large cortical flakes but non-cortical flakes of this size are less frequent or missing. Future analysis should concentrate on XRF sourcing of the larger bifacial flakes. My expectation is that these may aggregate around the Venator source, whereas Sourdough Mountain will dominate the cortical debitage assemblage.

Table 4.15 Frequency of Cortical Debitage by Size-Grade.

	Fill AB			Contact B			Fill C			Contact C			Fill D		
	0%	<=50%	>50%	0%	<=50%	>50%	0%	<=50%	>50%	0%	<=50%	>50%	0%	<=50%	>50%
<u>Obsidian</u>															
Size 1	82	52	45	82	63	67	87	50	50	94	55	100	94	67	100
Size 2	16	39	37	16	31	21	12	42	50	6	36	0	6	22	0
Size 3	2	9	18	1	6	13	1	8	0	0	9	0	0	11	0
Total	100	100	100	99	100	101	100	100	100	100	100	100	100	100	100
<u>Chert</u>															
Size 1	38	16	10	42	5	20	50	0	20	58	10	0	35	0	15
Size 2	42	20	35	34	29	20	28	22	60	28	20	0	31	23	45
Size 3	20	64	55	24	66	60	22	78	20	13	70	100	34	77	40
Total	100	100	100	100	100	100	100	100	100	99	100	100	100	100	100

Note: % represents 100% of obsidian sample and 20% of chert sample.

CHAPTER FIVE

SUMMARY AND DISCUSSION

Feature 2 of the Birch Creek Site presents a glimpse into prehistoric occupation along the Owyhee River at times between 4400 B.P. and 2400 B.P. This is an interval of generally wetter conditions in the northern Great Basin that in this semi-arid landscape imply relatively "good times" when compared to the antecedent arid period. During this time, previously abandoned sites indicate increased use. This may be associated with new different population dynamics.

Obsidian from the site suggests little change through time in distances – less than 40 km for most. When combined with evidence for pithouse occupation, this marks a different perspective on prehistory as compared to earlier upland travel distances portrayed by Dirty Shame Rockshelter (Hanes 1988).

Obsidian collection centers around two or possibly three major source areas. One of these remains unknown. Sourdough Mountain produces most obsidian transported to the site, which might infer use of a travel corridor north along the Owyhee River. More frequent cortical obsidian within the younger cultural stratum suggests that travels may have increased in frequency along this route. Obsidian procurement may have been "embedded" (Binford 1979) as an ancillary byproduct as folks passed by this source for purposes other than collecting useful stones.

The nearest source group (Venator) was popular for obsidian and may have been favored for large bifacial products. Trips northwest to this source produced less cortical obsidian, which suggests that either material was directly acquired or more time was spent at this location. As a result, products became more finished before return to the Owyhee River.

Indian Creek Buttes – A (ICB-A) is most intriguing among the few distant sources yet recognized. The frequency of hafted bifaces from this source rivals sources closer to home. This may illustrate some travel or interaction incentives that ultimately furnished more from this more distant resource than other distant localities. Whether material is mostly in the form of projectiles as the result of trade or simply having been worked by time of arrival to the Birch Creek Site remains unknown.

Raw Material Economy

Obsidian is preferred for hafted bifaces. Supply probably meets demand within all cultural occupations extant in the Feature 2 sample. Range of obsidian biface sizes most likely results from chert fulfilling the needs for large bifaces and not from availability. Debitage size and frequency confirm that this material underwent all stages of reduction to produce mostly these hafted bifaces. Cortical obsidian, particularly in younger strata, indicates that most of the obsidian was transported to the site in an unfinished state. Byproducts were large enough to convert into flake tools other than bifaces, but this occurred more frequently in younger strata. Without further XRF sourcing analysis, I can only infer that much of this probably belongs to the Sourdough Mountain source because most cortical debitage was identified to this locality.

Chert is the primary raw material of the Birch Creek Site's lithic industry. The technology centers on two major products: bifaces and expedient flake tools. Chert produces the largest bifaces, and most bifacial products that were deposited in the site ended their use lives without evidence for hafting. Whether other artifacts became hafted and did not return to the site or their function precluded need for hafting remains unknown.

Like obsidian, chert was processed into tools at the site. Evidence clearly establishes that minimally prepared cores provide the basis for creating finished products. Less small-sized chert debitage probably evidences fewer episodes of fine detailed work than on obsidian. This is consistent with the dominance of simple chert flake tools and proportionally fewer chert hafted bifaces of chert.

There is no evidence for a technological shift at the Birch Creek Site. As an interesting comparison, recent lithic analysis by Wegener (1998) of Locality-6 at Skull Creek Dunes (Catlow Valley) suggests little change in a technology dominated by abundant, local obsidian between ca. 2200 and 1700 B.P. In contrast to the Birch Creek Site, this Late Archaic site relied very little on chert (2% of the lithic assemblage). Little technological change observed in both assemblages may relate to a relatively constant raw material, despite possible influences from other aspects of prehistoric existence. This is consistent with previous studies, which show raw material availability to be the primary factor in the organization of lithic technology (Andrefsky 1994).

Site Activity

Whether from intact contacts or fill episodes, the array of discarded bifaces, flake tools, and core tools indicate that this assemblage did not come from specialized activity.

For example, a locality for crafting and maintaining projectiles would probably not have the diversity in flake tools present in the sample. Hide processing may require cutting and scraping tools, but probably not the high frequency of hafted bifaces recovered. Rather than being the result of an isolated event, the assemblage appears to conform more to the wider range of lithic-related behaviors one would associate with being at home. By this, I mean a place of occupation extended long enough to accumulate various tool type discards from multiple activities. Similar tool and debitage class frequencies were recovered from all cultural strata, with the exception that cores were not recovered from Fill C.

Future Research

The importance of the Birch Creek Site should not be underestimated. It provides a stratigraphic sequence of occupation during a time period not well represented in the archaeological record of the Owyhee Uplands. Because of the remote and rugged geography, this location in southeastern Oregon also provides a relatively undisturbed archaeological record. This record is rich in cultural remains, but survey and subsurface testing is still very much in their infancy.

The bar upon which the Birch Creek Site sits may contain a much larger palimpsest of prehistoric activity than is now recognized. As only part of a greater cultural setting, this location on the Owyhee Breaks remains but one of many possible settlements. I refer to the expansive Hole in the Ground area near recorded petroglyphs (Cressman 1937) as one potential source of great discovery.

My investigation centers only on one small fraction of activity at 35ML181. Stone tools are conducive to study for reasons of preservation, but ground stone and faunal remains recovered also provide important records for studying subsistence here (Andrefsky and Presler 2000).

Two important regional obsidian sources remain unidentified. Based on artifact cortex and frequency, I suggest they are located within similar travel distance to the Venator and Sourdough source areas. Unknown 1 is a material resembling the texture of obsidian sourced to Brown's Bench and may be the product of a fried tephra (William Lyons, personal communication). Another possibility is that this material is the product of a spatter feature (Mark Ferns, personal communication). Regardless, Unknown 1 is recognizable by surface characteristics that produce a unique matte finish. 100% of specimens that I identified as belonging together as one unique, identifiable group from the sample of 108 artifacts analyzed by XRF returned with a designation as Unknown 1.

I also note the occurrence within the Feature 2 sample of a unique, gray volcanic that occurs within the study area. This glassy material (called by some as gray opaque volcanic (GOV), William Lyons, personal communication) identifies to the Venator source area. Whether identified as obsidian or as GOV, this material is consistently identifiable as volcanic by its glassy sheen and "sugary" texture and should not be confused with gray cherts that also occur within the site assemblage. Future researches must separate these materials for consistent, accurate interpretation of site contents.

The record of lithic technology is extremely rich and I have only explored one of many possible venues. More still needs to be done. Indications of population increase on the peninsula at the Owyhee Breaks at approximately 2600 B.P. to 2400 B.P. needs testing. If confirmed, the extent of this apparent increase needs to be delimited within the context of the Owyhee Uplands. The travel corridor that I postulate by the frequency of Sourdough Mountain specimens should be recognizable by similar proportions of identified sources within other assemblages along the Owyhee River. As more regional sites provide axis of geologic source dispersion, the factors most affecting short-and-long distance travel may be more fully understood. Unfortunately, my research has little comparative material.

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APPENDIX A

XRF ANALYSIS AND HYDRATION MEASUREMENTS

X-Ray Fluorescence Analysis and Obsidian Hydration Measurement of Artifact Obsidian from the Birch Creek Site (35-ML-181), Malheur County, Oregon

PRELIMINARY REPORT

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Northwest Research Obsidian Studies Laboratory

One-hundred and twelve artifacts from the Birch Creek Site (35-ML-181), Malheur County, Oregon, were submitted for energy dispersive X-ray fluorescence trace element provenience analysis. Sixteen of the specimens were processed for obsidian hydration measurements. The samples were prepared and analyzed at the Northwest Research Obsidian Studies Laboratory under the accession number 2000-53.

Analytical Methods

X-Ray Fluorescence Analysis. Nondestructive trace element analysis of the samples was completed using a Spectrace 5000 energy dispersive X-ray fluorescence spectrometer. The system is equipped with a Si(Li) detector with a resolution of 155 eV FHWM for 5.9 keV X-rays (at 1000 counts per second) in an area 30 mm^2. Signals from the spectrometer are amplified and filtered by a time variant pulse processor and sent to a 100 MHZ Wilkinson type analog-to-digital converter. The X-ray tube employed is a Bremsstrahlung type, with a rhodium target, and 5 mil Be window. The tube is driven by a 50 kV 1 mA high voltage power supply, providing a voltage range of 4 to 50 kV.

The diagnostic trace element values used to characterize the samples are compared directly to those for known obsidian sources reported in the literature and with unpublished trace element data collected through analysis of geologic source samples (Skinner 2001). Artifacts are correlated to a parent obsidian source or chemical source group if diagnostic trace element values fall within about two standard deviations of the analytical uncertainty of the known upper and lower limits of chemical variability recorded for the source. Occasionally, visual attributes are used to corroborate the source assignments although sources are never assigned solely on the basis of megascopic characteristics.

