An Experimental Approach to Determine Skill Level at Obsidian Biface Cache Site 35MA375, Salem, Oregon

A Thesis
Presented in Partial Fulfillment of the Requirements for the
Degree of Master of Arts
with a
Major in Anthropology
in the
College of Graduate Studies
University of Idaho
by
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August 2019

Authorization to Submit Thesis

This thesis of Marci D. Monaco, submitted for the degree of Master of Arts with a Major in Anthropology and titled "An Experimental Approach to Determine Skill Level at Obsidian Biface Cache Site 35MA375, Salem, Oregon" has been reviewed in final form. Permission, as indicated by the signatures and dates below, is now granted to submit final copies to the College of Graduate Studies for approval.

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Abstract

A landowner in Salem, Oregon, recovered an obsidian biface cache during the excavation of a spring fed pond in 2015. This unique archaeological site (35MA375) is the only recorded obsidian biface cache within Oregon's Willamette Valley. The cache provided a unique opportunity to examine bifacial blanks and produce data useful for interpreting other biface caches in the region. These obsidian bifacial blanks had natural and anthropogenic attributes that may hinder further reduction. Assessing a flintknapper's skill level may give us insight into why the bifaces have characteristics and attributes undesirable to an experienced flintknapper. I worked with novice, intermediate, and expert flintknappers to produce 15 obsidian bifacial blanks each. The project goal is to determine if skill level can be designated by comparing the technological analysis of the original bifacial blanks to those produced by flintknappers who vary in skill level. This approach provides information about choices and strategies used by novice flintknappers as they become progressively familiar with stone tool production.

Acknowledgements

This thesis would not have been possible without the support from my Committee Chair Dr. Robert L. Sappington. His continued support, advice, and sense of humor kept me focused and enthusiastic about my research. Dr. Laura Putsche provided me with her invaluable wisdom that helped me navigate through the graduate program. Dr. Mark Warner helped me with facilitating the presentation of my research throughout my time at the University of Idaho.

I would like to thank Daniel Stueber for teaching me to flintknap and encouraging me to pursue my goals in lithic technology. I would like to acknowledge Dr. John Fagan and Terry Ozbun for training me in lithic technology and cheering me on in my adventures in graduate school. I would like to thank David Quinn who is a wealth of information that is invaluable to every student who crosses his path. Thank you for all time and knowledge you shared with me.

This thesis was funded by the Donald E. Crabtree Memorial Scholarship, which supported me in the research and study of lithic technology.

Dedication

This thesis is dedicated to my best friend and loving partner, Cam Walker. Thank you for all your support, late night encouraging phone calls, and last-minute edits.

To my daughter, Isabela Monaco, you are such an amazing person and I want to thank you for hanging in there these past two years.

To my son, Nicholas Monaco, thank you for all your encouragement, phone calls, and puppy pictures.

To my beautiful mother, Val Wallace, thank you for being such a wonderful role model. Your love and support are beyond measure.

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Chapter 1: Introduction

In 2015, a landowner in Salem, Oregon, recovered an obsidian biface cache during the excavation of a spring fed pond. This unique archaeological site (35MA375) is the only recorded obsidian biface cache within Oregon's Willamette Valley. Oregon has over 40,000 recorded archaeological sites, but fewer than 30 are biface caches (Pouley 2017). Fourteen obsidian bifacial blanks were recovered by the landowner; a fifteenth bifacial blank was found during a subsequent excavation (Figure 1.1). The discovery of the cache provided a unique opportunity to examine a series of bifacial blanks and produce data that will be useful for interpreting other biface caches.

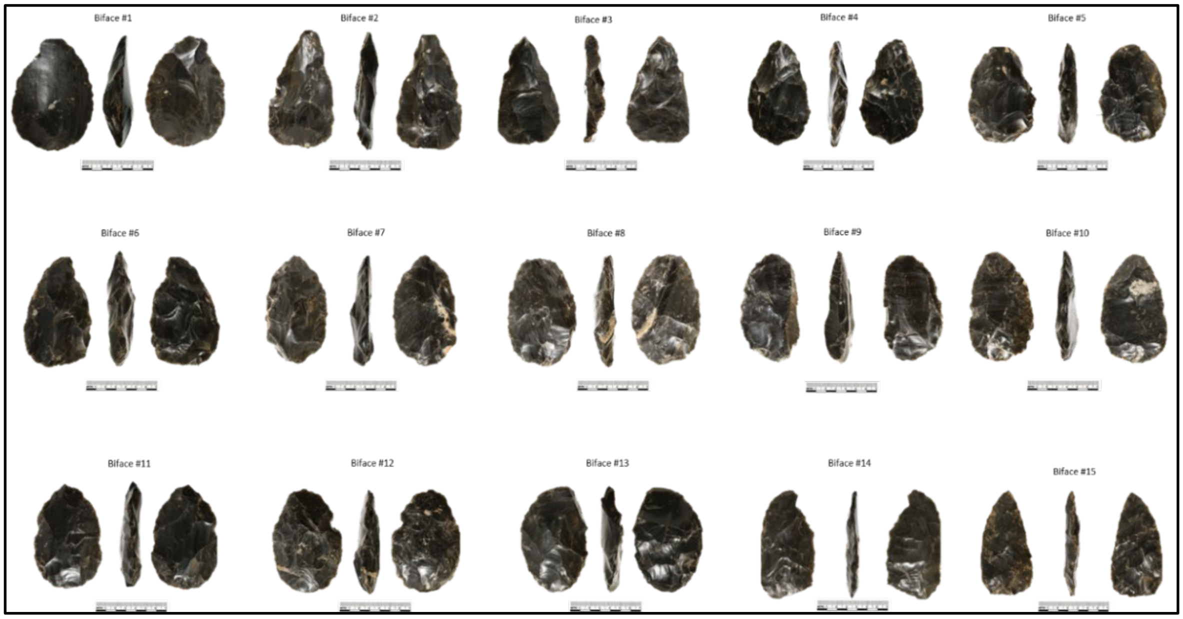

Figure 1.1: Obsidian Cache Bifaces from site 35MA375.

A bifacial blank is a piece of lithic material that has been reduced to a stage of reduction that is not intended to be the final product. This stage of reduction may occur at the lithic source to reduce the volume and weight for transportation. Northwest Research Obsidian Studies Laboratory geochemically sourced all 15 obsidian bifacial blanks from site 35MA375 to Obsidian Cliffs, Oregon (Figure 1.2), approximately 73 miles to the southeast if traveling in a straight line and much further if traveling by way of foot trails. Obsidian Cliffs obsidian is the most commonly identified obsidian in the Pacific Northwest (Baxter et al. 2015:224).

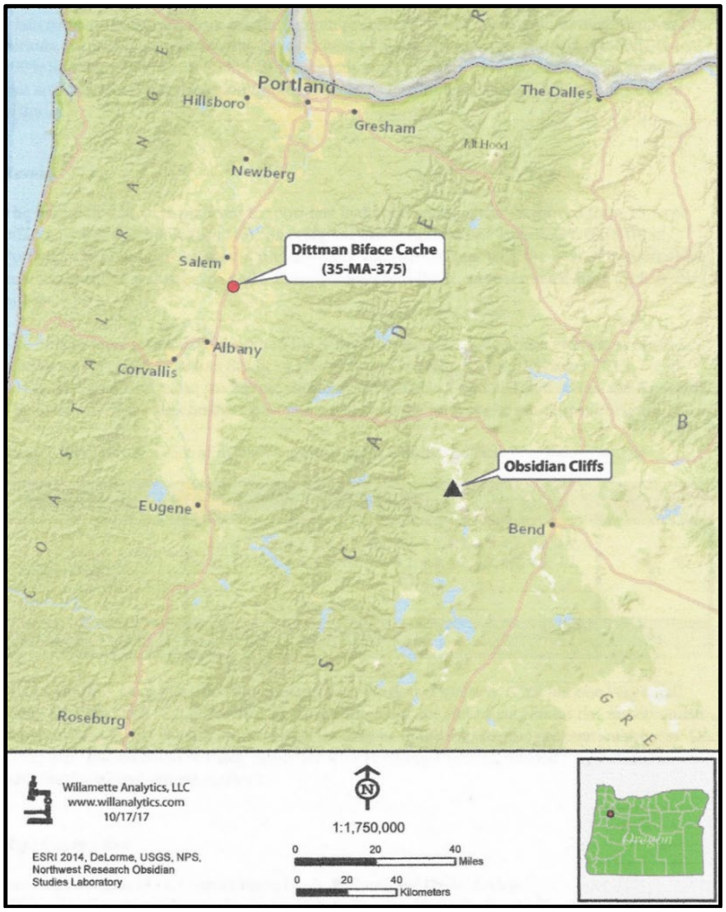

Figure 1.2: Location of 35MA375 and Obsidian Cliffs, Oregon. Adapted from Willamette Analytics Project 2017-15:2.

The obsidian bifacial blanks from site 35MA375 had several natural and anthropogenic attributes that are considered undesirable to an experienced flintknapper. The bifacial blanks were reduced minimally, crude in form, exhibited primary geologic cortex, phenocrysts, and square edges. Assessing a flintknapper's skill level may give us insight into why the bifaces have characteristics and attributes that could hinder further reduction.

Research Statement

The primary objective of this thesis is to employ an experimental archaeological approach to assess differing skill levels among flintknappers and apply this information to the bifacial blanks from site 35MA375. A secondary objective is to interpret theoretical underpinnings of caching behaviors at this site. Caches are defined as a collection of similar items stored for later use and are relatively rare in the archaeological record since they were generally intended for retrieval (Carpenter 2014:171). The stage of reduction varies greatly between lithic artifact caches. While many caches have artifacts similar to the bifacial blanks recovered from site 35MA375 in their triangular to oval shape, some have been reduced further to tool preforms (Scott et al. 1986:15).

All caches are the intentional action of a person or a group of people. Lithic artifact caching practices have occurred through time and space, and each cache must be assessed individually to determine if it was intended for a utilitarian or ritualistic function (Carpenter 2014:172-173). There are three prominent hypotheses regarding behavioral reasons for caching practices. One hypothesis suggests a cache is intended to provide a safety net of raw material or tools (utilitarian) that can be retrieved at a later date for use or trade

(Carpenter 2014:172; Scott et al. 1986:17). A second hypothesis is the cache was intended as a ritualistic or ceremonial cache and can be associated with burials. A third hypothesis suggests the combination of both ritual and utilitarian functions (Carpenter 2014:172). There was no evidence during excavation of site 35MA375 that the biface cache was associated with a burial and can therefore be interpreted as a utilitarian cache site that was meant for later retrieval.

Research Questions

Through the technological analysis of the cache bifaces and the experimental bifacial blanks the goal of this research is to determine if skill level can be determined by comparing the different sets of bifacial blanks. The experimental bifacial blank production was conducted in a controlled location where similar materials were provided to each volunteer. Flake blank and hammerstone selection was recorded as well as strategic and technological choices made by the flintknappers.

Volunteers came to this project with varying degrees of skill levels in lithic production. I worked with novice, intermediate, and expert flintknappers to produce 15 obsidian bifacial blanks per person. A novice flintknapper will have no experience with flintknapping and little to no theoretical background. An intermediate flintknapper will have some experience flintknapping and some theoretical background, whereas an expert flintknapper will have extensive flintknapping experience and theoretical background. A novice flintknapper with little to know theoretical background may not know or understand the fracture mechanics involved in stone tool production, whereas an intermediate or expert flintknapper are aware of fracture mechanics and able to apply it to the toolstone resulting in varying degrees of success.

This experiment is based on the analysis of the bifacial blanks recovered from the site, the use of similar material, and the employment of a similar reduction technology and strategy. I will address the following questions:

1. Can the flintknapper's skill level be determined by comparing the technological analysis of the cache and experimental bifaces?
2. Can behavioral attributes be inferred from the cache bifaces?

Chapter Overview

Chapter 1 provides the general background of site 35MA375 and the methods employed in this thesis, including the natural and cultural world of the Willamette Valley. Chapter 2 contains background on Oregon archaeology. Chapter 3 discusses general lithic studies and experiments. Chapter 4 discusses the theory and methods used in this project. Chapter 5 discusses the bifacial blank experiment with results. Chapter 6 concludes this thesis. Appendix A holds the technological analysis and attribute tables of the cache bifaces and the experimental bifaces. Appendix B has a table of other lithic caches in Oregon. Appendix C is the site report for 35MA375. Appendix D is the lithic analysis of site 35MA375.

Willamette Valley: Environmental Setting

Archaeological site 35MA375 is located within the Willamette Valley, in Salem, Oregon. The Willamette Valley ranges from 20 to 40 miles wide, bordered by the Cascade Mountain Range to the east, and the Coast Range to the west, and is entirely contained within Oregon. The Willamette Valley is named from the namesake river, which meanders approximately 130 miles from Cottage Grove in the south to the Columbia River in the north. The elevation within the Willamette Valley is 400 feet at Eugene and drops to approximately sea level at Portland (Orr et al. 2012:186). The Willamette Valley is an alluvial plain created by rivers coming from the Cascade Mountain Range and the Coastal Range. The McKenzie, Calapooia, North and South Santiam, Pudding, Molalla, and Clackamas rivers all have their headwaters in the Cascade Mountain Range, while the Long Tom, Marys, Luckiamute, Yamhill, and Tualatin rivers drain from the Coast range (Orr et al. 1012:186).

The Willamette Valley's geological history was shaped by the Missoula Floods, which were a series of catastrophic inundations that originated in Montana, crossed Idaho and Washington, and pressed through the Columbia River gorge to Oregon (Orr et al. 2012:194). The periodic Missoula flooding events began sometime after 19,000 years before present (BP) and continued through 13,000 years BP (Benito et al. 2003:637). These cataclysmic flood events are possibly some of the largest floods in Earth's history. After 13,000 years BP the Willamette River and the tributaries from the Cascade Mountain Range and the Coast Range were reestablished on the valley floor meandering around post-Missoula Flood deposits (Orr et al. 2012:198).

Willamette Valley: Ethnographic History

During the 19th century it was documented that the Kalapuya groups occupied the entire Willamette Valley. The Kalapuya were decimated by epidemic diseases which drastically decreased their population. The first epidemic was smallpox, which swept westward from Missouri in 1782, and most likely destroyed half of their population (Mackey 1974:20). Because their numbers had been so drastically diminished by disease, there is little direct information of the Kalapuya people, and the settlement of the Willamette Valley by Euro-Americans was with little or no struggle (Mackey 1974:20).