Obsidian Hydration Analysis. An appropriate section of each artifact is selected for hydration slide preparation. Two parallel cuts are made into the edge of the artifact using a lapidary saw equipped with 4-inch diameter diamond-impregnated .004" thick blades. The resultant cross-section of the artifact (approximately one millimeter thick) is removed and mounted on a petrographic microscope slide with Lakeside thermoplastic cement and is then ground to a final thickness of 30-50 microns.

The prepared slide is measured using an Olympus BHT petrographic microscope fitted with a filar screw micrometer eyepiece. When a clearly defined hydration layer is identified, the section is centered in the field of view to minimize parallax effects. Four rim measurements are typically recorded for each artifact or examined surface. Hydration rinds smaller than one micron often cannot be resolved by optical microscopy. Hydration thicknesses are reported to the nearest 0.1 µm and represent the mean value for all readings. Standard deviation values for each measured surface indicate the variability for hydration thickness measurements recorded for each specimen. It is important to note that these values reflect only the reading uncertainty of the rim values and do not take into account the resolution limitations of the microscope or other sources of uncertainty that enter into the formation of hydration rims.

Additional details about specific analytical methods and procedures used for the analysis of the elements reported in Table A-1 and the preparation and measurement of hydration rims are available at the Northwest Research Obsidian Studies Laboratory World Wide Web site at *www.obsidianlab.com.*

Results

X-Ray Fluorescence Analysis. Twenty-five geochemical source groups, 11 of which were correlated with known geologic sources, were identified among the 112 obsidian artifacts that were characterized by X-ray fluorescence analysis. The locations of the site and the identified obsidian sources are shown in figures 1 and 2. Analytical results are presented in Table A-1 in the Appendix and are summarized in Table 1 and figures 3 and 4. Descriptive information about all identified obsidian sources is outlined in Table 2.

Table 1. Summary of results of trace element analysis of artifacts.

Geologic Source	N=	Percentage
Black Bull Spring *	1	0.9
Coyote Wells	7	6.2
Dry Creek Canyon *	2	1.8
Gregory Creek	3	2.7
Indian Creek Buttes A	8	7.1
Owyhee (Idaho)	3	2.7
Skull Springs	2	1.8
Sourdough Mountain	32	28.6
Timber Butte (Idaho)	1	0.9
Venator	11	9.8
Wildcat Creek	3	2.7
Unknown 1	9	8.0
Unknown 2	13	11.6
Unknowns 3-14	17	15.2
Total	112	100.0

* Not obsidian; microcrystalline to glassy rhyolite or basaltic andesite raw material.

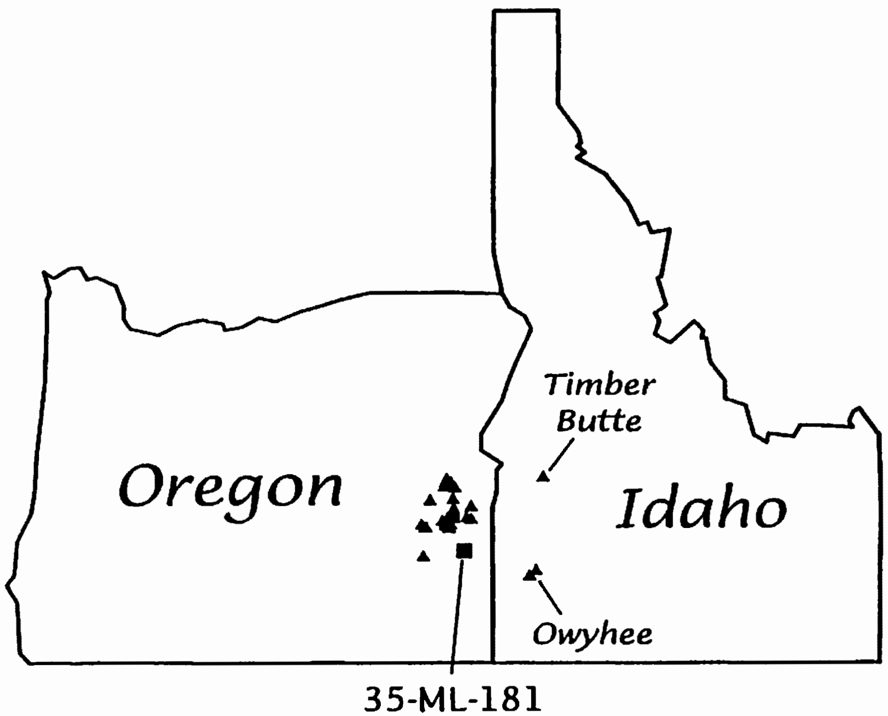

Figure 1 (above). Locations of the Birch Creek Site and obsidian sources identified by trace element studies.

Figure 2 (right). Locations of obsidian sources in southeastern Oregon that were found at 35-ML-181. Several of the sources are associated with large volcanic ashflows and are found over a large geographic area.

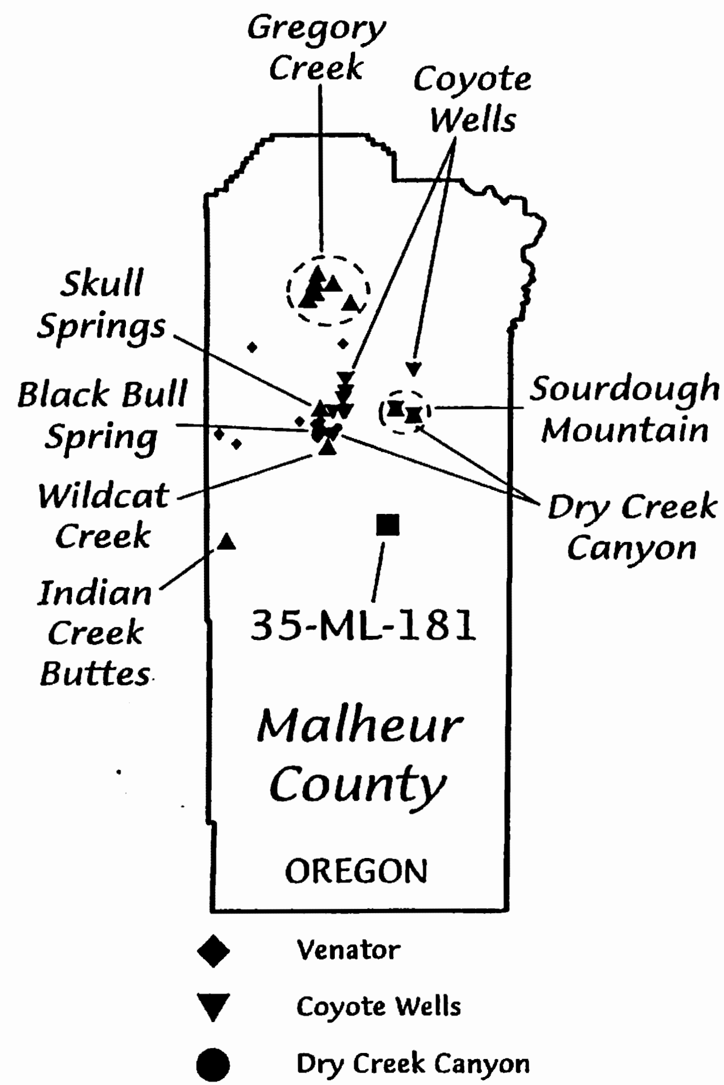

Table 2. Descriptions of obsidian and other toolstone sources identified in the current investigation. Summaries include results of unpublished field and geochemical source research conducted by Northwest Research (see Skinner 2001). Table continued on next page.

Geologic Source	Location	Description	References
Black Bull Spring	Malheur County, Oregon	Dark gray and glassy to very fine-grained rhyolite specimens have been gathered from the Black Bull Spring vicinity located just north of Dry Creek. Characterized geologic specimens were collected from the mapped Littlefield Rhyolite formation (unit Tlr in Evans and Binger 1998a) and it is likely that this material is found at many locations in association with this widespread unit. Although the Black Bull Spring source is not a true obsidian, it is an excellent toolstone and appears to be an suitable candidate for trace element provenience studies. The extent of the prehistoric use of this source is not known at this time.	Evans and Binger 1998a
Coyote Wells	Malheur County, Oregon	First described as the Skull Springs area source by Sappington (1981a), obsidian nodules correlated with the Coyote Wells geochemical source are distributed over a wide area in northcentral Malheur County. Although very few artifacts characterization studies have been carried out in the source region, obsidian artifacts correlated with Coyote Wells have been reported from as far west as the Lost Dune Site (35-HA-792) in the Malheur Basin, as far north as the Malheur National Forest, and at sites along the Malheur River and Oregon Highway 20. This source was also called the Riley Mimic source by Skinner and Thatcher (1998) because of its geochemical similarities to the Riley source located to the west of the Harney-Malheur Basin.	Brooks 1992a Lyons et al. 2001 Sappington 1981a Skinner and Thatcher 1998
Dry Creek Canyon	Malheur County, Oregon	Dark gray to black very fine-grained basaltic andesite make up the Dry Creek Canyon source. Characterized source material has been collected in exposures above Dry Creek in the King Brown Cabin area, in the alluvial deposits of Dry Creek to the east of the King Brown Cabin, and in the nearby Skull Springs vicinity. It is likely that other outcrops of the material can be found associated with Tba units mapped by Evans and Binger 1998a. Although the Dry Creek Canyon source is not obsidian, it is an excellent toolstone and appears to be an suitable candidate for trace element provenience studies. The extent of the prehistoric use of this material is not known at this time.	Evans and Binger 1998a Lyons et al. 2001
Gregory Creek	Malheur County, Oregon	The Gregory Creek source, first briefly reported by Sappington (1981a), is spread over an area of several square miles in the vicinity of Indian Creek and Gregory Creek. The source has also been called the Jonesboro source and is almost certainly the same as the one identified as the Sugarloaf Butte source by Nelson (1984). Artifacts correlated with the Gregory Creek source are known primarily from sites located in the Malheur National Forest and Upper John Day Basin and from sites located along Oregon Highway 20 in the Jonesboro area. This source was called the Jonesboro source by Skinner and Thatcher (1998) because of the large proportion of material that was identified at sites along Oregon Highway 20 in the Jonesboro area.	Brooks and O'Brien 1992 Evans and Binger 1998b Nelson 1984 Sappington 1981a Skinner and Thatcher 1998
Indian Creek Buttes	Malheur County, Oregon	High quality obsidian associated with Indian Creek Buttes, a 10.32 m.y.-old rhyolite complex, is spread over an area of several square kilometers. Obsidian from this source is also found several km to the east in secondary deposits in Barren Valley where it is known as the Petroglyphs source. Initial trace element analysis of obsidian collected at several locations at Indian Creek Buttes indicates that at least two geochemical varieties (A and B) are distinguishable. Although provenance studies of artifacts from the Indian Creek Buttes region are still relatively uncommon, obsidian from this source has been identified at several archaeological sites to the west in the Harney-Malheur Basin and at a few sites to the north in the Malheur National Forest.	Johnson 1995 Lyons et al. 2001 Sappington 1981a

Table 2 (continued). Descriptions of obsidian and other toolstone sources identified in the current investigation. Table continued on next page.

Geologic Source	Location	Description	References
Owyhee	Owyhee County, Idaho	Also known as the Brown's Castle, Oreana, and Toy Pass source, nodules of black glass have been reported from several locations in the Toy Pass area of southeastern Idaho. Although little is known of the prehistoric use of obsidian from the source, glass correlated with the Owyhee source has been reported from Wilson Butte Cave in southcentral Idaho (Bailey 1992) and at sites in southern Malheur County, Oregon (Hanes 1992, Sappington 1980).	Bailey 1992 Hanes 1988 Sappington 1980, 1981a
Skull Springs	Malheur County, Oregon	Known from several source localities in the vicinity of Skull Springs, obsidian from this geochemical group often co-occurs in geologic contexts with glass from the Venator source. The obsidian is typically purplish in color and contains numerous very small phenocrysts that are barely visible to the naked eye. Little is currently known of the prehistoric use of this source and few characterized artifacts have been correlated with the source. Artifacts originating from the Skull Springs (also known as Skull Spring) source are known primarily from sites located in the Harney-Malheur Basin and those north of the source along Oregon Highway 20 in the Jonesboro area.	Evans and Binger 1999 Lyons et al. 2001 Skinner and Thatcher 1998
Sourdough Mountain	Malheur County, Oregon	Little is currently known of the geographic distribution and geochemical characteristics of obsidian from the recently-recognized Sourdough Mountain source. Obsidian nodules which will likely be found to be correlated with the source are widely distributed throughout the Sourdough Mountain and Twin Springs quadrangles. Because of an absence of artifact characterization studies in the source region, the extent of the prehistoric use of this material is not known. However, the results of the current investigation indicate that the source was clearly exploited by local groups.	Lyons et al. 2001
Timber Butte	Gem and Boise counties, western Idaho	Situated approximately 30 mi (48 km) north of Boise, Idaho, geologic obsidian from this source is found at many scattered localities in the Timber Butte vicinity. During the prehistoric period, the Timber Butte source was the most intensively used western Idaho obsidian source. Obsidian from this source has been previously identified at archaeological sites throughout Idaho, far eastern Oregon, and southeastern Washington.	Arnold 1984 Bailey 1992 Hanes 1988 Holmer 1997 Mattson et al. 1983 Reid 1997 Sappington 1981a, 1981b, 1981c, 1982, 1984 Yohe 1996
Venator	Harney County, Oregon	Nodules of high quality obsidian correlated with the Venator geochemical source are distributed over a very large region east of Malheur Lake and the townsite of Venator. Obsidian nodules are common in the river gravels and terrace deposits of the South Fork of the Malheur River in the area from Venator to Riverside and have also been found to the north at Horseshoe Bend in the Juntura area. Venator obsidian is also common in the highlands east of Riverside and has been found at many locations in the vicinity of Skull Springs, Coyote Wells, and Dry Creek Canyon. In at least one location, the obsidian is directly associated with a volcanic ashflow, the probable primary source of this widespread toolstone. A gray microcrystalline variety of excellent toolstone quality also co-occurs with the glassy variety at most source locations. Both the glassy and gray varieties of Venator source artifacts are commonly found at sites located throughout the Harney-Malheur Basin. Characterized artifacts from the source are also occasionally identified at sites in the Malheur National Forest and along Oregon Highway 20 to the north of the source in the Jonesboro area.	Ambroz 1997 Lyons et al. 2001 Skinner and Thatcher 1998

Table 2 (continued). Descriptions of obsidian and other toolstone sources identified in the current investigation.

Geologic Source	Location	Description	References
Wildcat Creek	Malheur County, Oregon	Trace element studies of the Wildcat Creek source are in their very early stages and little is known of the geographic distribution of glass correlated with this source. Although the extent of the prehistoric use of this material is largely unknown, the current investigation does indicate that it was used by local groups.	Brooks 1992b Evans and Binger 1999 Lyons et al. 2001

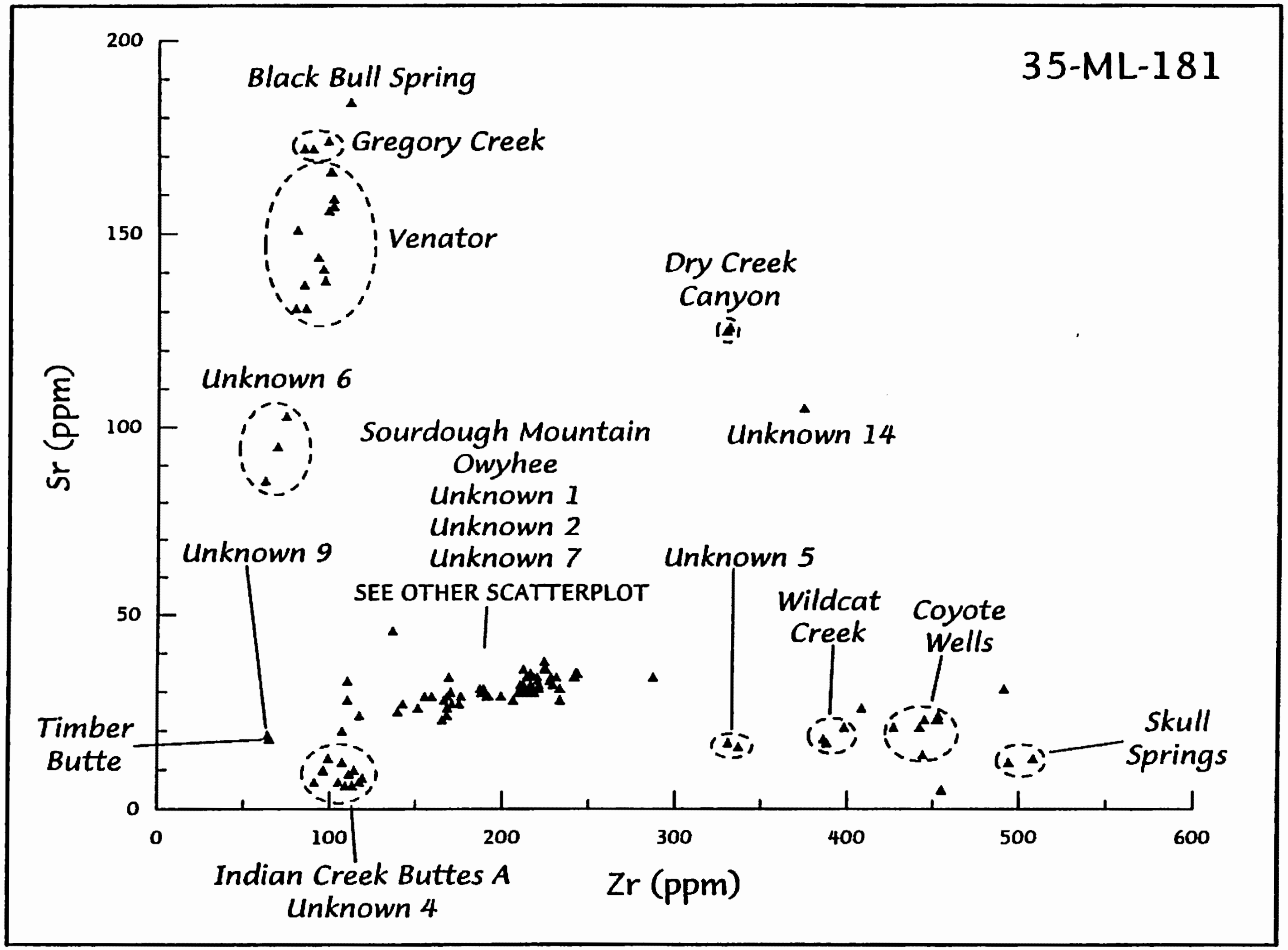

Figure 3. Scatterplot of strontium (Sr) plotted versus zirconium (Zr) for all analyzed artifacts. See the additional scatterplot (Figure 4) using a different trace element pair for a clearer visual discrimination of several of the obsidian sources.