The 13 bands of the Kalapuya in the Willamette Valley were described by Aikens (1993) as having their traditional territories along the Willamette River which separated the eastern and western groups (Figure 1.3). Each band had an elongated territory from the Willamette River that extended into the foothills of the Cascade Mountain Range to the east and the Coast Range to the west. Each independent band spoke a dialectically distinct language belonging to the Kalapuyan family (Aikens 1993:183). Site 35MA375 lies within the area traditionally inhabited by the Santiam band of the Kalapuya.

The traditional home of the Santiam is located on the east side of the Willamette River and extends east to the foothills of the Cascade Mountain Range. The Santiam band was abutted by the Ahantchuyuk to the north and the Tsankupi to the south. The Kalapuya lived in permanent winter villages and in transitory camps during the drier months. The autonomous winter villages were headed by tribal chiefs. However, this chieftainship may have been in response to the historical demands to deal with government agents. The chief, who was wealthier than other villagers, would look after the welfare of those in need and would assist in resolving disputes (Zenk 1990:549). Becoming a chief was usually passed from father to son, but this was not always the case. In the Kalapuya Mary’s band, women could become chief when a male relative was not available (Zenk 1990:550).

Figure 1.3: Kalapuya Bands in the Willamette Valley. Adapted from Atlas of Oregon 2001.

The Kalapuya had a close relationship with their environment and would travel the landscape to hunt and collect their various food sources. During the winter months, Kalapuya lived in a large multi-family dwelling, which is described as rectangular, constructed of bark or planks, laid against a gable structural framework, and floors excavated to two or three feet below the surface (Zenk 1990:549). During the summer months, the Kalapuya traveled to their less elaborate summer camps to utilize the various food resources and were often in the open or with little more than a brush shelter (Aikens 1993:187).

The Kalapuya seasonal rounds involved an extensive emphasis on gathering wild plants for food. Harvesting roots started in early summer and continued into late summer. Camas, a starchy bulb, was among the most prominent root foods and was gathered from camas lily meadows throughout the Willamette Valley. The bulbs were baked in large rock lined pits dug into the ground and roasted for several days. The bulbs, once removed, would be pounded into cakes and stored for the winter months (Aikens 1993:186). Other plant foods used included Wapato, tarweed seeds, hazel nuts, and berries (Zenk 1990:547).

The Kalapuya hunted and fished the diverse species of animals in the Willamette Valley in addition to gathering plant foods. There were various species of mammals and birds that were harvested, and many aquatic species that were fished. Among the mammals and birds that were commonly hunted were deer (black- and yellow-tailed), elk, black bear, and waterfowl. Aquatic species harvested included lamprey, trout, steelhead, and salmon (Aikens 1993:187; Zenk 1990:548).

Willamette Valley: Euro-American Settlement

There are a few accounts of Europeans in Oregon prior to the Lewis and Clark expedition in the 19th century. The recorded sightings were limited in the 18th century to fur trappers from Spain, Russia, Great Britain, and the United States (Morrison 1999:115). In 1792, Captain Robert Gray, an American merchant, was the first to navigate the Columbia

River in search of sea otter pelts for trade to China and established claims to the lower Oregon Country (Whaley 2010:12). British ships eventually followed suit and eventually drew the lower Oregon Country into the Trans-Pacific economy. This imperial claim on the interior of Oregon led to a pattern of colonizing the indigenous inhabitants (Whaley 2010:12).

In 1803, Thomas Jefferson commissioned The Corps of Discovery led by Merriweather Lewis and William Clark. The Corps of Discovery followed the Louisiana Purchase, which resulted in the United States purchasing land from France, stretching from the Great Plains to east of the Rockies. At this time, there were already Euro-Americans present in Oregon Country. The area was jointly occupied by Great Britain and United States fur trappers, government agents, and missionaries (Bowen 1978:9). Although Oregon was not included in the Louisiana Purchase, Lewis and Clark tried to establish United States trade relations with the Native people in Oregon Country with the intent of excluding Great Britain (Whaley 2010:24). In 1805, Lewis and Clark documented the existence of trade networks and described several groups who used the trails (Stern 1998:641). The Columbia River Trade Network (Figure 1.4) connected Northwest Coast people from the west, Plateau to the east, Great Basin to the south, and the Columbia Plateau to the north all who could access trade goods such as food and obsidian toolstone.

John Jacob Astor, the owner of the Pacific Fur Company had established posts in the interior of Oregon by 1812, posts that he subsequently sold to the North West Fur Company in 1813 after the loss of the ship Tonquin (Bowen 1978:7; Morrison 1999:118). Since the early 19th century, the Europeans in Astoria, Oregon, had become increasingly interested in the Willamette Valley and dispatched trading, trapping, and hunting parties with the Kalapuya bands (Whaley 2010:37). The continued use of existing Native trade trails and networks were employed during this colonial trade period (Whaley 2010:20).

In 1846, a treaty was signed between the United States and Great Britain establishing a boundary at the 49th parallel where Great Britain would occupy the land to the north and the United States would occupy the land to the south. During the late 1840s thousands of people arrived in the Willamette Valley and by the 1850s, Oregon's Donation Land Act was established to encourage settlement in Oregon. In 1854, a treaty was signed between the United States Congress and the remaining Kalapuya that would remove them from the Willamette Valley and relocate them to the Grand Ronde Reservation (Lewis 2019). In February of 1859, Oregon became the 33rd state in the Union.

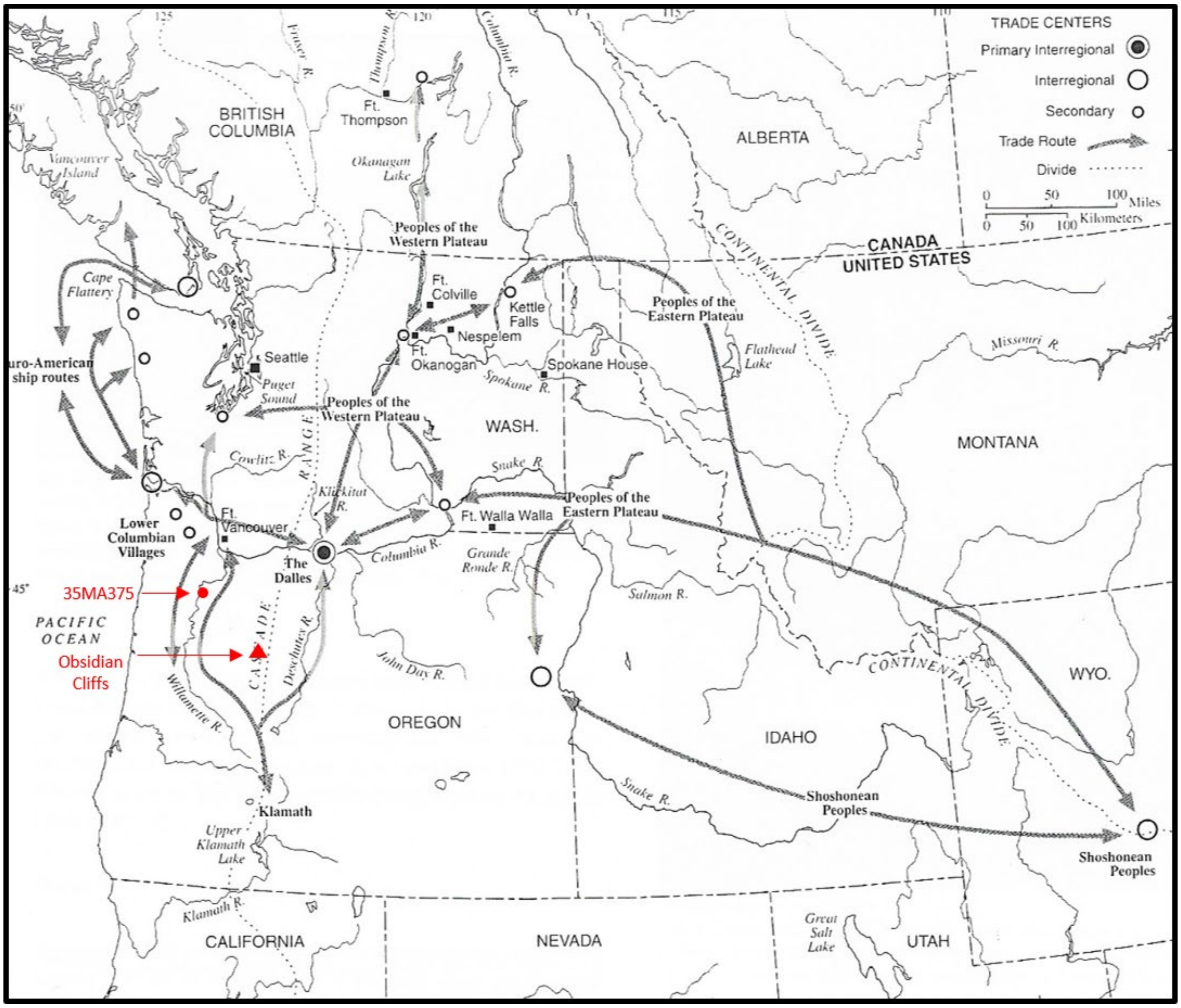

Figure 1.4: Columbia River Trade Network. Adapted from Stern 1998:642.

Chapter 2: Oregon Archaeology

No discussion about Oregon archaeology is complete without mentioning Dr. Luther Cressman (1897-1994). Luther Cressman arrived in Oregon in 1929 after accepting a position with the University of Oregon. He went on to establish the University of Oregon's anthropology department and became the first director of the Oregon State Museum of Anthropology. In the 1930s, professional archaeology in the United States was nonexistent, which led to universities performing the bulk of the archaeological work, and Cressman led the way in documenting the antiquity of the Native people of Oregon. He often collaborated with ranchers, students, and scientists in his research and played a pivotal role in bringing science into archaeology (Butler 2009; Cressman 1943). Luther Cressman discovered several sites that have resulted in some of the oldest dates in North America.

In 1938, Cressman excavated at Fort Rock Cave in Oregon where several sage brush sandals were recovered beneath Mazama Ash (7000 BP). The sandals were eventually dated to 9000 BP in the 1950s after the development of radiocarbon dating. In 1939, Cressman was leading archaeological excavations at Paisley Caves in central Oregon. At Paisley Caves he uncovered lithic artifacts, fire hearths, and faunal remains of horse and camel, also beneath a layer of Mazama Ash. In recent years Paisley Caves has yielded dates over 14,000 years (Aikens 1993:36-38; Jenkins et al. 2012; Shillito et al. 2018).

Luther Cressman advised several students who went on to be Oregon's next generation of archaeologists. One of his students was Dr. Mel Aikens, who became a professor of anthropology at the University of Oregon, and a director of the Museum of Natural and Cultural History. Like Cressman, Aikens spent decades leading archaeological investigations in Oregon. He is widely published and has presented the information he collected in *Archaeology of Oregon,* which summarizes and documents his conclusions of Oregon's prehistory to provide information for any reader who is interested in Oregon archaeology (Aikens 1993).

Oregon has a variety of cultural areas and unique environments that have yielded some of the oldest dates of human settlement in North America. There are three cultural areas within Oregon: The Northern Great Basin, the Southern Plateau, and the Northwest Coast (Figure 2.1). In addition to the three cultural areas, a discussion of the Lower Columbia Basin and the Willamette Basin will be included as their borders merge with the defined cultural areas of Oregon contributing to Oregon's unique environments (Aikens 1993:iii).

Northern Great Basin

Survey crews first documented archaeological materials within Oregon's expanse of the Great Basin in the mid-19th century. By 1930, Cressman had begun his excavations in the Great Basin. It is abutted by the Plateau to the north, the Northwest Coast to the west, and the Willamette Valley to the northwest. This was continued by Aikens in the 1960s, and into the present day by Dr. Dennis Jenkins and Dr. Pat O'Grady. There are late Pleistocene megafauna with associated lithic scatters found on the surface. Whether they are the same age is a point of contention. Numerous Clovis projectile points have been found on the surface of the Great Basin and have been relatively dated by comparing to dates of Clovis points in other cultural areas. The antiquity of the human occupation of the Great Basin was finally established with the advent of radiocarbon dating in the 1950s.

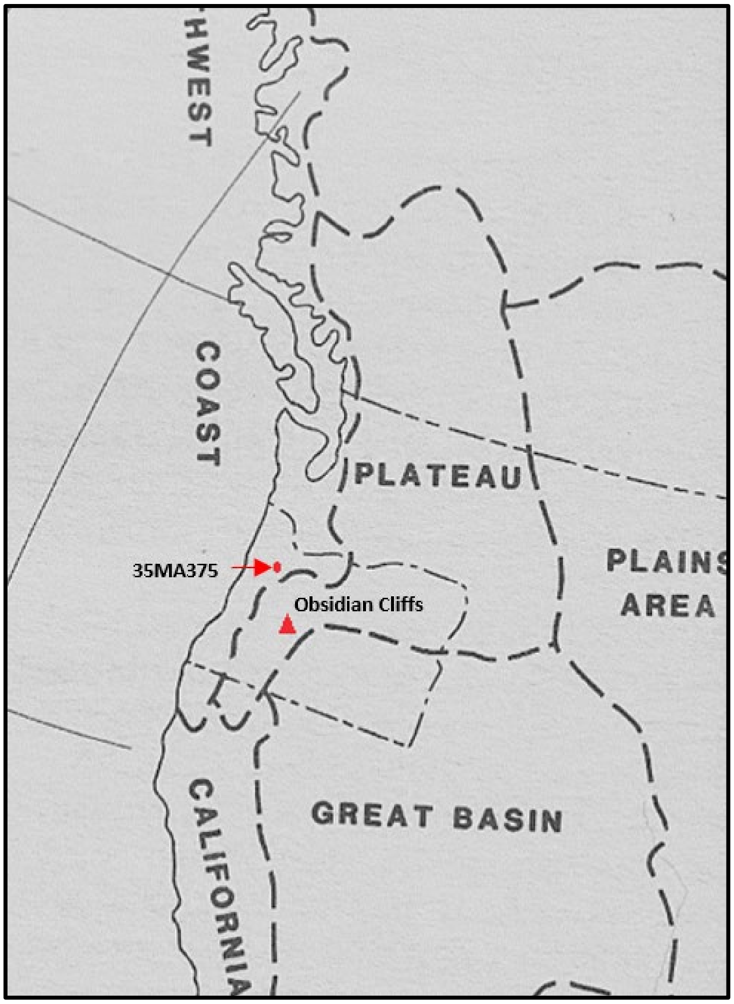

Figure 2.1: Cultural Areas. Adapted from Aikens 1993:8.