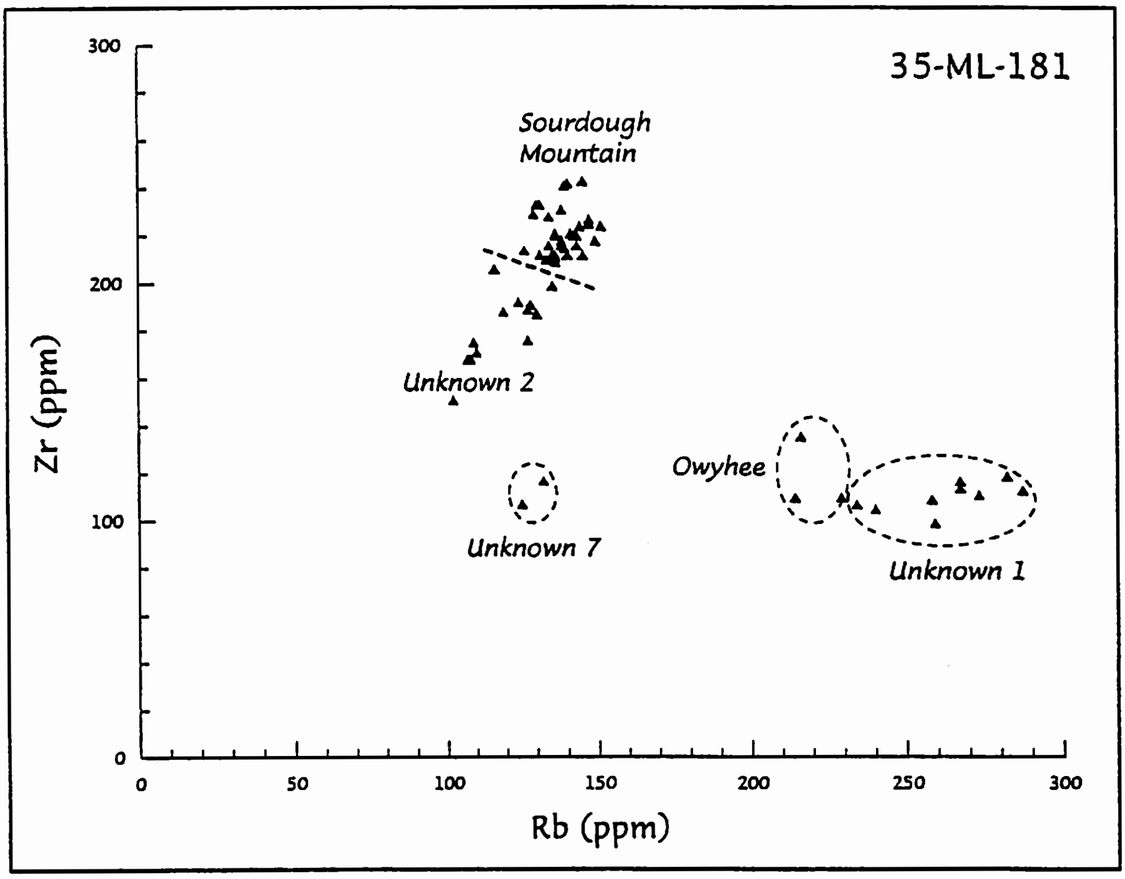

Figure 4. Scatterplot of rubidium (Rb) plotted versus zirconium (Zr) for selected samples.

Trace element studies of obsidian sources in southeastern Oregon are still in their infancy and our knowledge of their geographic distribution and geochemical characteristics is currently very incomplete. Despite an early and unfinished attempt by Sappington (1981a, 1981b) to characterize and inventory sources in this region, only recently have serious efforts begun once again to complete the inventory that he began. Without exception, the obsidian sources found at the Birch Creek Site are still incompletely mapped and inadequately characterized. Due to our insufficient knowledge of the available source universe and because of instrument difficulties encountered during the analysis of some small specimens in this project, the results of the trace element investigation reported here should be considered to be preliminary. The results of the trace element analysis of the Birch Creek collection will be reevaluated after initial field and trace element investigations of southeast Oregon are completed in the near future.

Fourteen different unknown geochemical source groups were identified among the 39 specimens that did not correlate with known obsidian sources, comprising almost 35 percent of the analyzed collection. We anticipate that further geochemical investigations of regional obsidian sources (that are now actively underway) will indicate that some of these unknown sources will be included in known source groups. For example, the trace element composition of the Unknown 2 source suggests that it is chemically genetically related to the Sourdough Mountain source (see Figure 4). After further geochemical studies are completed, it is likely that the chemical composition of this source group will prove to fall within the as yet undetermined range of geochemical variability of the Sourdough Mountain source.

Obsidian Hydration Analysis. Sixteen of the characterized obsidian artifacts were also prepared for obsidian hydration measurements and yielded 15 measurable rims. The specimen slides are curated at the Northwest Research Obsidian Studies Laboratory under accession number 2000-53. The results are summarized in Table 3 and are reported in Table B-1 in the Appendix.

Table 3. Summary of obsidian hydration measurements for analyzed artifacts.

Geologic Source	Rim Width (microns)	Total
Coyote Wells	4.0, 4.7, 4.7, 5.1, 6.9	5
Indian Creek Buttes A	5.0, 5.1, 5.2, 5.8	4
Sourdough Mountain	3.3, 4.0, 4.3, 4.5, 4.7, 4.8	6
Total	—	**15**

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Appendix

Results of X-Ray Fluorescence and Obsidian Hydration Analysis

Northwest Research Obsidian Studies Laboratory

Table A-1. Preliminary 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	Artifact Source
35-ML-181	1	9165	109	20	92	26	57	408	24	758	341	1043	1.19	37.3	52.4	Unknown 12
			± 7	4	3	7	3	5	2	86	58	20	0.11			
35-ML-181	2	7747	91	20	102	184	25	111	9	906	648	930	1.51	22.4	55.1	Black Bull Spring
			± 6	4	3	7	3	5	2	86	58	18	0.11			
35-ML-181	3	14541	83	23	136	30	35	212	24	652	230	447	0.66	36.2	35.6	Sourdough Mountain
			± 7	4	3	7	3	5	2	85	58	19	0.11			
35-ML-181	4	14635	75	22	188	30	55	170	33	325	202	189	0.85	54.0	88.1	Indian Creek Buttes A
			± 6	4	3	7	3	5	2	84	58	18	0.11			
35-ML-181	5	14536	62	24	145	35	38	243	26	807	216	502	0.90	52.3	38.3	Sourdough Mountain
			± 6	3	3	7	3	5	2	85	58	19	0.11			
35-ML-181	6	11880	161	20	96	105	69	374	18	1057	380	1355	2.52	67.2	77.3	Unknown 14
			± 7	3	3	7	3	5	2	87	58	19	0.11			
35-ML-181	7	7158	86	23	183	28	56	166	32	526	339	140	1.29	40.6	81.2	Indian Creek Buttes A
			± 6	3	3	7	3	5	1	85	58	18	0.11			
35-ML-181	8	7749	59	18	143	35	34	216	25	856	204	463	0.93	58.0	37.1	Sourdough Mountain
			± 6	3	3	7	3	5	2	85	58	18	0.11			
35-ML-181	9	--	112	28	267	10	72	114	49	220	365	23	0.67	20.5	104.2	Unknown 1
			± 6	3	4	7	3	5	2	84	58	18	0.11			
35-ML-181	10	14599	58	19	135	31	36	212	26	787	236	417	0.95	48.6	41.2	Sourdough Mountain
			± 6	3	3	7	3	5	2	85	58	18	0.11			
35-ML-181	11	14613	88	23	113	174	30	98	12	400	250	NM	0.43	22.3	39.7	Unknown 8 *
			± 8	4	4	8	3	5	2	84	58	NM	0.11			
35-ML-181	12	14611	29	22	136	30	39	211	23	559	166	417	0.65	57.2	41.0	Sourdough Mountain
			± 7	4	3	7	3	5	2	85	58	19	0.11			
35-ML-181	13	13099	42	17	126	34	35	214	19	273	113	NM	0.26	52.6	38.0	Sourdough Mountain *
			± 9	5	4	7	3	5	2	84	58	NM	0.11			
35-ML-181	14	14521	82	23	168	29	54	155	26	232	159	165	0.53	51.2	80.9	Indian Creek Buttes A
			± 6	4	4	7	3	5	2	84	58	18	0.11			
35-ML-181	15	14117	49	28	229	28	31	110	9	243	122	136	0.53	80.9	77.0	Owhyee
			± 6	4	4	7	3	5	2	84	58	18	0.11			
35-ML-181	16	13100	59	21	84	131	21	79	6	254	244	NM	0.43	22.9	61.2	Venator *
			± 7	4	3	7	3	5	2	84	58	NM	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.

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Table A-1. Preliminary 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	Artifact Source
35-ML-181	17	7832		42	20	68	86	18	62	11	166	221	NM	0.26	17.4	61.4	Unknown 6 *
			±	7	4	3	7	3	5	2	84	58	NM	0.11			
35-ML-181	18	7786A		35	23	138	34	38	231	22	814	217	549	0.95	54.2	39.8	Sourdough Mountain
			±	6	3	3	7	3	5	2	85	58	18	0.11			
35-ML-181	19	7786B		49	25	240	7	63	105	41	80	166	1	0.31	31.0	139.5	Unknown 1
			±	7	4	4	7	3	5	2	84	58	17	0.11			
35-ML-181	20	7783		40	16	92	131	22	85	10	356	427	805	0.80	19.8	76.1	Venator
			±	6	3	3	7	3	5	2	85	58	19	0.11			
35-ML-181	21	7674		117	20	234	12	60	107	42	247	159	NM	0.26	28.5	42.4	Unknown 1 *
			±	8	4	4	7	3	5	2	84	58	NM	0.11			
35-ML-181	22	14399		97	18	101	21	57	398	27	705	303	752	1.12	40.7	53.2	Wildcat Creek
			±	6	4	3	7	3	5	2	85	58	20	0.11			
35-ML-181	23	14480		36	19	142	33	39	220	24	626	194	411	0.74	51.1	41.3	Sourdough Mountain
			±	6	4	3	7	3	5	2	85	58	19	0.11			
35-ML-181	24	14452		68	21	139	34	39	241	21	783	282	503	0.81	33.1	35.6	Sourdough Mountain
			±	6	3	3	7	3	5	2	85	58	19	0.11			
35-ML-181	25	14461		36	15	128	29	30	191	21	504	159	NM	0.58	55.3	41.0	Unknown 2 *
			±	6	4	3	7	3	5	2	85	58	NM	0.11			
35-ML-181	26	14257		52	16	147	25	44	139	26	247	160	NM	0.54	50.9	76.6	Indian Creek Buttes A *
			±	6	4	3	7	3	5	2	84	58	NM	0.11			
35-ML-181	27	14449		111	27	193	34	54	169	29	388	257	NM	0.71	33.5	63.6	Indian Creek Buttes A
			±	6	4	4	7	3	5	2	84	58	NM	0.11			
35-ML-181	28	7859		63	22	109	159	29	101	12	430	470	924	0.91	20.1	71.6	Venator
			±	6	3	3	7	3	5	2	85	58	19	0.11			
35-ML-181	29	14456		162	35	181	5	83	455	25	597	205	38	1.44	86.2	79.5	Unknown 3
			±	7	4	4	7	3	5	2	85	58	18	0.11			
35-ML-181	30	7801		56	17	131	28	38	233	21	671	178	575	0.67	52.9	35.3	Sourdough Mountain
			±	6	3	3	7	3	5	2	85	58	18	0.11			
35-ML-181	31	14478		147	22	112	21	62	427	31	1142	599	765	1.75	28.1	50.4	Coyote Wells
			±	6	3	3	7	3	5	2	87	58	18	0.11			
35-ML-181	32	16414		56	19	132	24	38	117	24	122	108	NM	0.24	54.5	77.7	Unknown 7 *
			±	7	4	4	7	3	5	2	84	58	NM	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.

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Table A-1. Preliminary 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	Artifact Source
35-ML-181	33	15599		95	19	141	31	41	221	23	1027	439	451	1.22	28.4	39.7	Sourdough Mountain
			±	5	3	3	7	3	5	1	86	58	18	0.11			
35-ML-181	34	12355		53	23	130	31	34	233	22	859	240	539	0.94	47.0	37.3	Sourdough Mountain
			±	6	3	3	7	3	5	2	85	58	18	0.11			
35-ML-181	35	5991		85	24	109	141	30	95	17	338	503	879	0.76	15.8	76.8	Venator
			±	5	3	3	7	3	5	2	85	58	19	0.11			
35-ML-181	36	6062		68	22	175	29	56	168	33	346	210	172	0.88	52.8	85.8	Indian Creek Buttes A
			±	6	3	3	7	3	5	2	84	58	18	0.11			
35-ML-181	37	15219		80	19	132	34	37	287	19	851	313	501	0.93	33.1	37.5	Unknown 11
			±	6	3	3	7	3	5	2	86	58	18	0.11			
35-ML-181	38	6764		107	31	258	6	66	109	49	188	325	15	0.79	27.3	139.9	Unknown 1
			±	5	3	3	7	3	5	2	84	58	18	0.11			
35-ML-181	39	8040		130	19	117	21	56	442	29	1331	641	805	2.04	30.2	50.2	Coyote Wells
			±	6	3	3	7	3	5	1	87	58	18	0.11			
35-ML-181	40	7448		56	19	133	32	36	210	20	973	245	446	1.07	51.4	37.3	Sourdough Mountain
			±	5	3	3	7	3	5	1	86	58	18	0.11			
35-ML-181	41	7112		52	18	134	34	35	228	25	818	245	503	1.00	48.3	41.5	Sourdough Mountain
			±	5	3	3	7	3	5	2	85	58	18	0.11			
35-ML-181	42	6822		53	14	131	30	37	212	21	801	226	397	0.98	52.8	41.6	Sourdough Mountain
			±	5	3	3	7	3	5	2	85	58	18	0.11			
35-ML-181	43	5813		120	18	126	24	64	453	31	1045	421	839	1.53	36.9	48.4	Coyote Wells
			±	6	3	3	7	3	5	2	86	58	19	0.11			
35-ML-181	44	17865		73	23	106	156	29	98	12	434	509	922	1.01	20.2	78.3	Venator
			±	5	3	3	7	3	5	2	85	58	19	0.11			
35-ML-181	45	6871		42	27	151	36	40	224	24	836	221	464	0.92	51.7	37.8	Sourdough Mountain
			±	6	3	3	7	3	5	2	85	58	18	0.11			
35-ML-181	46	14544		117	23	135	29	39	199	23	501	203	401	0.41	28.3	30.5	Unknown 2?
			±	8	4	4	7	3	5	2	85	58	20	0.11			
35-ML-181	47	12296		56	23	203	7	50	91	35	79	183	14	0.35	29.2	153.3	Unknown 4
			±	6	4	4	7	3	5	2	84	58	19	0.11			
35-ML-181	48	14601		81	18	101	17	58	388	27	1142	449	800	1.78	39.5	51.2	Wildcat Creek
			±	5	3	3	7	3	5	1	87	58	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.

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Table A-1. Preliminary 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	Artifact Source
35-ML-181	49	CS-22-10		44	19	119	30	31	188	16	496	160	404	0.53	50.9	38.7	Unknown 2
			±	6	4	3	7	3	5	2	85	58	19	0.11			
35-ML-181	50	CS-24-10		39	24	139	31	40	215	20	972	251	434	1.16	53.6	40.0	Sourdough Mountain
			±	6	3	3	7	3	5	1	86	58	18	0.11			
35-ML-181	51	9223		153	22	116	31	70	491	29	1047	455	1113	1.60	35.3	50.6	Unknown 13
			±	7	4	3	7	3	5	2	86	58	21	0.11			
35-ML-181	52	14599		139	23	127	23	67	452	34	1157	472	781	1.56	32.9	44.6	Coyote Wells
			±	6	3	3	7	3	5	2	86	58	20	0.11			
35-ML-181	53	7741		121	36	282	8	72	119	50	300	307	7	0.73	27.1	82.8	Unknown 1
			±	6	3	4	7	3	5	2	84	58	22	0.11			
35-ML-181	54	CS-14-11		114	20	104	166	24	99	11	626	549	900	0.99	18.2	53.7	Venator
			±	6	3	3	7	3	5	2	85	58	19	0.11			
35-ML-181	55	13991		32	15	102	26	27	151	18	338	130	300	0.40	57.2	44.2	Unknown 2
			±	7	4	3	7	3	5	2	84	58	19	0.11			
35-ML-181	56	CS-14-11		65	20	97	144	28	92	13	259	304	734	0.49	19.5	67.5	Venator
			±	7	4	3	7	3	5	2	84	58	23	0.11			
35-ML-181	57	14059		168	31	117	12	80	494	32	664	424	431	1.46	35.1	72.8	Skull Springs
			±	8	4	3	7	3	6	2	85	58	21	0.11			
35-ML-181	58	14149		90	29	273	9	71	111	45	155	215	21	0.56	34.1	122.9	Unknown 1
			±	7	4	4	7	3	5	2	84	58	19	0.11			
35-ML-181	59	14620		38	16	129	32	34	229	26	799	214	550	1.01	58.6	42.8	Sourdough Mountain
			±	6	3	3	7	3	5	2	85	58	18	0.11			
35-ML-181	60	7615		55	18	104	157	23	101	13	374	368	890	0.76	22.5	69.2	Venator
			±	6	4	3	7	3	5	2	85	58	20	0.11			
35-ML-181	61	14309		138	32	259	13	64	99	41	171	161	NM	0.27	29.1	62.7	Unknown 1 *
			±	8	5	5	7	3	5	2	84	58	NM	0.11			
35-ML-181	62	14523		63	19	81	103	19	74	13	79	220	NM	0.24	16.6	113.5	Unknown 6 *
			±	7	4	3	7	3	5	2	84	58	NM	0.11			
35-ML-181	63	14523		84	21	98	17	45	331	26	542	231	NM	0.76	40.4	48.2	Unknown 5 *
			±	7	4	3	7	3	5	2	85	58	NM	0.11			
35-ML-181	64	14523		55	20	125	20	40	107	19	176	135	NM	0.41	53.6	83.6	Unknown 7 *
			±	7	4	3	7	3	5	2	84	58	NM	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. Preliminary 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	Artifact Source
				Trace Element Concentrations											Ratios		
35-ML-181	65	14149		90	32	220	10	58	96	33	89	160	NM	0.28	29.5	114.1	Unknown 4 *
			±	7	4	4	7	3	5	2	84	58	NM	0.11			
35-ML-181	66	14613		44	19	87	137	24	84	12	248	232	NM	0.44	25.0	63.8	Venator *
			±	8	4	3	7	3	5	2	84	58	NM	0.11			
35-ML-181	67	6664		56	22	144	38	38	224	22	954	281	458	1.11	44.7	39.3	Sourdough Mountain
			±	5	3	3	7	3	5	1	86	58	18	0.11			
35-ML-181	68	6791		61	19	140	32	37	212	21	753	182	462	0.75	56.4	34.7	Sourdough Mountain
			±	6	3	3	7	3	5	2	85	58	18	0.11			
35-ML-181	69	7498		125	38	184	18	46	65	39	160	652	26	0.35	6.1	80.9	Timber Butte
			±	6	3	3	7	3	5	2	84	58	18	0.11			
35-ML-181	70	7437		42	17	124	29	34	192	19	559	178	387	0.64	50.4	40.1	Unknown 2
			±	6	4	3	7	3	5	2	85	58	19	0.11			
35-ML-181	71	6775		53	18	147	36	41	225	26	1010	257	454	1.10	49.4	36.6	Sourdough Mountain
			±	5	3	3	7	3	5	1	86	58	18	0.11			
35-ML-181	72	4869		55	18	138	30	39	218	22	1042	259	443	1.19	52.9	38.4	Sourdough Mountain
			±	5	3	3	7	3	5	1	86	58	18	0.11			
35-ML-181	73	13298		59	21	136	30	39	209	21	892	257	438	1.13	50.8	42.5	Sourdough Mountain
			±	5	3	3	7	3	5	1	86	58	18	0.11			
35-ML-181	74	14387		58	21	143	33	41	220	20	803	190	469	0.86	60.2	37.0	Sourdough Mountain
			±	5	3	3	7	3	5	2	85	58	18	0.11			
35-ML-181	75	7618		114	25	122	23	63	453	32	1060	424	822	1.58	37.8	49.3	Coyote Wells
			±	6	3	3	7	3	5	2	86	58	19	0.11			
35-ML-181	76	13298		120	25	118	23	62	445	34	1211	430	796	1.66	39.1	45.4	Coyote Wells
			±	6	3	3	7	3	5	2	86	58	19	0.11			
35-ML-181	77	8367		59	19	134	32	41	216	21	921	300	405	1.17	43.0	42.6	Sourdough Mountain
			±	5	3	3	7	3	5	1	86	58	18	0.11			
35-ML-181	78	14618		94	21	109	138	28	96	13	342	557	851	0.78	14.4	77.8	Venator
			±	6	3	3	7	3	5	2	85	58	19	0.11			
35-ML-181	79	15375		37	23	214	33	29	110	10	355	143	215	0.67	74.0	65.2	Owhyee
			±	6	3	3	7	3	5	2	84	58	18	0.11			
35-ML-181	80	7552		59	19	138	30	38	216	20	842	226	420	1.02	54.9	41.2	Sourdough Mountain
			±	5	3	3	7	3	5	2	85	58	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.