Paisley Caves in south central Oregon, within the Great Basin, has yielded radiocarbon dates as early as 14,300 calibrated years BP. Archaeologists uncovered coprolites with human DNA, lithic tools, faunal remains that were culturally modified, and Pleistocene faunal remains (Jenkins 2012:223; Shillito et al. 2018:82). This early range places Paisley Caves in the Pre-archaic cultural phase that began at an indeterminate time and lasted until approximately 8000 B.C. Artifacts associated with Paleo-Indians such as Clovis projectile points and Western Stemmed points have been recovered from the Great Basin. Following the Pre-Archaic cultural phase was the Early Archaic from 8000 B.C. to

2000 B.C., followed by the Middle and Late Archaic ranging from 2000 B.C. to 500 A.D. (Jennings 1986:115-117).

Southern Plateau

The Southern Plateau (Figure 2.2) is located to the east and northeast of the Willamette Valley extending from its western boundary at the Cascade Mountain range in Oregon and Washington to the Bitterroot mountain range in the east. In the north, the Southern Plateau is bounded by the Okanagan Highlands at the Canadian border and in the south by the Deschutes and John Day rivers in Oregon, to the Snake River in Idaho (Ames et al. 1998:103).

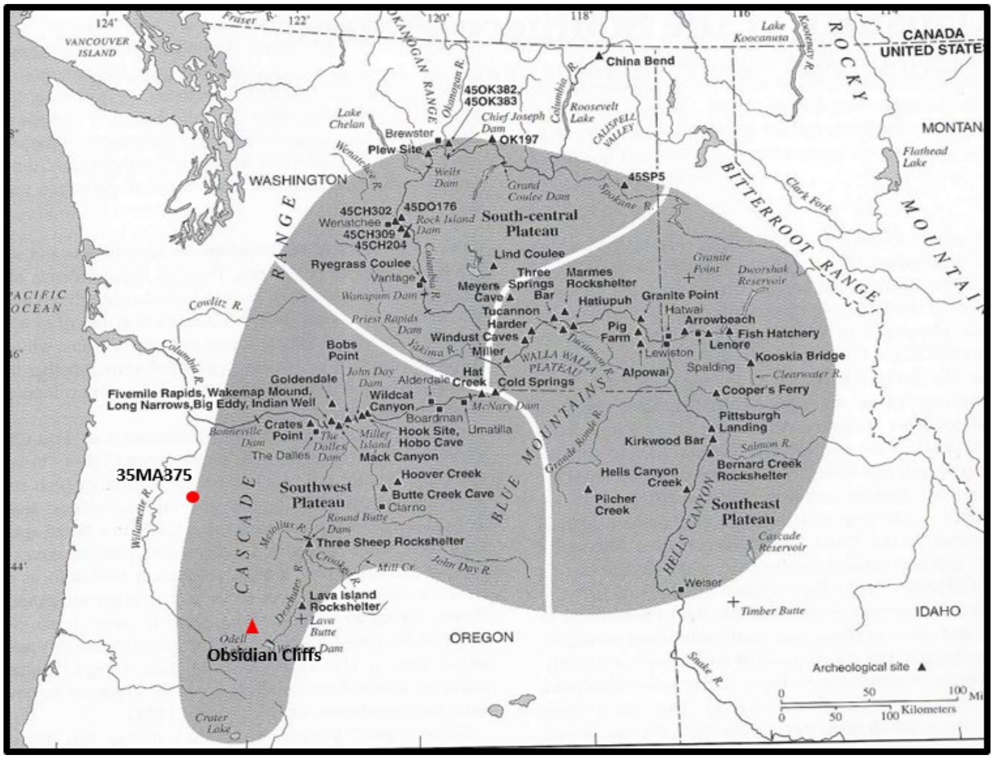

Figure 2.2: Southern Plateau. Adapted from Ames et al. 1998:104.

There are three cultural periods and many subperiods associated with the Southern Plateau. The oldest is Period I and is associated with the pre-archaic with dates ranging from 11,500 to approximately 5000 B.C. These dates are supported by radiocarbon dating, ash from the Mount Mazama eruption, and projectile point chronologies including Clovis and Windust points. Clovis technology has long been disputed within archaeology as to whether it is the oldest technological tradition in the New World. Clovis points date to approximately 11,500 years BP and are identified by the fluting flake scar at the base of the projectile point (Aikens 1993:20). The Windust phase occurred approximately 11,000-9000 BP and is characterized by a distinctive lanceolote shaped projectile point technology that has been recovered from several sites in the Southern Plateau (Sappington et al. 2001:355).

Hunting, fishing, and food processing are represented in the artifact assemblages recorded in Period I. The artifacts have been recorded in open sites, caves, and rock shelters, and include cobble, flaked, groundstone, bone, and antler tools; ocher, beads, and many other items (Ames et al. 1998:103). During this time period Pleistocene megafauna disappeared.

Period II consists of dates ranging from 5000 to 1900 B.C. and is documented by changes in resource usage and settlement patterns. Semi-subterranean pit houses are present along with evidence for an increase in root collection, consumption, and storage. Hunting, fishing, and food processing are represented by the artifact assemblages with some changes in technology. There are fewer projectile points present during Period II and the technology employed in the manufacturing of stone tool changed as evidenced by the discontinued manufacture of Clovis points. Edge ground cobbles and prepared cores become rare during this period (Ames et al. 1998:108-109).

Period III dates range from 1900 B.C. to A.D. 1720 and is also documented by resource and settlement pattern changes. Pit houses are the main dwellings early in this period with longhouses appearing later. Resources were collected during seasonal rounds from mountains, canyons, and rivers. Fishing implements include harpoons, barbed points, and numerous net sinkers in various sizes, shapes, and manufacture. Projectile points are the most abundant artifact during Period III and are represented by a variety of notched points and eventually arrow-sized points (Ames et al. 1998:112).

Northwest Coast

The Northwest Coast is located to the west and northwest of the Willamette Valley and is one of the most diverse linguistic areas, represented by 45 distinct languages (Thompson et al. 1990:30). This cultural area encompasses the unique environments of both the Pacific Coast and the Lower Columbia. Although their environments are different, they shared many of the same food sources and cultural traditions (Aikens 1993:137). The Pacific Coast is divided into three areas: South Coast, Central Coast, and North Coast (Figure 2.3). The Northwest Coast extends from the Copper River delta in Alaska to the Winchuk River that meanders along the border of Oregon and California and extends eastward to the Cascade Mountain Range (Suttles 1990:1). The Willamette Valley is in the Northwest Coast cultural area.

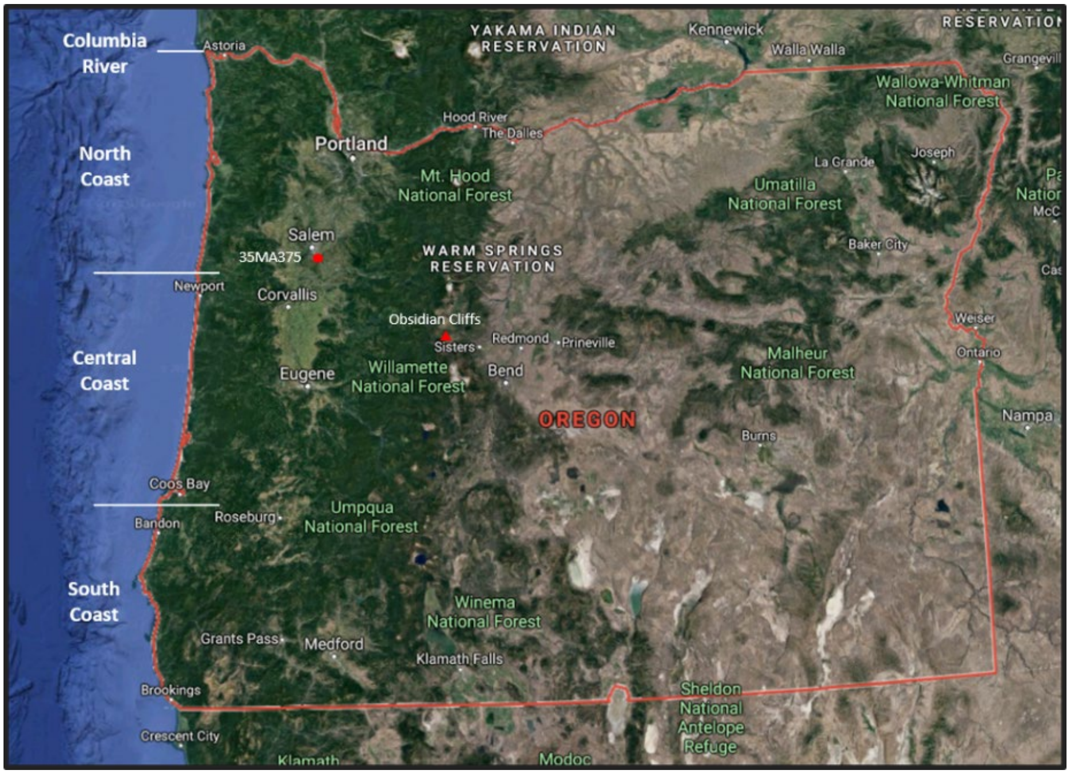

Figure 2.3: North Coast and Lower Columbia. Adapted from Google Maps 2019.

The evidence for Paleo-Indian occupation of the Northwest Coast is present but sparse due to rising sea levels that flooded many early sites (Aikens et al 2011:18). A few surface finds such as a Clovis point fragment and other fluted points yields dates ranging to 11,500 BP when compared to the Clovis period in other cultural areas. Following the Paleo-Indian cultural phase is the Early Archaic from 10,000-5500 BP, also known as the Youngs River Complex on the Northwest Coast and Lower Columbia. The projectile points in this time period are large, lanceolate, leaf shaped, and stemmed projectile points (Aikens 1993: 144; Pettigrew 1990:520-521). The Northwest Coast chronology of occupation is similar to the Lower Columbia Valley Basin which is described in detail below.

Lower Columbia Valley Basin and Willamette Valley Basin

The Lower Columbia River encompasses two basins within Oregon: Lower Columbia Valley Basin and the Willamette Valley Basin. The Lower Columbia Valley Basin extends from the mouth of the Columbia River in the west, to The Dalles in the east, and then travels south to the Willamette Falls in Oregon City, Oregon, where it meets the Willamette River. Willamette Falls is the boundary between the Lower Columbia Valley Basin and the Willamette Valley Basin (Aikens 1993:137).

Within the Lower Columbia Valley Basin lies the Portland Basin which has a dating sequence from 600 B.C. or 2500 BP developed by Pettigrew. Pettigrew recognizes two cultural phases in the Portland Basin, the Merrybell Phase and the Multnomah Phase. The Multnomah Phase is further subdivided into Multnomah 1, 2, and 3. Projectile points are the most common artifact in the Portland Basin and Pettigrew used the shifts in technological manufacturing as temporal markers. The Merrybell Phase (2500-1750 BP) consisted of smaller, corner notched projectile points with a narrow neck, whereas the Multnomah Phase (1750-700 BP) consisted of small side notched projectile points (Aikens 1993:145; Pettigrew 1990:518).

The people of the Lower Columbia River Valley and the Willamette Valley inhabited similar environments with one major difference, the Lower Columbia River had a minimum of 13 species of fishes not found in the Willamette River. The difference in aquatic species played a significant role in the people of the two basins diverging into two cultures (Pettigrew 1990:518). The Paleo-Indian phase (11,500 to 10,500 BP) is the earliest occupation in the Lower Columbia and Willamette Basin and is documented by the presence of Clovis fluted projectile points (Aikens 1993:144, 199). Earlier dates in the Lower Columbia Basin are rare as sea levels began to rise around 8000 B.C. and continued until approximately 3000 B.C. The rise of the sea level would place earlier sites along the Columbia River under water and covered with river deposits (Pettigrew 1990:519).

Following the Paleo-Indian cultural period is the Early Archaic from 10,000 to 5500 BP, also known as the Youngs River Complex in the Lower Columbia and Cascadia Phase near the foothills of the Cascade Mountain range. The projectile points in this time period are large, lanceolate, leaf shaped, and stemmed projectile points. Other common artifacts include mortars and pestles, carved cobbles, and stone weights (Pettigrew 1990:520-521).

By the Middle Archaic period (6000 to 2000 BP), known as the Sea Island Phase on the Lower Columbia Basin and Baby Rock Phase at the Cascade Foothills, dart-sized, broad necked, stemmed points are the most common projectile point (Pettigrew 1990:519). It is during this time period that intensive toolstone quarrying began at Obsidian Cliffs and other obsidian sources in the Cascade Mountain range. Approximately 4000 BP, systemized reduction of obsidian toolstone into bifacial blanks intensified, as seen with the numerous biface caches identified in central Oregon (Connolly et al. 2015:184). The Late Archaic period started around 2000 BP to historic times is represented by small triangular stemmed arrow-sized points (Aikens 1993:192).

Oregon Archaeological Sites

As previously mentioned, Oregon has over 40,000 recorded archaeological sites, but fewer than 30 are biface caches (Appendix B) (Pouley 2017). Biface caches have multiple bifacial blanks that have been reduced to a uniform size and shape, with variable tool completeness between caches. Typically, the bifaces are reduced to an early stage. The Cascade Mountain range is east of the Willamette Valley and has over 150 volcanic vents, with a number of these obsidian sources (Figure 2.4) (Baxter et al. 2015:222). Willamette Valley obsidian sources from 116 archaeological sites were compiled. Approximately 45% of the obsidian came from Obsidian Cliffs, 31% comes from Inman Creek in the Willamette Basin, and 15% from other Willamette Basin sources (Baxter et al. 2015:219). Obsidian was a commodity for local use and was traded to groups throughout the region and as far north as British Columbia suggesting the people of the Willamette Valley were part of a regional trade network (Baxter et al. 2015:229; Connolly et al. 2015:181).