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

Site	Specimen No.	Catalog No.		Trace Element Concentrations											Ratios		Artifact Source
				Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	$Fe_2O_3^T$	Fe:Mn	Fe:Ti	
35-ML-181	81	7552		86	18	106	18	53	386	32	575	279	636	0.87	35.9	51.6	Wildcat Creek
			±	7	4	3	7	3	5	2	85	58	20	0.11			
35-ML-181	82	14452		56	22	140	35	39	242	22	1070	290	511	1.22	46.8	38.3	Sourdough Mountain
			±	5	3	3	7	3	5	1	86	58	18	0.11			
35-ML-181	83	14660		115	28	267	7	74	117	54	197	363	17	0.71	21.7	121.8	Unknown 1
			±	6	3	4	7	3	5	2	84	58	18	0.11			
35-ML-181	84	7550		64	21	169	29	50	159	30	354	221	168	0.77	43.9	74.6	Indian Creek Buttes A
			±	6	3	3	7	3	5	2	84	58	18	0.11			
35-ML-181	85	13061		60	19	147	33	41	227	25	762	217	443	0.90	51.4	40.3	Sourdough Mountain
			±	6	3	3	7	3	5	2	85	58	18	0.11			
35-ML-181	86	13017		56	30	85	151	22	80	12	97	306	NM	0.39	15.7	138.0	Gregory Creek? *
			±	7	4	3	7	3	5	2	85	58	NM	0.11			
35-ML-181	87	13017A		95	21	145	36	36	212	26	644	240	379	0.61	32.1	33.9	Sourdough Mountain
			±	7	4	3	7	3	5	2	85	58	19	0.11			
35-ML-181	88	13017B		52	11	136	34	38	220	21	584	180	403	0.68	52.5	41.0	Sourdough Mountain
			±	6	4	3	7	3	5	2	85	58	20	0.11			
35-ML-181	89	13017C		45	22	130	31	37	187	13	554	167	NM	0.64	55.2	40.4	Unknown 2 *
			±	6	4	3	7	3	5	2	85	58	NM	0.11			
35-ML-181	90	13017D		39	10	107	24	31	168	16	403	136	354	0.44	56.8	40.6	Unknown 2
			±	6	4	3	7	3	5	2	84	58	19	0.11			
35-ML-181	91	13153		33	21	116	28	36	206	19	752	229	474	0.96	51.0	43.4	Unknown 2
			±	6	3	3	7	3	5	2	85	58	18	0.11			
35-ML-181	92	13018		83	26	94	172	27	89	16	285	475	2154	0.71	15.7	84.8	Gregory Creek
			±	6	3	3	7	3	5	2	86	58	25	0.11			
35-ML-181	93	13018A		62	18	161	27	42	142	27	282	187	151	0.75	54.1	90.6	Indian Creek Buttes A
			±	6	4	3	7	3	5	2	84	58	19	0.11			
35-ML-181	94	13018B		52	20	127	31	34	189	17	695	204	349	0.86	53.9	42.3	Unknown 2
			±	5	3	3	7	3	5	2	85	58	19	0.11			
35-ML-181	95	13977		39	22	127	29	30	176	14	337	134	NM	0.39	53.1	43.7	Unknown 2 *
			±	7	4	4	7	3	5	2	84	58	NM	0.11			
35-ML-181	96	15087		170	21	122	13	78	508	35	942	543	601	1.86	33.3	64.8	Skull Springs
			±	7	4	3	7	3	5	2	86	58	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.

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

				Trace Element Concentrations											Ratios		
Site	Specimen No.	Catalog No.		Zn	Pb	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	$Fe_2O_3^T$	Fe:Mn	Fe:Ti	Artifact Source
35-ML-181	97	13152		99	21	149	34	39	218	21	759	297	421	0.85	32.4	38.4	Sourdough Mountain
			±	6	3	3	7	3	5	2	85	58	19	0.11			
35-ML-181	98	13152B		31	15	110	27	31	171	16	584	174	409	0.66	54.1	39.8	Unknown 2
			±	6	3	3	7	3	5	2	85	58	18	0.11			
35-ML-181	99	13153		62	32	94	172	24	84	15	193	503	2012	0.77	15.9	132.7	Gregory Creek
			±	6	3	3	7	3	5	2	86	58	26	0.11			
35-ML-181	100	13153A		39	18	108	26	33	168	22	349	136	293	0.39	50.9	41.4	Unknown 2
			±	6	4	3	7	3	5	2	84	58	19	0.11			
35-ML-181	101	CS-17-11		51	8	33	19	12	64	4	681	127	210	0.36	54.2	20.5	Unknown 9
			±	6	4	3	7	3	5	2	85	58	18	0.11			
35-ML-181	102	CS-17-10		49	21	109	27	28	175	23	412	142	304	0.40	48.6	36.2	Unknown 2
			±	7	4	3	7	3	5	2	84	58	21	0.11			
35-ML-181	103	14709		81	17	87	16	44	337	24	647	285	597	0.98	38.9	51.2	Unknown 5
			±	6	4	3	7	3	5	2	85	58	20	0.11			
35-ML-181	104	14467		176	21	100	14	65	444	24	680	420	420	1.39	33.7	67.6	Coyote Wells
			±	8	4	3	7	3	5	2	85	58	21	0.11			
35-ML-181	105	14968		69	29	216	46	30	136	13	469	160	525	0.93	83.3	66.8	Owhyee?
			±	5	3	3	7	3	5	1	85	58	18	0.11			
35-ML-181	106	5503		48	17	68	95	18	69	9	87	181	NM	0.17	17.5	83.8	Unknown 6 *
			±	7	4	3	7	3	5	2	84	58	NM	0.11			
35-ML-181	107	14649		99	19	148	126	30	331	17	1580	348	990	1.49	45.1	31.4	Dry Creek Canyon
			±	6	3	3	7	3	5	2	87	58	19	0.11			
35-ML-181	108	15051		25	16	85	23	25	165	17	381	149	459	0.49	53.0	46.3	Unknown 10
			±	7	4	3	7	3	5	2	85	58	19	0.11			
35-ML-181	109	8039		88	23	152	125	30	329	19	1819	281	979	1.59	62.7	29.1	Dry Creek Canyon
			±	6	3	3	7	3	5	2	87	58	19	0.11			
35-ML-181	110	6794		97	29	287	6	75	113	46	229	320	11	0.83	29.0	121.0	Unknown 1
			±	6	3	4	7	3	5	2	84	58	19	0.11			
35-ML-181	111	9082		67	20	109	166	29	100	14	526	553	917	1.14	20.5	72.2	Venator
			±	5	3	3	7	3	5	1	85	58	18	0.11			
35-ML-181	112	15046		85	21	136	32	38	221	23	1110	368	487	1.28	36.5	38.5	Sourdough Mountain
			±	5	3	3	7	3	5	1	86	58	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.