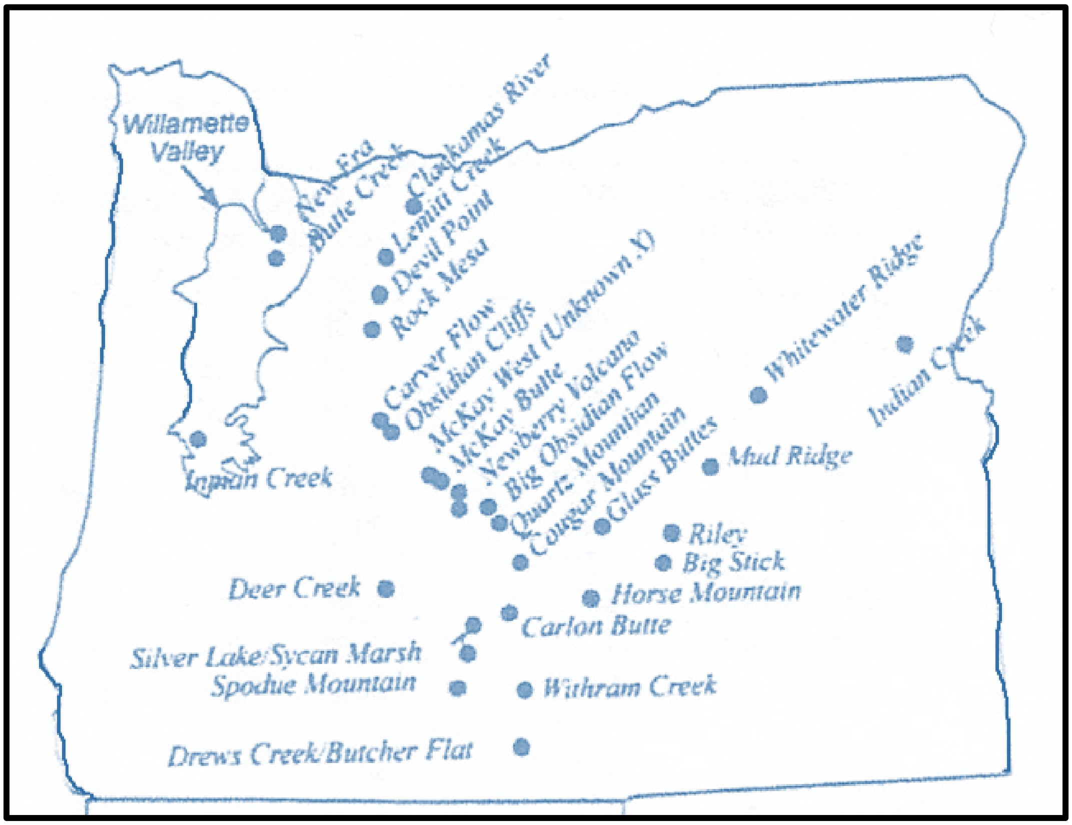

Figure 2.4: Obsidian Sources in Oregon. Adapted from Baxter et al. 2015:219.

Cache Sites

Lithic caches are rare in the archaeological record, which suggests that the people who placed the stone tools in the ground showed anticipation of a future need. The artifacts within lithic caches are usually at an early stage of reduction and have little to no evidence of use, suggesting they were intentionally cached for later use. Caching may represent seasonal rounds of a group who were familiar with their environment, aware of the distance to the lithic source, and could anticipate where they would be at a future date. Caching would reduce the amount of time spent to acquire lithic raw material from a desired source and minimize the potential of a toolstone shortage (Kilby et al. 2014:258, 267).

Two utilitarian cache sites to note in Oregon are Paul's Fire Cache (35LIN542) and the Pahoehoe Cache Site (35DS268). The similarities between them and cache site 35MA375 are represented by the high number of bifacial blanks, toolstone geochemically sourced to Oregon's Cascade Mountain range, and the early stage in the reduction sequence indicating their value as a commodity.

Paul's Fire Cache (35LIN542) was discovered in 1992, after an escaped control burn in the Willamette National Forest. During the fire suppression, a fire management officer found eight obsidian bifacial blanks on a previously disturbed logging skid trail. The archaeological excavations revealed a trail of bifaces that led to a cut bank formed when the logging skid trail was constructed and in this cut bank there were an additional 14 bifaces in situ. All totaled 33 obsidian bifacial blanks (Figure 2.5) were recorded, and geochemically sourced to Obsidian Cliffs, Oregon, 30 miles from the site if walking in a straight line.

Samples of charcoal were recovered during excavation and yielded dates of 4,075 years BP (Bennett Rogers 1993:3-4).

The second site, the Pahoehoe Biface Cache (35DS268), in Central Oregon, was discovered in 1984 when the US Forest Service removed 90 obsidian bifaces from artifact collectors. Archaeological investigations were conducted, and an additional 20 bifaces (Figure 2.6) were recorded. The bifaces were recovered from a deposit above Mount Mazama tephra (6,800 BP). There is lithic debitage located near the cache which suggests the bifaces were reduced on site. Most of the obsidian was sourced to McKay Butte approximately 15 miles east of the site. (Scott et al. 1986).

Figure 2.5: Paul's Fire Cache 35LIN542. Adapted from Connolly et al. 2015:185.

Figure 2.6: The Pahoehoe Site 35DS268. Adapted from Scott et al. 1986:9.

History of site 35MA375

Daniel Delaney and his family arrived in Salem, Oregon, in 1843 and claimed 640 acres in Marion County (Figure 2.7) under Oregon Territory's Provisional Government that entitled white male citizens and their wives to each claim 320 acres. In 1850 Congress accepted the land claims of 1843 under the Organic Act (Robbins 2019). Marion County was established the same year the Delaney family arrived in Oregon and Salem became the county seat by 1849. The Delaney family built their home in 1845 and in 2004 the Delaney house was placed on the National Register of Historic Places (Pouley 2017).

Site 35MA375 is located on the land the Delaney family claimed in 1843 but has since been parceled out to other landowners. The current landowner, as of 2019, recovered the biface cache and contacted Oregon's SHPO who subsequently led archaeological excavations and recovered other lithic debitage and tools. The 15th biface recovered during archaeological excavations was the only artifact associated with the cached bifaces.

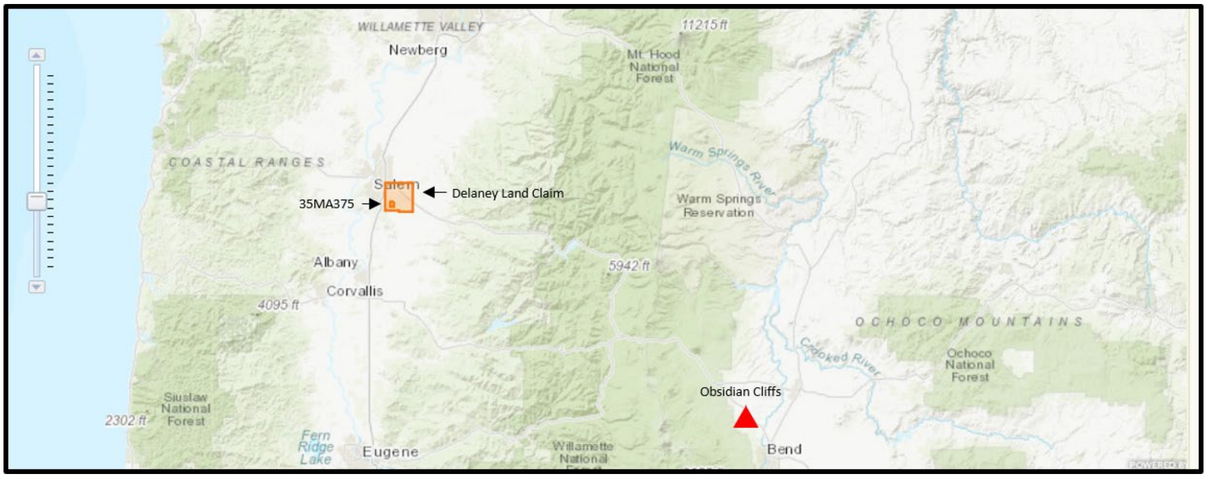

Figure 2.7: Delaney Land Claim of 1843. Adapted from Glorecords.blm.gov 2019.

Chapter 3: General Lithic Studies

The earliest lithic technology, Oldowan, first appeared in East Africa approximately 2.4 million years ago and is associated with *Homo habilis* (Ayala et al. 2017:229). Stone tool manufacturing occurred throughout space and time and has changed as humans evolved. The manufacture and use of stone tools by ancient people were an important aspect of their survival and ranged from simple flakes for cutting to masterfully crafted tools (Ozbun 2015:1). Behavioral activities, technological approach, and spatial and temporal changes are but a few questions that can be answered with lithic analysis.

There are many forms of lithic analysis performed in archaeology to determine certain behavioral aspects of indigenous people. A variety of hypotheses may be tested when combining lithic analysis with obsidian hydration, obsidian sourcing, protein residue, plant residue, and use-wear analysis. Lithic analysis approaches that will be discussed in this section are: Aggregate analysis or mass analysis, typological analysis, flake completeness, and replication reduction sequence modeling.

Before discussing different approaches to lithic analysis, it is important to understand the basic principles of flintknapping. The first step in flintknapping is to obtain good lithic material (Crabtree 1999:4; 1967a). Being able to recognize good lithic material from poor lithic material is an element of skill (Ozbun 2015:1). Flakeable stone such as cryptocrystalline silicates (CCS), obsidian, vitrophyre, and high-quality basalt were procured for various purposes involving flaked stone technologies (Sappington 2018:1). The best materials for flintknapping are homogeneous and free of differences in flaws, cracks, and other irregularities, and being brittle and elastic. The toolstone with the previous attributes will have a conchoidal fracture when force is applied, which is what is desirable when producing flaked stone tools (Sappington 2018:1; Whittaker 1994:12).

The conchoidal fracture is best represented when thinking of a BB fired through a window. When this occurs a Hertzian cone is produced and that cone is removed from the opposite side of the window (Figure 3.1). An expression of the Hertzian cone is produced when force is applied to the toolstone by changing the angle of the force, one can predict how the lithic material or flake will be removed from the parent stone. By applying the principle of the cone fracture a flintknapper can understand and control the flake removal process (Whittaker 1994:12).

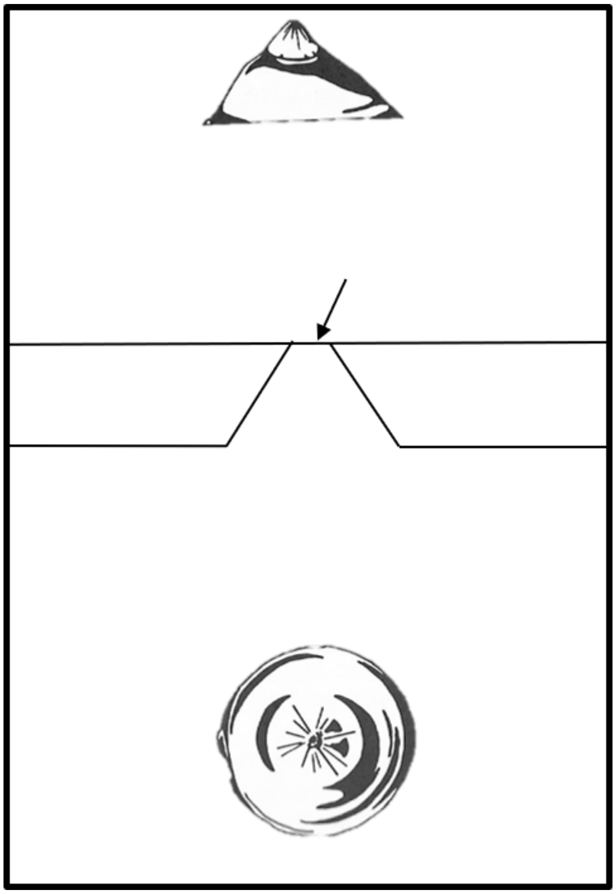

Figure 3.1: Hertzian Cone. Adapted from Whittaker 1994:13.

The first of the four approaches in lithic analysis to be discussed is aggregate analysis, also known as mass analysis. Mass analysis has some advantages over other forms of lithic analysis because it is an expedient approach that can be applied to large collections and takes very little training to perform (Ozbun 2017). This approach focuses on the size and shape of the flakes by size grading the material through nested screens and is considered an objective form of analysis as every flake is size graded, counted, and weighed regardless of the flake size or completeness (Ahler 1990:85; Andrefsky 2007:392-393). Mass analysis does not take into account the size and shape of the raw material, flintknapping techniques, and more than one reduction episode (Andrefsky 2007:392). Mass analysis is a replicable approach but gives very little detail of behavioral information aside from documenting early and late stages of reduction (Ozbun 2017; Sappington 2018).

Typological analysis, also referred to as Triple Cortex, uses the individual flake's distinctive characteristics to determine the technological reduction. Triple cortex is a measurement of the amount of cortex on a flake and is documented as primary, secondary, or tertiary. Because toolstone was transported in various stages from unworked nodules to well- worked preforms the question posed asks how much or little cortex needs to be present in an archaeological assemblage? The amount of cortex depends on the reduction technology and is only useful for determining the earliest and latest stage of reduction (Dibble et al. 2005:545-546). Little behavioral information may be gleaned from this approach. Typological analysis is an expedient approach to lithic analysis that is replicable and requires little training of the analyst (Ozbun 2017).

Flake completeness was developed by Sullivan and Rozen. There are four categories: complete flakes, broken flakes, flake fragments, and debris. The authors claim this approach is interpretation free and not linked to a reduction sequence or technology (Sullivan et al. 1985:759). Flakes from every reduction sequence and technology will be in various stages of completion so this approach tells us nothing about the behavioral information of the flintknapper. The flake completeness approach is an expedient form of lithic analysis that can be replicated and also takes little training to perform the analysis (Ozbun 2017).

The lithic analysis approach used for this project is the replication reduction sequence modeling. This analysis is based from work stemming from Crabtree's *An Introduction to Flintworking: An Introduction to the Technology of Stone Tools,* published in 1972. This modeling reduction sequence, chaînes opératoires, is a sequence of events from the procurement of raw material to the stage of discard. A chaînes opératoires is a technological approach that investigates the technological organization at an archaeological site (Sellet 1993:106). The downside to this approach is that extensive training is needed for the analysis, the process of analysis is time consuming, and it is difficult to replicate if the replicator is not a flintknapper, but there is a tremendous amount of behavioral information to be learned from this approach (Ozbun 2017).

In this experiment, the replication reduction sequence modeling is represented by the objects (artifacts), the technical sequence or gestures (methods employed), and the technical knowledge (decisions) made by the flintknappers (Sellet 1993:107). The lithic technological analysis of artifacts from site 35MA375 was performed based on identification of technologically distinctive attributes from flintknapping experiments conducted by my colleagues and I and corroborated by reference to the lithic technological literature (e.g., Crabtree 1972). Constellations of diagnostic attributes were used to identify the reduction strategies and techniques used that resulted in the tools and debitage. Stone tools were assigned technological and functional classes based on attributes, such as character of flake scars, breakage patterns, use-wear, and overall form. In manufacturing stone tools, many flakes are produced that are discarded without further use or modification. This debris constitutes debitage useful for understanding manufacturing processes.