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Table B-1. Obsidian Hydration Results and Sample Provenience: Birch Creek Site (35-ML-181), Malheur County, Oregon

Site	Specimen No.	Catalog No.	Unit	Depth (cm)	Artifact Type[A]	Artifact Source	Hydration Rims Rim 1	Hydration Rims Rim 2	Comments[B]
35-ML-181	1	9165	N17/W7	Level 10	BIF	Unknown 12	NM ± NM	NM ± NM	--
35-ML-181	2	7747	N19/W6	Level 15	BIF	Black Bull Spring	NM ± NM	NM ± NM	--
35-ML-181	3	14541	N19/W6	Level 16	BIF	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	4	14635	N17/W8	Level 11	BIF	Indian Creek Buttes A	5.0 ± 0.1	NM ± NM	Same rim on BRE
35-ML-181	5	14536	N19/W6	Level 18	DEB	Sourdough Mountain	4.0 ± 0.1	NM ± NM	--
35-ML-181	6	11880	N17/W7	Level 29	PPT	Unknown 14	NM ± NM	NM ± NM	--
35-ML-181	7	7158	N17/W7	Level 12	UFT	Indian Creek Buttes A	NM ± NM	NM ± NM	--
35-ML-181	8	7749	N19/W6	Level 15	PPT	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	9	--	N17/W6	Level 12	DEB	Unknown 1	NM ± NM	NM ± NM	--
35-ML-181	10	14599	N17/W8	Level 11	DEB	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	11	14613	N19/W5	Level 24	DEB	Unknown 8 *	NM ± NM	NM ± NM	--
35-ML-181	12	14611	N19/W5	Level 24	DEB	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	13	13099	N19/W9	Level 25	DEB	Sourdough Mountain *	NM ± NM	NM ± NM	--
35-ML-181	14	14521	N19/W6	Level 23	BIF	Indian Creek Buttes A	NA ± NA	NM ± NM	NVH
35-ML-181	15	14117	N19/W7	Level 23	BIF	Owhyee	NM ± NM	NM ± NM	--
35-ML-181	16	13100	N19/W7	Level 25	DEB	Venator *	NM ± NM	NM ± NM	--
35-ML-181	17	7832	N19/W6	Level 26	DEB	Unknown 6 *	NM ± NM	NM ± NM	--
35-ML-181	18	7786A	N19/W6	Level 21	DEB	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	19	7786B	N19/W6	Level 21	DEB	Unknown 1	NM ± NM	NM ± NM	--
35-ML-181	20	7783	N19/W6	Level 21	DEB	Venator	NM ± NM	NM ± NM	--
35-ML-181	21	7674	N19/W5	Level 22	DEB	Unknown 1 *	NM ± NM	NM ± NM	--
35-ML-181	22	14399	N19/W7	Level 21	DEB	Wildcat Creek	NM ± NM	NM ± NM	--
35-ML-181	23	14480	N19/W6	Level 39	DEB	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	24	14452	N19/W6	Level 29	DEB	Sourdough Mountain	NM ± NM	NM ± NM	--

[A] BIF = Biface; DEB = Debitage; PPT = Projectile Point; UFT = Utilized Flake Tool
[B] See text for explanation of comment abbreviations
NA = Not Available; NM = Not Measured; * = Small sample

Northwest Research Obsidian Studies Laboratory

Table B-1. Obsidian Hydration Results and Sample Provenience: Birch Creek Site (35-ML-181), Malheur County, Oregon

Site	Specimen No.	Catalog No.	Unit	Depth (cm)	Artifact Type[A]	Artifact Source	Hydration Rims: Rim 1	Hydration Rims: Rim 2	Comments[B]
35-ML-181	25	14461	N19/W6	Level 37	DEB	Unknown 2 *	NM ± NM	NM ± NM	--
35-ML-181	26	14257	N19/W5	Level 29	BIF	Indian Creek Buttes A *	NM ± NM	NM ± NM	--
35-ML-181	27	14449	N19/W6	Level 29	BIF	Indian Creek Buttes A	5.1 ± 0.1	NM ± NM	Same rim on BRE
35-ML-181	28	7859	N19/W6	Level 36	PPT	Venator	NM ± NM	NM ± NM	--
35-ML-181	29	14456	N19/W6	Level 37	PPT	Unknown 3	NM ± NM	NM ± NM	--
35-ML-181	30	7801	N19/W6	Level 42	BIF	Sourdough Mountain	3.3 ± 0.1	NM ± NM	Same rim on BRE
35-ML-181	31	14478	N19/W6	Level 39	UFT	Coyote Wells	6.9 ± 0.0	NM ± NM	--
35-ML-181	32	16414	N19/W6	Level 36	DEB	Unknown 7 *	NM ± NM	NM ± NM	--
35-ML-181	33	15599	N19/W7	Level 5	DEB	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	34	12355	N19/W6	Level 9	PPT	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	35	5991	N17/W5	Level 8	PPT	Venator	NM ± NM	NM ± NM	--
35-ML-181	36	6062	N17/W5	Level 8	BIF	Indian Creek Buttes A	5.2 ± 0.1	NM ± NM	Same rim on BRE
35-ML-181	37	15219	N19/W7	Level 8	DEB	Unknown 11	NM ± NM	NM ± NM	--
35-ML-181	38	6764	N17/W5	Level 4	DEB	Unknown 1	NM ± NM	NM ± NM	--
35-ML-181	39	8040	N17/W8	Level 4	BIF	Coyote Wells	5.1 ± 0.1	NM ± NM	--
35-ML-181	40	7448	N17/W6	Level 6	DEB	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	41	7112	N17/W7	Level 4	DEB	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	42	6822	N16/W8	Level 4	DEB	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	43	5813	N17.63/W3.9	Level 4	PPT	Coyote Wells	NM ± NM	NM ± NM	--
35-ML-181	44	17865	N19/W5	Level 19	PPT	Venator	NM ± NM	NM ± NM	--
35-ML-181	45	6871	N16/W5	Level 4	BIF	Sourdough Mountain	4.3 ± 0.1	NM ± NM	Same rim on BRE
35-ML-181	46	14544	N19/W6	Level 16	DEB	Unknown 2?	NM ± NM	NM ± NM	--
35-ML-181	47	12296	N19/W6	Level 19	DEB	Unknown 4	NM ± NM	NM ± NM	--
35-ML-181	48	14601	N17/W8	Level 11	DEB	Wildcat Creek	NM ± NM	NM ± NM	--

[A] BIF = Biface; DEB = Debitage; PPT = Projectile Point; UFT = Utilized Flake Tool

[B] See text for explanation of comment abbreviations

NA = Not Available; NM = Not Measured; * = Small sample

Northwest Research Obsidian Studies Laboratory

Table B-1. Obsidian Hydration Results and Sample Provenience: Birch Creek Site (35-ML-181), Malheur County, Oregon

Site	Specimen No.	Catalog No.	Unit	Depth (cm)	Artifact Type[A]	Artifact Source	Hydration Rims: Rim 1	Hydration Rims: Rim 2	Comments[B]
35-ML-181	49	CS-22-10	N17/W8	Level 11	DEB	Unknown 2	NM ± NM	NM ± NM	--
35-ML-181	50	CS-24-10	N16/W6	Level 11	DEB	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	51	9223	N17/W7	Level 10	DEB	Unknown 13	NM ± NM	NM ± NM	--
35-ML-181	52	14599	N17/W8	Level 11	DEB	Coyote Wells	4.7 ± 0.1	NM ± NM	--
35-ML-181	53	7741	N19/W6	Level 15	DEB	Unknown 1	NM ± NM	NM ± NM	--
35-ML-181	54	CS-14-11	N19/W6	Level 16	DEB	Venator	NM ± NM	NM ± NM	--
35-ML-181	55	13991	N17/W7	Level 14	DEB	Unknown 2	NM ± NM	NM ± NM	--
35-ML-181	56	CS-14-11	N17/W7	Level 38	DEB	Venator	NM ± NM	NM ± NM	--
35-ML-181	57	14059	N19/W5	Level 25	DEB	Skull Springs	NM ± NM	NM ± NM	--
35-ML-181	58	14149	N17/W7	Level 38	DEB	Unknown 1	NM ± NM	NM ± NM	--
35-ML-181	59	14620	N19/W5	Level 25	DEB	Sourdough Mountain	4.7 ± 0.1	NM ± NM	--
35-ML-181	60	7615	N17/W6	Level 39	DEB	Venator	NM ± NM	NM ± NM	--
35-ML-181	61	14309	N19/W5	Level 23	DEB	Unknown 1 *	NM ± NM	NM ± NM	--
35-ML-181	62	14523	N19/W6	Level 23	DEB	Unknown 6 *	NM ± NM	NM ± NM	--
35-ML-181	63	14523	N19/W6	Level 23	DEB	Unknown 5 *	NM ± NM	NM ± NM	--
35-ML-181	64	14523	N19/W6	Level 23	DEB	Unknown 7 *	NM ± NM	NM ± NM	--
35-ML-181	65	14149	N17/W7	Level 38	DEB	Unknown 4 *	NM ± NM	NM ± NM	--
35-ML-181	66	14613	N19/W5	Level 24	DEB	Venator *	NM ± NM	NM ± NM	--
35-ML-181	67	6664	N17/W5	Level 6	DEB	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	68	6791	N16/W6	Level 5	DEB	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	69	7498	N17/W8	Level 5	PPT	Timber Butte	NM ± NM	NM ± NM	--
35-ML-181	70	7437	N16/W7	Level 5	DEB	Unknown 2	NM ± NM	NM ± NM	--
35-ML-181	71	6775	N17/W5	Level 4	PPT	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	72	4869	N16/W8	Level 8	DEB	Sourdough Mountain	NM ± NM	NM ± NM	--

[A] BIF = Biface; DEB = Debitage; PPT = Projectile Point; UFT = Utilized Flake Tool

[B] See text for explanation of comment abbreviations

NA = Not Available; NM = Not Measured; * = Small sample

Northwest Research Obsidian Studies Laboratory

Table B-1. Obsidian Hydration Results and Sample Provenience: Birch Creek Site (35-ML-181), Malheur County, Oregon