Experimental Archaeology Literature Review

The literature on assessing skill level in lithic tool production is sparse in North America. This study adds to it and strives to make it a more recognized line of inquiry in the future. A few studies have assisted me with the application of replicative studies to determine skill level. One study regarding skill level is *Variation in Lithic Assemblages: An Experiment*, by Phillip H. Shelley collected samples from novice and experienced flintknappers and compared the errors, successful error corrections, and the morphological style of the tool related to the level of expertise. This pattern of varied attributes may be used to test skill in archaeological collections. People are not born knowing how to flintknap and across time and space there will be people of varying skill level in a given population. Novice flintknappers make more errors and more consistent errors that can be recorded during experimental observation (Shelley 1990:187). The attributes considered to be errors on the experimental bifaces produced for this study will be compared to the cache bifaces to determine if the indigenous flintknapper's skill can be verified.

A second article titled, *Palaeo-Eskimo Novice Flintknapping in the Eastern Canadian Arctic,* published in 2005, by S. Brooke Milne, applied results from Shelley's experiment to that of a collection in the Canadian Arctic to determine if novice flintknappers could be identified at the archaeological sites. Milne suggests there are fewer studies in the New World directly related to skill level than there are in the Old World because the analysts studying New World sites remain largely focused on typological and functional explanations for assemblage variability. This approach does not take into account the individual and material situations (Milne 2005).

Milne believes novice flintknappers were present at these Palaeo-Eskimo archaeological sites because there is an abundance of lithic raw material, and the lithic artifacts have attributes consistent with manufacturing errors. This suggests people were coming to these sites to learn how to flintknap without the risk of running out of raw material. Bifacial tools at the sites recorded by Milne exhibited the following attributes that are inherent with a novice skill level: Stacked-step fractures, hinge and step terminations, platform preparation, and overshot flakes. Stacked-step fractures occur when the angle of the applied force is incorrect and the flintknapper continues to try to remove a flake from the same location. Too much applied force can also cause an overshot flake possibly breaking the biface. Hinge and step terminations are caused by the flintknapper not applying enough force.

An expert flintknapper has better control of the force applied to the tool and will have fewer manufacturing errors. Attributes of stone tools representing expert skill level is reflected with platform preparation, grinding of the edges and arrises, and fewer termination errors (Milne 2005:331; Shelley 1990:191-192). The replication reduction sequence modeling used in the analysis of the cache bifaces and the experimental bifaces record the attributes associated with novice flintknapper errors, such as termination types and count, and attributes associated with expert flintknappers like platform preparation and grinding.

A third replicative experiment was performed based on the artifacts recovered from the Pahoehoe site in Central Oregon to determine the lithic reduction undertaken at the site. The authors produced 40 bifaces and compared the debitage from the experiment to the debitage that was collected during field excavations. The lithic debitage at the site contained very few flakes with cortex, indicating the flintknappers brought in minimally reduced bifacial cores and further reduced them at the site. The authors collected their debitage after manufacturing minimally reduced bifacial cores and concluded that all subsequent stages of the reduction sequence from their experiment was found at the archaeological site. They determined that the Pahoehoe flintknappers reduced the bifacial blanks by first removing large percussion flakes, thinning and shaping them into a lanceolate form, and then finished the bifacial blanks with one series of pressure flaking. The replication study concluded that it would take one flintknapper three and a half hours to produce 30 bifacial blanks from the minimally reduced bifacial core (Scott et al. 1986:8-11).

The results of this study were then compared to other biface caches in the region that exhibited similar reduction strategies. The authors hypothesized that biface caches were maintained throughout the region to forestall a shortage of lithic material. They argued that obsidian is scarce in some cultural areas and was traded as a highly valued commodity in a prehistoric exchange system (Scott et al. 1986:17).

Previous Experiment from 35MA375

After the discovery of the cache bifaces from site 35MA375 I participated in a simulation experiment to gain a better understanding of the production, use, and trade of obsidian bifacial blanks in the Willamette Valley (Monaco 2017). This experiment was a simulation and not a replication, as we were not trying to produce exact copies of the archaeological artifacts but to produce bifacial blanks that were similar in size and had comparable attributes. This experiment attempted to answer the following research questions:

1. Which reduction technology was employed at the site?
2. Can a reduction strategy be identified?
3. Was the cache intended for local use or trade?

Obsidian nodules were chosen that exhibited similar natural attributes to those documented on the cache bifaces. Primary geological cortex, square edges, and visual flaws (phenocrysts or cracks) are three of the natural attributes. The two 9 lb. nodules were reduced using a hard hammerstone to produce 15 flake blanks that were large enough to produce bifacial blanks similar in size to the cache bifaces.

The flake blanks were first reduced to bifacial blanks by using percussion core reduction and then further reduced by either percussion core reduction to produce flakes to be used as expedient tools or pressure flaked into arrow sized points or by percussion bifacial reduction to produce spear or dart sized points (Figure 3.2). Arrow sized points have a tendencey to be triangular in form and smaller than dart sized points. Arrow sized points were distinguished from dart sized points by using a Dart-Arrow Index (Hildebrandt et al. 2012). The Dart-Arrow Index is produced by adding the neck width to the maximum thickness of the point. Points less than 11.8 mm are considered arrow sized points, greater than 11.8 mm are considered to be dart sized points. All the corresponding lithic debitage was collected, and a sample was analyzed using the replication reduction sequence modeling approach.

The experiment took place prior to the analysis of the lithic artifacts recovered during field excavations of site 35MA375. Meghan Johnson and I performed the lithic analysis in the lithic laboratory at Archaeological Investigations Northwest, Inc. (AINW), and we were supervised by Dr. John Fagan and Terry Ozbun. The results of the lithic analysis performed on the debitage recovered from field excavations of site 35MA375 did not match the lithic debitage produced in the simulation experiment which indicated the bifacial blanks were reduced at the quarry or en route to site 35MA375. There is no archaeological evidence suggesting the bifacial blanks were further reduced at the site and may have been intended for later retrieval. Because the bifacial blanks were not produced or further reduced on site the lithic debitage produced by the volunteer flintknappers will not be discussed in this thesis. The complete lithic analysis of site 35MA375 is included as Appendix D.

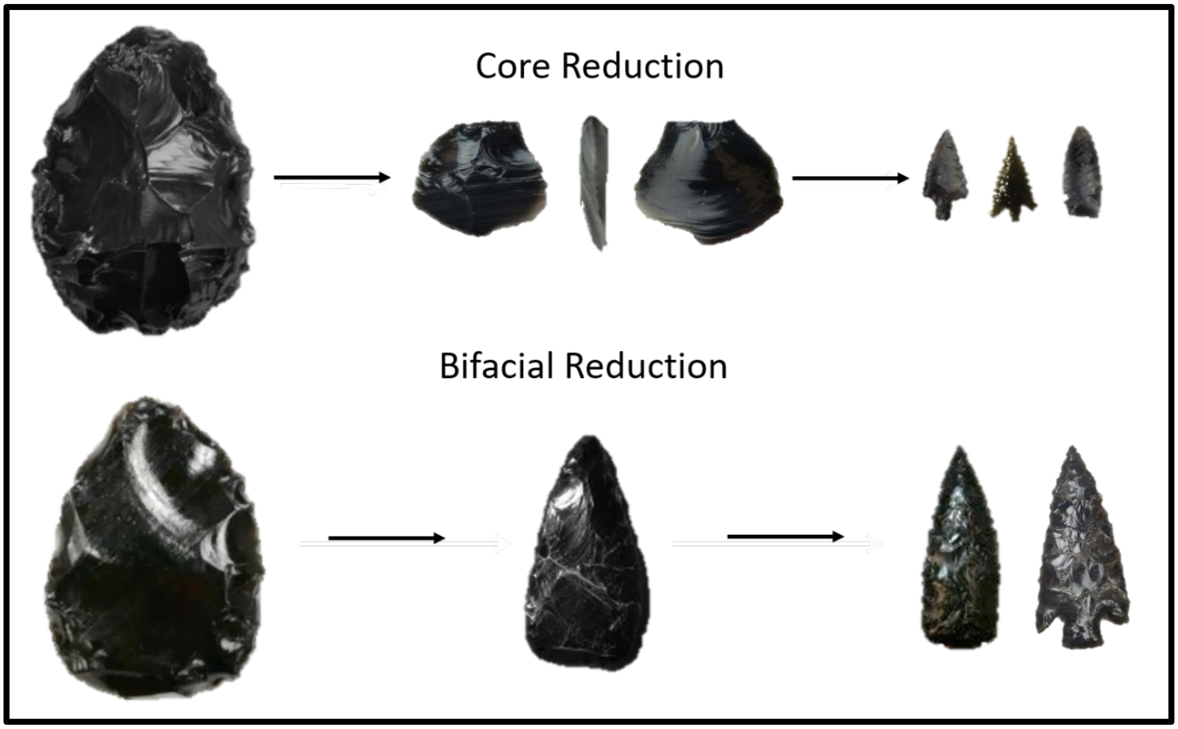

Figure 3.2: Bifacial and Core Percussion Reduction. Adapted from Monaco 2017.

Chapter 4: Theory and Method

Cultural ecology is an approach in anthropology that started in the 1950s and continues to be used today. Cultural ecologists wanted to move anthropology away from the humanities and make it a science by supplementing their knowledge by using theories from natural science fields. One way of implementing the scientific method was to use a positivist approach using empirical data to derive universal laws.

Julian Steward was the father of cultural ecology. He was a multilinear evolutionist who believed cultures evolved along different paths depending on distinguishing sets of attributes and argued that the environment was a major factor in culture change (Fagan 2005:197-198). These distinguishing characteristics are what Steward called a cultural core consisting of environment, technology, and subsistence. Steward assumed that human cultures would take similar evolutionary paths when having similar cultural cores and based these assumptions on global comparative studies (Fagan 2005:198). Cultural ecologists focused on the relationship between humans and their environment but did not believe that environment determined culture.

Julian Steward, who was a minority in his field, was speaking out against the cultural anthropology thinking of his time and was a major influence on Lewis R. Binford (Johnson 2010:28). In the 1960s, Binford pulled several trends together and helped establish anthropology in archaeology and he became a mouthpiece for New Archaeology (Fagan 2005:201). His goal was to bring theory into archaeology and address the behaviors of people. There were several others who influenced Binford in establishing New Archaeology. Leslie White exposed him to logic and explicit assumptions and Albert

Spaulding introduced him to statistical analysis in archaeology. Binford argued for scientific testing in archaeology and that archaeology had a similar goal as anthropology, that is, to explain the full range of cultural behavior (Fagan 2005:201).

Binford's approach in New Archaeology, now referred to as processual archaeology, became known as Middle Range Theory, which deals with linking the static archaeological record to the dynamics of past societies by generalizing what we can observe in the present (Tschauner 1996:1-2). Binford studied living contemporary systems, observed them from a non-participating viewpoint, and then correlate the observations to the past. He argued that science is a way of questioning our preconceived ideas and Middle Range Theory is the experimental part of the research, ultimately making archaeology an experimental science by observing the past through the archaeological record (Tschauner 1996:5).

Binford developed a collector and forager model that describes different site types within two hunter gatherer subsistence settlement strategies. Foragers have seasonal residential moves along a series of resources within a certain radius of travel. There are two types of archaeological sites within the forager model, the residential and the location. Foragers are gathering resources daily on an encounter basis and then return to the residential base each day. The location is where the forager collects the resource. Binford compares the residential and location sites to a daisy where the middle of the flower is the residential base and the petals are the resource locations. The archaeological deposits in a residential base will document the processing of resources, manufacturing events, and maintenance of existing items. The location sites are considered a low bulk procurement area and limited to the resource being procured. Artifacts at location sites tend to be scattered throughout the landscape. To summarize Binford's forager model, the forager will have a high residential mobility, low bulk inputs, and daily resource procurement strategies reflecting the different seasonal activities (Binford 1980:5-9).

While forager sites are generally reflected in either a residential base site or a location site, collectors have three additional site types; field camps, stations, and caches. Collectors supply themselves by obtaining resources in specially organized task groups. A task group will leave a residential location and move to a temporary location called a field camp where daily activities such as sleeping, eating, and maintaining field gear will occur. The field camps will differ depending on which resource is being procured. Stations are sites where the task group performs a specific function such as scouting game. Cache sites occur when a task group has a successful resource procurement. Because the small task group is transporting a large amount of resources to the residential base caches are sometimes required to temporarily store the resources (Binford 1980:10-12).

A second approach within processual archaeology is what Michael B. Schiffer coined "behavioral archaeology" in the 1970s (Johnson 2010:65). Schiffer argued that archaeology examines the relationship between human behavior and material culture in all times and places (Fagan 2005:203). Behavioral archaeology brings together the study of the prehistoric past with studies of much more recent artifacts, including objects in the present (Johnson 2010:65). Processual archaeologists (New Archaeology) were determined to bring anthropology into archaeology by considering the behavior of indigenous people. One component of New Archaeology is called experimental archaeology, which attempts to test the hypothesis of the archaeologist. Experimental archaeology is one of the four strategies in behavioral archaeology and involves setting up a system of study with controlled variables to understand the processes involving production, use, discard, deterioration, or recovery of material culture (Schiffer et al. 1994:198).

Experimental archaeology has been an approach in flintknapping since the early 19th century but it did not become established until the rise of processualism in the 1960s. In the early 19th century Sven Nilsson studied lithic artifacts and practiced chipping them into desired shapes. He eventually applied his knowledge of flintknapping into forming flints for his rifle and he is the first to use his flintknapping knowledge to explain prehistory (Johnson 1978:337). Experimental archaeology is used by archaeologists to determine possible ways that artifacts were made and used in the past (Coles 1979:1; Schiffer et al. 1994:197).

One important experimental archaeologist is Don Crabtree. Crabtree was a self-taught flintknapper who contributed to experimental archaeology greatly with his work stemming from *An Introduction to Flintworking: An Introduction to the Technology of Stone Tools,* published in 1972. There is nothing as potent as experimentation for verifying lithic techniques. It allows the worker to record all the stages of manufacture, to study the characteristics of the debitage flakes, and to prove or disprove a theory (Crabtree 1999:3). As noted by Don Crabtree, by using experimental replication, the analyst can verify their theories by completing the experiment. This process provides useful information as the analyst becomes familiar with the mechanical and physical problems that are involved with stone tool production. The important factor of both analysis and experiment is to consider the traits of each stage of manufacture and evaluate the technical methods of the work from start to finish (Crabtree 1999:3).

The experimental approach employed in this project was developed from the work of Don Crabtree to better understand the lithic technology and strategies used to produce the cache bifaces. Binford's Middle Range Theory of linking the archaeological record to past societies is used to explain behaviors of caching by applying his collector and forager model. While Schiffer's "behavioral archaeology" examines the relationship between human behavior and material culture and brings together the study of the prehistoric past with studies of recent artifacts. Experimental archaeology is the aspect of processual archaeology employed in this project for the purpose of understanding the behavioral aspects of the people who once inhabited the Willamette Valley in Oregon.

Experiment Methods

The methodology used in this experiment is designed to be replicable by using a positivist approach and implementing the scientific method. As discussed earlier, one of the criticisms of replication reduction sequence modeling is that it is difficult to replicate. There is an ample amount of behavioral information that can be gathered from this approach as the reduction strategies and technologies are observed and recorded.

There were eight volunteers of varying skill levels who each produced a series of 15 bifacial blanks. Steps were taken to ensure there was a controlled environment and consistent variables. The reductions occurred in the Lithics Lab at the University of Idaho, the lithics area at AINW, and the lithics area at my home.

When choosing the raw material for the experiment it was important to select nodules with characteristics that were similar to the toolstone used in the cache bifaces. One natural attribute in the cache bifaces is the presence of primary geologic cortex. The presence of cortex and the type of cortex on the bifacial blanks provided information about the source of the raw material. Primary geologic cortex consists of raw material with smooth exterior surfaces that may exhibit evidence of chemical weathering typical of bedrock formations that usually occur in upland sources (AINW Lithic Glossary 2018). One key difference is the obsidian from the experiment was obtained from Glass Buttes, Oregon, and not Obsidian Cliffs, Oregon, where the bifacial blanks were sourced (Figure 4.1). Unfortunately for this simulation, Obsidian Cliffs is protected by the United States Forest Service (USFS), and the collection of obsidian is not permitted. The raw material collected from Glass Buttes, Oregon, presented similar natural attributes that were comparable to the obsidian from Obsidian Cliffs, Oregon.

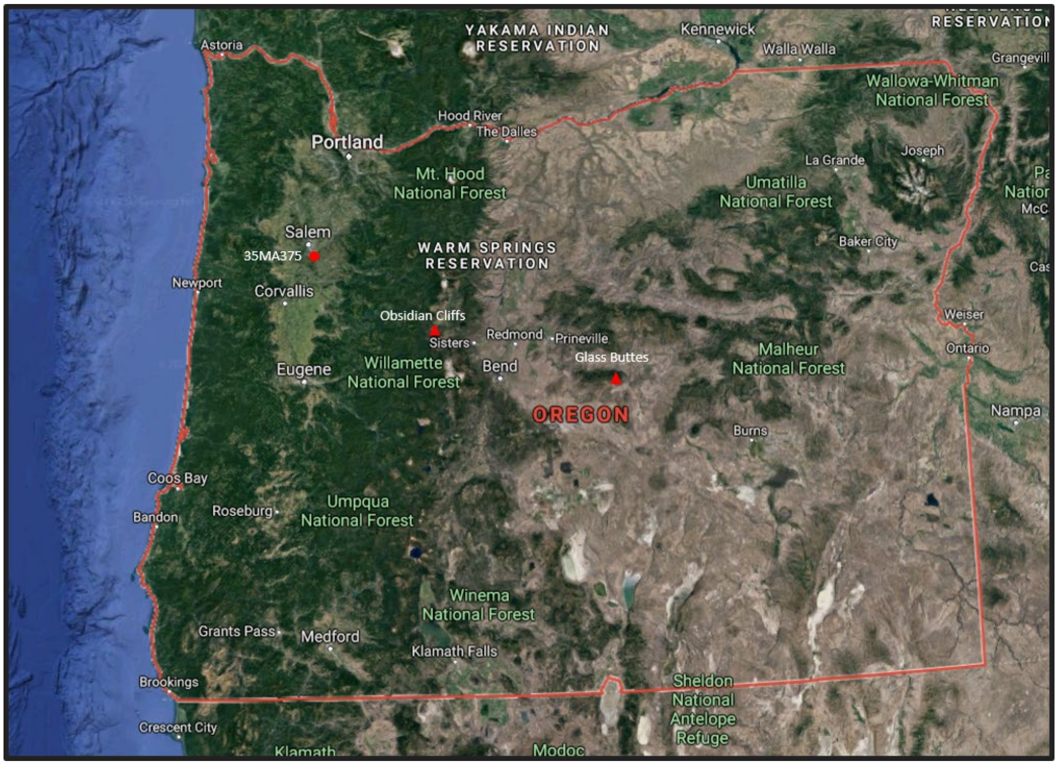

Figure 4.1: Obsidian Cliffs and Glass Buttes Locations. Adapted from Google Maps 2019.

Along with the presence of primary geologic cortex, (n=13) of the cache bifaces exhibited phenocrysts and square edges. These natural attributes aided in the selection of the raw material for the experiment, however it was not possible to select material that presented every natural attribute observed on the cache bifaces. Phenocrysts are an attribute that can hinder reduction as they can cause problems for the flintknapper during flake removal. Raw material characteristics are inherent to the material and one factor that might reflect the flintknapper's skill is the ability to recognize good vs. poor quality materials before selecting them for reduction.

The next step I took in the experiment was to reduce the obsidian nodules using a hard quartzite hammerstone in a manner to produce flake blanks that would later be reduced to bifacial blanks. The technological strategy I used to reduce the nodules into flake blanks was percussion core reduction. It is important to identify the reduction technology of the artifacts and employing the technique to produce a valid sample (Flenniken 1984:197). I produced flake blanks for the flintknappers except for one expert individual who produced his own (n=15) and one novice flintknapper who requested to make a few of her own (n=3). The volunteer flintknappers then selected fifteen flake blanks to produce a series of bifacial blanks. A sample of the flake blanks were hand drawn, photographed, and measured in centimeters (length, width, and height), before being reduced to bifacial blanks (Figure 4.2). The volunteer flintknappers employed percussion bifacial reduction to reduce the flake blanks into bifacial blanks. The flintknappers were offered a selection of soft (sandstone) and hard (quartzite) hammerstones, and antler (moose or deer) billets for the reduction of the obsidian. Each flake blank reduced during this step was timed and the corresponding debitage was collected, labeled, and stored for future research. I observed the reduction of the bifaces and took notes on the strategies employed by the individual flintknappers.

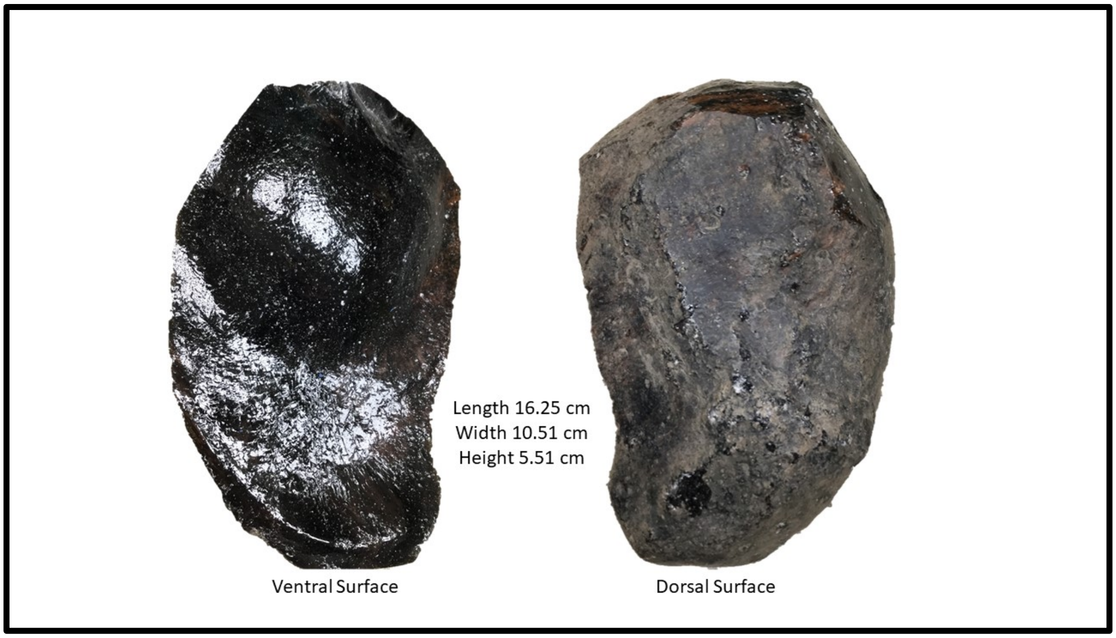

Figure 4.2: Example of a Flake Blank.

The anthropogenic attributes on the cache bifaces used to indicate a novice skill level included mistakes such as stacked-step fractures, big step and hinge terminations, the inability to bevel bifacial edges, the inability to remove cortex or other obstructions, and the inability to flake beyond the center of a convex face as indicated by large remnant ventral surfaces and steep surfaces. The technical knowledge and the proficiency needed in the execution of stone tools are elements of skill. There are certain kinds of mistakes that correspond with different levels of skills. These attributes inhibit further reduction and are indicative of poor skill in planning and execution.

Attributes exhibited on the bifaces indicating an increased skill level include decrease in time to produce a biface, platform preparation, and the correction of errors. Platform preparation is a technique used to strengthen the edge by reducing the amount of crushing that can occur when it is struck with a hammerstone. Small errors such as step and hinge terminations occur throughout every skill level and only becomes a problem when the errors compound and become big step and hinge fractures or stacked-step fractures. These errors can hinder further reduction and correcting these is an element of skill.

The goal in this experiment is for each flintknapper to produce 15 bifacial blanks and through analysis determine skill level and compare the experimental bifacial blanks to those recovered from 35MA375. The bifacial blanks prepared in this study was analyzed using the same criteria as the bifacial blanks from site 35MA375. The attribute measurements include raw material composition, cortex type, remnant surface type, breakage patterns, and size. Evaluations of the quantitative relationships between the various attributes and the tools measurements within the archaeological assemblage and the experimental bifacial blanks was recorded.

A typical analysis starts with measuring the length, width, and thickness of the bifacial blanks in centimeters using calipers. Following the measurements, the biface is examined on a macroscopic level observing certain attributes or characteristics that are either present or absent, remnant surfaces, cortex, arris grinding, platform preparation, inclusions, and successfully producing a bifacial blank. Other details noted during the analysis includes cortex type, complete or broken tool, break type, centered edges, shape, cross-section, and type of remnant surfaces. The next step is to look at the tool under magnification using a handheld jeweler loupe (10x). This microscopic analysis also identifies the previous observations, the number of flake removals, count and types of fractures and terminations. The weight of the finished tool and the weight of the debitage is recorded in grams to determine the amount of waste material removed.

Chapter 5: Experiment

This experiment was designed to look at attributes on the bifaces manufactured by flintknappers who vary in skill level and apply the observations to the bifaces from site 35MA375. The time and labor it can take to acquire a skill is distributed differently among individuals, but with practice and application one can become more skilled. When looking at skill it is important to acknowledge that not everyone learns at the same rate. There are some people who will understand the task and immediately produce the desired tool, while others will have several failed attempts. The ability to recognize and describe skill is achieved by understanding the processes and the technological applications in stone tool manufacture (Bamforth et al. 2008:2-3; Bleed 2008:154-155; Pelegrin 1990:118).

People are not born knowing how to flintknap. In any population there were people who were learning to flintknap while others had mastered the craft. Merriam Webster's definition of skill is the ability to use one's knowledge effectively and readily in execution or performance (2019). Becoming a skilled flintknapper requires different types of knowledge and abilities when flintknapping. The *connaissance* or the cognitive knowledge and decision-making strategies can be observed during the flintknapping process beginning with their choice of toolstone or hammerstone. The *savoir-faire* or the practical knowledge and motor skill may be observed in the application of force or the angle they strike the parent material (Bamforth et al. 2008:2-3; Milne 2005:329; Pelegrin 1990:118).

I worked with eight volunteers who ranged from novice (n=4) and intermediate (n=2), to expert (n=2). The novice flintknappers were anthropology students attending the University of Idaho in Fall semester 2018 who showed an interest in learning how to flintknap but had little to no experience in either flintknapping or theoretical background.

The range in experience for the intermediate flintknappers varies with one individual who had flintknapped for a year prior to this study and the other (self) who had flintknapped for five years and was trained in lithic technology. The intermediate level will have more variation in *connaissance* (cognitive knowledge) and the *savoir-faire* (practical knowledge), and this difference may lead to conflicting results ranging into the novice and expert levels (Bamforth et al. 2008:19). The expert flintknappers have extensive knowledge of flintknapping, they have taught numerous individuals how to flintknap, and are well versed in theoretical background. Because the categories of skill are broad, I asked each volunteer flintknapper a series of questions.

1. Have you worked as an archaeologist?
2. If yes, how long have you worked as an archaeologist?
3. Have you encountered lithics while conducting fieldwork?
4. How much experience flintknapping have you had prior to making bifaces for my research?
5. Can I have permission to use the results of the bifaces you made during Fall semester 2018 for my thesis research?

Flintknapper #1 Novice:

1. I have never worked as an archaeologist.
2. (N/A)
3. (N/A)
4. No experience.
5. Yes, you have permission to use my work.

Flintknapper #2 Novice:

1. Yes, mostly office and GIS work but a little bit of field work was involved.
2. My first archaeological experience was in 2012, but I officially worked in archaeology for three years plus three months of field school.
3. Yes
4. I flintknapped for a few hours in 2012 and was not directed.
5. You have permission to use the results of the bifaces I made.

Flintknapper #3 Novice:

1. I have not yet worked (as in paid) as an archaeologist.
2. NA
3. NA
4. Before making bifaces for you I had no prior experience in flintknapping.
5. Yes, you may use the results from the bifaces I made last semester for your thesis.

Flintknapper #4 Novice:

1. Yes
2. 4.5 years
3. Yes
4. None
5. I give you permission to use the bifaces I made for your thesis.

Flintknapper #5 Intermediate:

1. Yes, I have worked as an archaeologist.
2. I have been doing archaeological fieldwork since June 2017.
3. Yes, lithics are the primary material culture I have found in the field pre-contact sites. (All debitage from various stages of lithic reduction).
4. I had one year of experience flintknapping prior to taking part in this experiment.
5. You have my permission to use any info/data you have collected from me for this experiment.