Site	Specimen No.	Catalog No.	Unit	Depth (cm)	Artifact Type[A]	Artifact Source	Hydration Rims Rim 1	Hydration Rims Rim 2	Comments[B]
35-ML-181	73	13298	N19/W6	Level 10	DEB	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	74	14387	N19/W7	Level 13	DEB	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	75	7618	N19/W7	Level 10	PPT	Coyote Wells	NM ± NM	NM ± NM	--
35-ML-181	76	13298	N19/W6	Level 10	UFT	Coyote Wells	4.0 ± 0.1	NM ± NM	DFV
35-ML-181	77	8367	N17/W6	Level 11	UFT	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	78	14618	N19/W5	Level 26	DEB	Venator	NM ± NM	NM ± NM	--
35-ML-181	79	15375	N17/W7	Level 47	PPT	Owhyee	NM ± NM	NM ± NM	--
35-ML-181	80	7552	N17/W5	Level 25	DEB	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	81	7552	N17/W5	Level 25	DEB	Wildcat Creek	NM ± NM	NM ± NM	--
35-ML-181	82	14452	N19/W6	Level 29	DEB	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	83	14660	N17/W7	Level 49	PPT	Unknown 1	NM ± NM	NM ± NM	--
35-ML-181	84	7550	N17/W5	Level 25	BIF	Indian Creek Buttes A	NM ± NM	NM ± NM	--
35-ML-181	85	13061	N17/W7	Level 44	PPT	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	86	13017	N17/W8	Level 34	DEB	Gregory Creek? *	NM ± NM	NM ± NM	--
35-ML-181	87	13017A	N17/W8	Level 34	DEB	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	88	13017B	N17/W8	Level 34	DEB	Sourdough Mountain	NM ± NM	NM ± NM	--
35-ML-181	89	13017C	N17/W8	Level 34	DEB	Unknown 2 *	NM ± NM	NM ± NM	--
35-ML-181	90	13017D	N17/W8	Level 34	DEB	Unknown 2	NM ± NM	NM ± NM	--
35-ML-181	91	13153	N17/W8	Level 33	DEB	Unknown 2	NM ± NM	NM ± NM	--
35-ML-181	92	13018	N17/W8	Level 34	DEB	Gregory Creek	NM ± NM	NM ± NM	--
35-ML-181	93	13018A	N17/W8	Level 34	DEB	Indian Creek Buttes A	5.8 ± 0.1	NM ± NM	--
35-ML-181	94	13018B	N17/W8	Level 34	DEB	Unknown 2	NM ± NM	NM ± NM	--
35-ML-181	95	13977	N17/W8	Level 32	DEB	Unknown 2 *	NM ± NM	NM ± NM	--
35-ML-181	96	15087	N17/W7	Level 34	PPT	Skull Springs	NM ± NM	NM ± NM	--

[A] BIF = Biface; DEB = Debitage; PPT = Projectile Point; UFT = Utilized Flake Tool
[B] See text for explanation of comment abbreviations
NA = Not Available; NM = Not Measured; * = Small sample

Northwest Research Obsidian Studies Laboratory

Table B-1. Obsidian Hydration Results and Sample Provenience: Birch Creek Site (35-ML-181), Malheur County, Oregon

Site	Specimen No.	Catalog No.	Unit	Depth (cm)	Artifact Type[A]	Artifact Source	Hydration Rims Rim 1	Hydration Rims Rim 2	Comments[B]
35-ML-181	97	13152	N17/W8	Level 33	DEB	Sourdough Mountain	4.5 ± 0.1	NM ± NM	--
35-ML-181	98	13152B	N17/W8	Level 33	DEB	Unknown 2	NM ± NM	NM ± NM	--
35-ML-181	99	13153	N17/W8	Level 33	DEB	Gregory Creek	NM ± NM	NM ± NM	--
35-ML-181	100	13153A	N17/W8	Level 33	DEB	Unknown 2	NM ± NM	NM ± NM	--
35-ML-181	101	CS-17-11	N17/W7	Level 30	DEB	Unknown 9	NM ± NM	NM ± NM	--
35-ML-181	102	CS-17-10	N17/W8	Level 34	DEB	Unknown 2	NM ± NM	NM ± NM	--
35-ML-181	103	14709	N19/W5	Level 30	DEB	Unknown 5	NM ± NM	NM ± NM	--
35-ML-181	104	14467	N19/W6	Level 27	DEB	Coyote Wells	4.7 ± 0.0	NM ± NM	--
35-ML-181	105	14968	N19/W6	Level 17	PPT	Owhyee?	NM ± NM	NM ± NM	--
35-ML-181	106	5503	N16/W7	Level 10	PPT	Unknown 6 *	NM ± NM	NM ± NM	--
35-ML-181	107	14649	N17/W5	Level 21	BIF	Dry Creek Canyon	NM ± NM	NM ± NM	--
35-ML-181	108	15051	N19/W7	Level 6	DEB	Unknown 10	NM ± NM	NM ± NM	--
35-ML-181	109	8039	N17/W8	Level 4	BIF	Dry Creek Canyon	NM ± NM	NM ± NM	--
35-ML-181	110	6794	N17/W7	Level 8	DEB	Unknown 1	NM ± NM	NM ± NM	--
35-ML-181	111	9082	N17/W4	Level 12	BIF	Venator	NM ± NM	NM ± NM	--
35-ML-181	112	15046	N19/W7	Level 16	DEB	Sourdough Mountain	4.8 ± 0.1	NM ± NM	--

[A] BIF = Biface; DEB = Debitage; PPT = Projectile Point; UFT = Utilized Flake Tool
[B] See text for explanation of comment abbreviations
NA = Not Available; NM = Not Measured; * = Small sample

Abbreviations and Definitions Used in the Comments Column

A, B, C - 1st, 2nd, and 3rd cuts, respectively.
All hydration rim measurements are recorded in microns.

BEV - (Beveled). Artifact morphology or cut configuration resulted in a beveled thin section edge.

BRE - (BREak). The thin section cut was made across a broken edge of the artifact. Resulting hydration measurements may reveal when the artifact was broken, relative to its time of manufacture.

DES - (DEStroyed). The artifact or flake was destroyed in the process of thin section preparation. This sometimes occurs during the preparation of extremely small items, such as pressure flakes.

DFV - (Diffusion Front Vague). The diffusion front, or the visual boundary between hydrated and unhydrated portions of the specimen, are poorly defined. This can result in less precise measurements than can be obtained from sharply demarcated diffusion fronts. The technician must often estimate the hydration boundary because a vague diffusion front often appears as a relatively thick, dark line or a gradation in color or brightness between hydrated and unhydrated layers.

DIS - (DIScontinuous). A discontinuous or interrupted hydration rind was observed on the thin section.

HV - (Highly Variable). The hydration rind exhibits variable thickness along continuous surfaces. This variability can occur with very well- defined bands as well as those with irregular or vague diffusion fronts.

IRR - (IRRegular). The surfaces of the thin section (the outer surfaces of the artifact) are uneven and measurement is difficult.

1SO - (1 Surface Only). Hydration was observed on only one surface or side of the thin section.

NOT - (NOT obsidian). Petrographic characteristics of the artifact or obsidian specimen indicate that the specimen is not obsidian.

NVH - (No Visible Hydration). No hydration rind was observed on one or more surfaces of the specimen. This does not mean that hydration is absent, only that hydration was not observed. Hydration rinds smaller than one micron often are not birefringent and thus cannot be seen by optical microscopy. "NVH" may be reported for the manufacture surface of a tool while a hydration measurement is reported for another surface, e.g. a remnant ventral flake surface.

OPA - (OPAque). The specimen is too opaque for measurement and cannot be further reduced in thickness.

PAT - (PATinated). This description is usually noted when there is a problem in measuring the thickness of the hydration rind, and refers to the unmagnified surface characteristics of the artifact, possibly indicating the source of the measurement problem. Only extreme patination is normally noted.

REC - (RECut). More than one thin section was prepared from an archaeological specimen. Multiple thin sections are made if preparation quality on the initial specimen is suspect or obviously poor. Additional thin sections may also be prepared if it is perceived that more information concerning an artifact's manufacture or use can be obtained.

UNR - (UNReadable). The optical quality of the hydration rind is so poor that accurate measurement is not possible. Poor thin section preparation is not a cause.

WEA - (WEAthered). The artifact surface appears to be damaged by wind erosion or other mechanical action.

Hydration Rind Measurements

Under certain conditions, obsidian hydration (OH) measurements may further refine a chronological sequence. However, recent studies indicate the difficulties associated with OH procedures. Optical measurements may prove inadequate for purposes of replicating results (Anovitz et al. 1999). Variability in relative humidity and site temperature influence OH rind thickness (Mazer et al. 1991). OH values have also proven susceptible to ground temperature and depth of artifact recovery (Ridings 1991). Artifact source and location must be controlled if results are to be of any use. I attempt to limit variability by selecting a total of 16 artifacts from three identified sources that have produced material throughout the stratigraphic sequence. These include Coyote Wells, Indian Creek Buttes–A (ICB–A), and Sourdough Mountain.

Results from Obsidian Hydration

OH results from Craig Skinner's Northwest Research Obsidian Studies Laboratory (hereafter NROSL) indicate that samples from three sources display thick rinds on flaked surfaces (Table 2.3, see also Appendix A). Average values range between four and five microns. However, variability produces conflicting interpretations. For example, the ICB-A source produces thicker rinds within Fill C than the stratigraphically lower Fill D. The Sourdough Mountain source produces thicker rinds in the uppermost layers than strata deep below it.

Table B.2 Hydration Rind Measurements by Stratum.

Inv #	Unit	Level	Stratum	Chemical Source	Hydration Rind (μ)	NROSL Specimen #
13298	N19-W6	10	Fill AB	Coyote Wells	4	76
8040	N17-W8	4	Fill AB	Coyote Wells	5.1	39
14599	N17-W8	11	Contact B	Coyote Wells	4.7	52
14467	N19-W6	27	Fill D	Coyote Wells	4.7	104
14478	N19-W6	39	Fill D	Coyote Wells	6.9	31
6062	N17-W5	8	Fill AB	ICB-A	5.2	36
14635	N17-W8	11	Contact B	ICB-A	5	4
13018	N17-W8	34	Fill C	ICB-A	5.8	93
14521	N19-W6	23	Contact C	ICB-A	0*	14
14449	N19-W6	29	Fill D	ICB-A	5.1	27
6871	N16-W5	4	Fill AB	Sourdough	4.3	45
15046	N19-W7	6	Fill AB	Sourdough	4.8	112
14536	N19-W6	18	Contact B	Sourdough	4	5
13152	N17-W8	33	Fill C	Sourdough	4.5	97
14620	N19-W5	25	Contact C	Sourdough	4.7	59
7801	N19-W6	42	Fill D	Sourdough	3.3	30

* No Measurable Rind.