Flintknapper #6 (Self) Intermediate:

1. Yes, I have worked as an archaeologist.
2. I have 10 years of experience as an archaeologist.
3. Yes
4. I had five years of experience flintknapping and I was trained as a lithic analyst.
5. Yes

Flintknapper #7 Expert:

1. No
2. NA
3. NA
4. 15 years of experience flintknapping and I have been teaching flintknapping for 13 years.
5. Yes

Flintknapper #8 Expert:

1. Yes
2. I have been working as an archaeologist for 55 years.
3. Yes
4. I have been flintknapping for 65 years.
5. Yes, you can use the bifaces I made in your thesis.

Novice Flintknapper Observations

All levels of flintknappers were encouraged to select their choice of flake blanks and hammerstone(s) to be used during the reduction process. The novice flintknappers chose a soft sandstone hammerstone and used the same one for the entire reduction. Choosing the right tool for the job is an aspect of skill. For example, when reducing a large thick flake, a harder hammerstone is ideal to remove the thick areas and a softer hammerstone or an antler billet is a better choice for removing flakes from thinner areas. There were a few instances when the novice flintknapper used a different hammerstone when unable to remove a flake after several strikes.

The novice flintknappers repeatedly chose flake blanks that were large, thick, and chunky. The larger flake blanks are more difficult to reduce and proved challenging for the novice flintknappers to reduce into the desired tool shape. When I suggested they select a thinner flake blank for the reduction I was met with hesitation because the thinner flake may break, which they viewed as a failed attempt. There were two flintknappers who mimicked my techniques such as arris grinding (grinding the ridges on the surface of the tool) and platform preparation from the start and they were successful at producing bifaces early in the experiment. Whereas the other two flintknappers developed the technique as they progressed in their biface production. There was a strong learning curve present with each of the novice flintknappers.

Intermediate Flintknapper Observations

In the intermediate skill level, flintknapper #5, did not receive a demonstration prior to the manufacture of the bifaces as she had a year of experience with flintknapping. The same hammerstones were offered as were for the novice flintknappers but she chose to use her personal hammerstone from her flintknapping kit. She used a hard hammerstone for each reduction except biface #14. I had noticed several large hinge terminations on the bifaces that were manufactured up to this point and suggested she use a soft hammerstone to see if that would decrease the amount of hinge terminations. The soft hammerstone was used but eventually replaced with the initial hard hammerstone.

Each bifacial blank produced by flintknapper #5 was performed in a way that was thorough and well-planned. She understood the *connaissance* (technical knowledge) and applied it accordingly. The *savoir-faire* (practical knowledge) or the skill and dexterity to strike the parent material in the correct place with the right amount of force was still being developed.

I am flintknapper #6 and I had five years of experience flintknapping prior to this experiment. I tended to choose the flake blanks that were rejected by the other flintknappers so as not to waste material, and because I like the challenge of producing a successful bifacial blank from a difficult flake blank. I used a hard hammerstone to remove thick square edges and then used a soft hammerstone to finish the biface. In addition to my five years of flintknapping experience I have taught lithic technological classes and have been trained as a lithic analyst. I have the technical knowledge and understanding of how to produce stone tools, but my practical knowledge still needs development.

Expert Flintknappers Observations

Flintknapper #7 has been flintknapping for 15 years and has been teaching others to flintknap for the past 13 years. He was offered flake blanks that were challenging and others that were ideal for manufacturing bifacial blanks. During the reduction he would often switch from a moose antler billet to a hard hammerstone to successfully remove the flakes from the parent material. There was continuous adjustment of angles in which he would strike the material. He employed platform preparation and he reduced the flake blanks into bifacial blanks in an efficient manner.

Flintknapper #8 has been flintknapping for 65 years and is a first-generation student of Don Crabtree’s field school. He has taught many flintknapping workshops during his archaeological career. Flintknapper #8 produced all 15 of his flake blanks and reduced them into bifacial blanks using both hard and soft hammerstones. There was continuous adjustment of angles on the parent material. He reduced the flake blanks in a quick and efficient manner to remove only the necessary amount of raw material which left a desirable amount of remaining useful toolstone.

Attributes Indicating Skill

There are several attributes and characteristics I have identified indicating skill level of the flintknappers (Table 5.1). The attributes I have identified are as follows: quality of material (flake blank), successful manufacture (Figure 5.1) of the desired tool and shape, complete or broken tool, stacked-step fractures, step and hinge terminations (Figure 5.2), the time it took to produce the tool, and platform preparation. The ability to recognize and choose quality raw material is key to a successful reduction.

Table 5.1: Skill Level Attributes

Attributes	Novice	Intermediate	Expert	Cache
Total Number of Bifaces Manufactured	60	30	30	15
Unsuccessful at Manufacturing a Biface	16	3	1	NA
Broken During Manufacture and Discarded	5	4	0	NA
Broken During Manufacture and Produced a Successful Biface	5	3	7	NA
Percent of Successful Bifaces	73%	90%	96.6%	100%
Oval	35	22	25	5
Oval/Triangular	10	2	2	2
Oval/Square	2	-	-	-
Rectangular	3	-	2	-
Square	1	1	-	-
Triangular	7	2	1	8
NA	2	3	-	-
Phenocrysts	28	15	3	8
Manufacturing Errors Average Per Biface	12.53	11.23	7.87	11.06
Big Errors Average Per Biface	3.13	2.1	1.3	3.2
Platform Preparation	50	29	29	8
Platform Preparation % of Total Bifaces Manufactured	83.3%	96.7%	96.7%	53.3%
Average Time in Minutes to Manufacture a Biface	24.52	12.44	5.53	NA

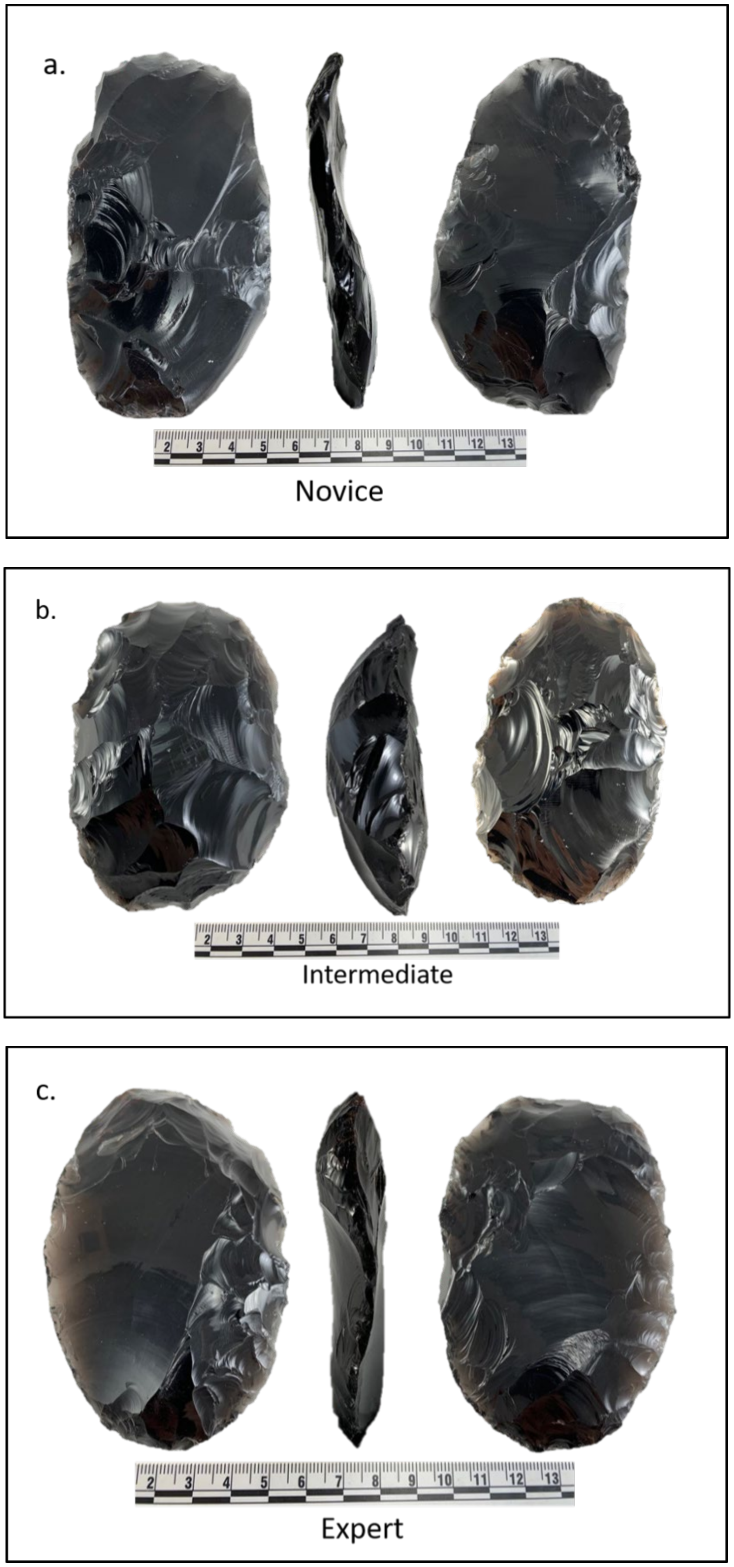

Figure 5.1: Successful Experimental Bifacial Blanks.

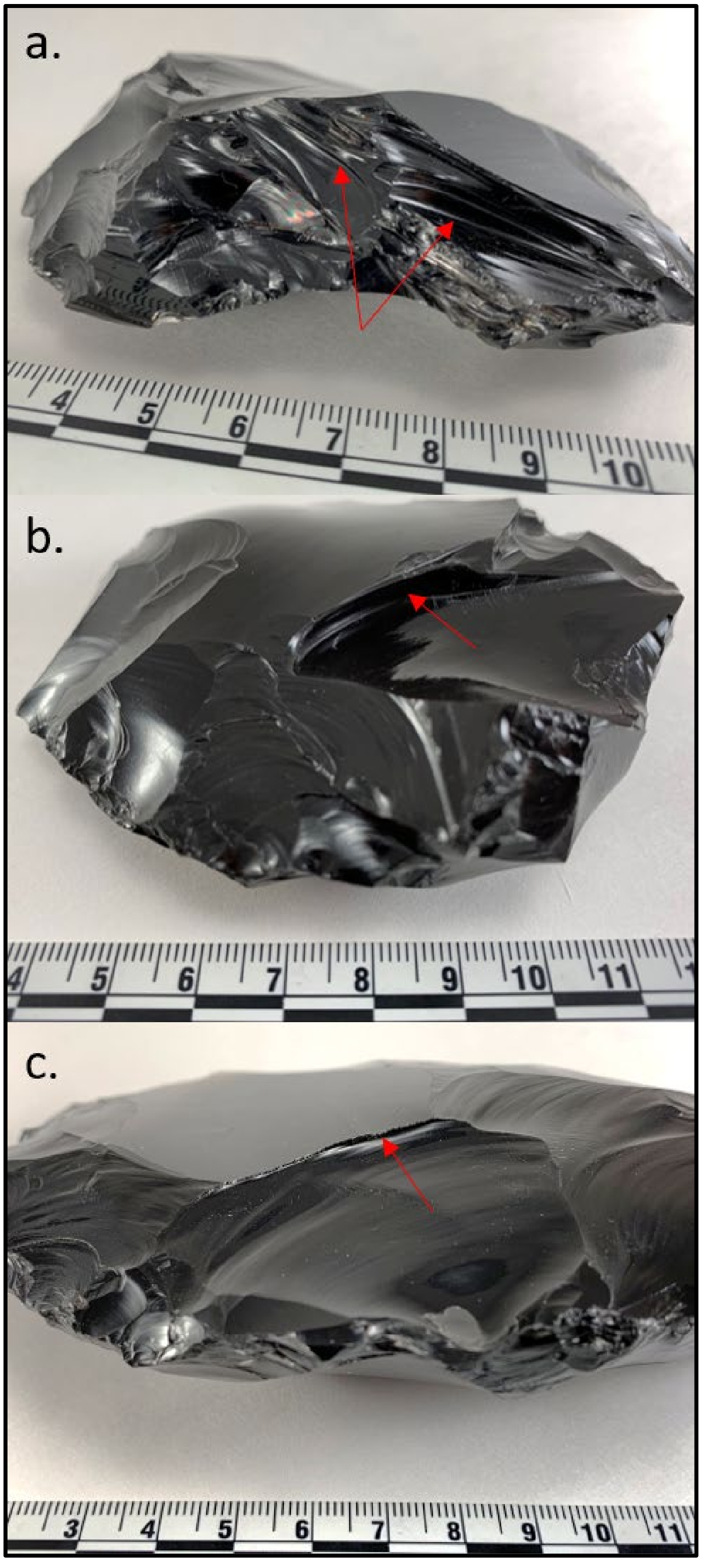

Figure 5.2: Termination Errors. a. Stacked-step: Novice b. Hinge: Novice c. Step: Expert.

Successfully producing 15 bifacial blanks was the goal for each of the flintknappers. The flintknappers were shown an example and asked to produce a similar tool with a similar shape. Observing choices made by the flintknappers when selecting the flake blanks and hammerstones may give insights into why the manufacturing of the biface was successful (or not). Observing the episode of flake removal helps determine how far along the flintknapper was in the manufacturing process.

Documenting the manufacturing breaks are important in the replication reduction sequence modeling analysis because they exhibit evidence of the reduction sequence and the stage of the reduction process. There were two types of manufacturing breaks recorded during this analysis: Bend break and *outrepasse* or an overshot flake. A bend break (Figure 5.3) is not exclusive to the manufacturing process and can occur during tool use. It is caused when the flexing of the material exceeds its elasticity, and usually initiates at the center of the artifact and terminates on the opposite face. Two ways bend breaks can occur during the manufacturing process are by excessive percussive wave shock, or not supporting the material while striking to remove a flake. An overshot flake (Figure 5.4) occurs when too much force is applied to the parent material, resulting in a flake with a reverse hinge termination that removes part of the biface on the opposite margin from which it initiated (AINW Lithic Glossary 2018).

Ideally, a feather termination is desired due to the smooth surface left on the biface. Other terminations leave an undesirable surface on the biface, making subsequent flake removal difficult. All flintknappers err when producing stone tools, while some errors can be corrected, others will prevent further reduction of the tool or simply cause the tool to break. Stacked-step fractures, hinge, and step terminations do not inherently cause the stone tool to become unusable, but the degree of the fractures and terminations may. An experienced flintknapper can successfully correct errors made during the reduction process that a novice flintknapper may discard.


Figure 5.3: Bend break: Expert.

Figure 5.4: Overshot Flake: Intermediate.

Knowing the amount of force needed to remove a successful flake from the parent material is a part of the practical knowledge of skill (Bamforth et al. 1990:188, 191). Too much force can result in an overshot flake that may cause the tool to break while not enough force can cause hinge and step terminations. Multiple unsuccessful strikes to the parent material can cause stacked-step fractures (Milne 2005:329). The errors recorded in this experiment (stacked-step fractures, hinge and step terminations) have been combined to document the average error and average big error (difficult to correct) per biface by skill level.

Platform preparation is a process employed during flintknapping to strengthen the edge of the biface and is more commonly used by expert flintknappers who tend to invest more energy into preparing the striking platform (Milne 2005:329). Platform preparation is necessary to produce a successful biface. If the platform of the biface is neglected, the tool can break, and the platform can become crushed which can disperse the applied force without removing a flake. The edge of the platform needs to be less than a 90-degree angle, and this angle can be manipulated by preparing the platform. The closer the angle is to 90 degrees the likelihood of producing hinge terminations and overshot flakes increases. Platform preparation is achieved by removing short trimming flakes from the platform by controlled strikes to the edge along with rubbing the edge with an abrader for strength (Whittaker 1994:98-101).

Cache Biface Attribute Analysis

The cache bifaces from site 35MA375, had morphological variations, but as a whole, the biface shapes could be classified as oval (n=8), triangular (n=5), and two that were roughly oval to triangular in shape. The bifaces exhibited two to three episodes of flake removal on either one or both surfaces of the biface. The first episode of flake removal produced larger flakes spaced widely apart, while the second and third episodes removed smaller flakes and were placed roughly between the larger negative flake scars. One exception is cache biface #1, which exhibits only two percussion scars on the ventral surface and two episodes of flake removal on the dorsal surface.

Of the fifteen cache bifaces, fourteen were made from obsidian with phenocrysts present throughout the raw material. Phenocrysts can hinder the reduction process as they can cause hinge and step terminations, and difficulty in removing flakes past the midline. Being able to flake to or past the midline of the biface is a critical step in the manufacturing process of thinning a biface. All of the bifaces exhibited hinge terminations, step terminations, and/or stacked step terminations. These flake terminations are considered to be errors in the manufacturing process, which in some cases could be due to the presence of phenocrysts (Figure 5.5). The cache biface exhibited an average of 11.1 errors per biface and 3.2 big errors that could prevent further reduction.

Platform preparation techniques employed in the production of the cache bifaces involved removal of short flakes from the biface margins to strengthen striking platforms for subsequent reduction. Of the fifteen bifaces, eight retained evidence of platform preparation that included grinding, rounding of margins, and removal of several short flakes from square edges. Interestingly, the flintknapper(s) who produced the cache bifaces from site 35MA375 only applied platform preparation on 53.3% of the bifaces.

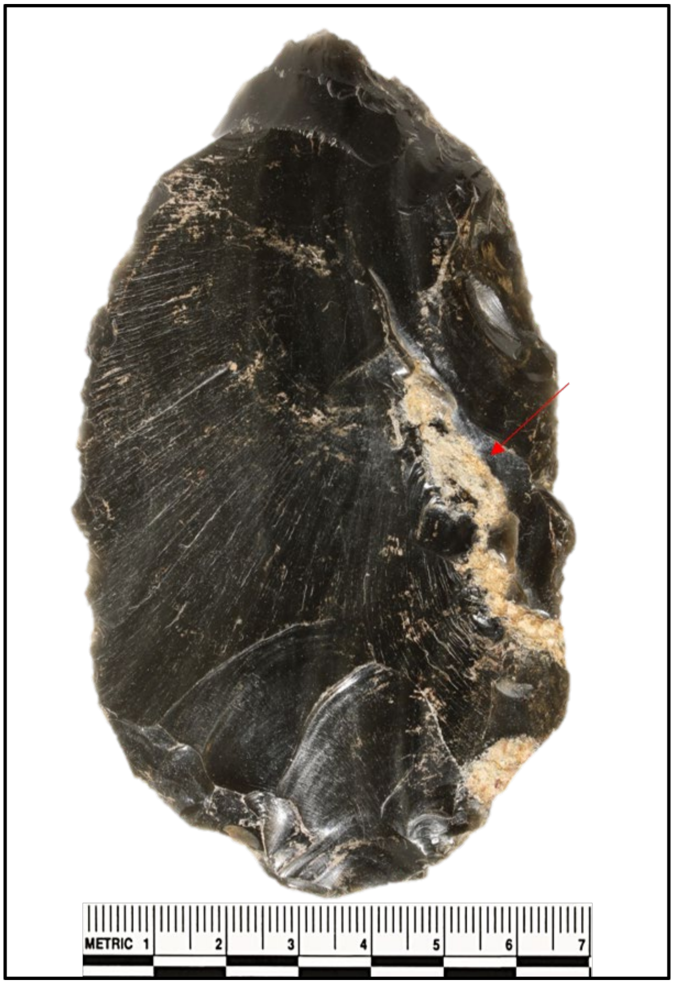

Figure 5.5: Phenocrysts: Cache Biface #7.

Experimental Biface Attribute Analysis

There is a significant amount of morphological variation among the experimental bifaces produced by the novice group. They are classified as oval (n=35), oval to triangular (n=10), triangular (n=7), rectangular (n=3), oval to square (n=2), square (n=1), and indeterminate (n=2). The novice flintknappers had a modal rate of two episodes of flake removal per bifacial blank. The first episode removed large flakes, at times leaving large concave surfaces, and the second round removing smaller flakes between and within the large concave surfaces, which at times created big errors.

The intermediate group also had a significant amount of morphological variation and are classified as oval (n=22), oval to triangular (n=2), rectangular (n=2), and indeterminate (n=3). The intermediate group has a modal rate of 2-3 episodes of flake removal per biface which is slightly higher than the novice group. Compared to the expert group who had less variation and are classified as oval (n=25), oval to triangular (n=2), rectangular (n=2), and triangular (n=1). The expert group had a modal rate of 1-2 episodes of flake removal indicating less time was spent preparing each bifacial blank.

Of the 60 bifacial blanks attempted by the novice flintknappers, 44 (73%) were successfully manufactured into the desired tool. Out of the 44 bifacial blanks produced by this group, five (11.4%) were broken during manufacture and then successfully corrected to form the desired tool. There were 16 unsuccessful bifacial blanks produced (Figure 5.6), and four (25%) of those were broken during the manufacturing process and discarded. The nine breaks recorded on the bifaces manufactured by the novice flintknappers during the manufacturing process (corrected and discarded) are represented by bend (n=8) and overshot (n=1).

Of the 30 bifacial blanks attempted by the intermediate flintknappers 25 (83.3%) were successfully manufactured into the desired tool. Out of the 30 bifacial blanks produced by this group, there were four (16%) that were broken during manufacturing and successfully corrected and formed into a functional biface. There were five unsuccessful bifacial blanks produced and three (60%) of those were broken during the manufacturing process and discarded. One of the bifacial blanks broken during manufacturing had cracks in the parent material that caused the break. The seven breaks on the bifacial blank that occurred during the manufacturing process (corrected and discarded), are represented by bend (n=6) and overshot (n=1).

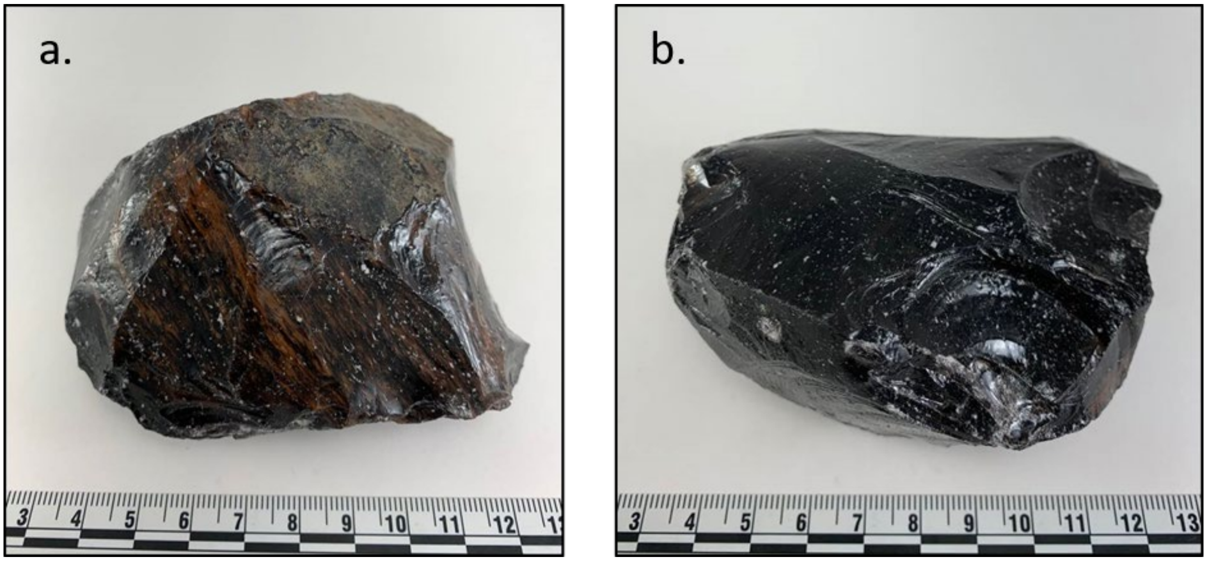

Figure 5.6: Unsuccessful Biface Novice: a. Dorsal Surface b. Ventral Surface.

In comparison, the expert flintknappers successfully manufactured 29 (96.6%) of the 30 bifacial blanks. Of the 29 successful bifacial blanks, seven (24.1%) were broken during the manufacturing process and successfully repaired to form the desired tool. Interestingly, the expert flintknappers did not discard any broken bifaces, but instead repaired them to form functional bifaces. All seven breaks are represented as bend breaks. The cache bifaces are all complete tools and it is unknown if there were breaks during the manufacturing process as the debitage associated with the cache bifaces was not recovered from site 35MA375.

The novice flintknappers had a total of 28 (46.7%) bifacial blanks that contained phenocrysts in the raw material, which may contribute to the error rate. This group averaged 12.5 errors per biface and 3.1 big errors that could prevent the tool from being further reduced. The intermediate flintknappers had 15 (50%) bifacial blanks exhibiting phenocrysts which is slightly higher than the novice flintknappers, but their average error per tool decreased slightly to 11.2 and 2.1 big errors. The expert flintknappers had significantly fewer bifacial blanks with phenocrysts consisting of three (or 10%). Also, a noticeable decrease in the average error rate per biface at 7.9 errors and 1.3 for the big errors.

Platform preparation was employed in every skill level in this experiment. During the demonstration I performed for the novice flintknappers I applied platform preparation and each one repeated my actions. The novice flintknappers used platform preparation on 83.3% of the bifacial blank. This group spent an average of 24.52 minutes to produce a single bifacial blank and it would take them each approximately 6 hours to produce all 15 tools. The intermediate flintknappers employed platform preparation technique 96.7% of the time. This group spent an average of 12.44 minutes to produce one bifacial blank and it would take them approximately three hours to produce all 15 tools. The expert flintknappers also used platform preparation 96.7% of the time. This group averaged 5.53 minutes to produce one bifacial blank which would take them approximately 1.5 hours to produce 15 tools.

There are some questions that cannot be answered by this study. For instance, it is unknown if any cache bifaces were broken during the manufacturing process. This study has the potential to answer questions regarding the amount of time it would take a single flintknapper to produce 15 bifacial blanks and which attributes or combination of attributes indicate a low vs. high skill level. These results do not conclusively place the cache bifaces within a certain skill level, nor is the sample size of flintknappers large enough to become statistically significant. In order to more adequately define skill level, a larger sample size is needed.

Performing the debitage analysis on the experimental bifaces could add additional information regarding skill as the type and count of terminations could be documented, whereas this study documents the error terminations that are present on the tool. This average error rate places the skill level of the cache flintknapper(s) within the intermediate skill level and the average big error within the novice skill level. The high error rate average in the cache bifaces could be explained by the phenocrysts in the obsidian used to produce the bifaces. The ability to produce the bifacial blanks while working around large phenocrysts suggests the flintknapper who produced the cache bifaces had a higher level of skill even though there were several errors.

Assessing the skill level exhibited in an assemblage can give the lithic analyst insights into the behavioral components of an archaeological site and may prove useful in assessing site function. If a significant amount of raw material at an archaeological site with artifacts holds a number of errors in manufacture, the lithic analyst may be able to determine that someone was learning how to flintknap. With more experiments into skill level, we may be able to define the amount of time it takes a person to become an efficient flintknapper. Determining that individuals within a group were being taught to flintknap, along with the requisite investments in material and time also speak to the relative importance of lithic tools in the community making use of them. This provides a window into the past previously underutilized in lithic analysis.

Chapter 6: Conclusion

This study took an experimental approach to the manufacture of bifacial blanks and compared the technological attributes to those found at 35MA375 and addressed research questions regarding the skill level of flintknappers in the past. This study does have the potential to answer questions about the time it would take a single flintknapper to produce 15 bifacial blanks and which attributes or combination of attributes indicate a low vs. high skill level. Because lithic debitage associated with the cache bifaces is not present at site 35MA375 it is unknown if any cache bifaces were broken during the manufacturing process.

Performing debitage analysis on the experimental bifaces could add information regarding skill, as the type and count of terminations could be documented, whereas this study documents the error terminations that are only present on the tools because there was no debitage associated with the cache bifaces recorded at site 35MA375. The average error rate places the skill level of the cache flintknapper(s) within the intermediate skill level and the average big error within the novice skill level. The high error rate average in the cache bifaces could be explained by the phenocrysts in the obsidian used to produce the bifaces. The ability to produce bifacial blanks while working around large phenocrysts suggests the flintknapper who produced the cache bifaces had a higher level of skill even though there were several errors.

These results do not conclusively place the cache bifaces within a certain skill level, nor is the sample size of flintknappers large enough to be statistically significant. Over time, it is my goal to reach a statistically significant number of flintknappers to more effectively define each skill level and apply those results to site 35MA375 and other caches in the region.

The secondary research questions in this study address behavioral aspects that go beyond skill level to determine the function (utilitarian or ritualistic) of the cache bifaces. The location of archaeological site 35MA375 in the Willamette Valley is documented to be in proximity to prehistoric trade networks, suggesting that this site had a utilitarian function and the bifacial blanks were meant for later retrieval.

We know from archaeological excavations, results of obsidian hydration and sourcing, and the lithic technological analysis that the cache bifaces were procured from Obsidian Cliffs, Oregon approximately 4000 years ago. There was no lithic debitage recovered from site 35MA375 that would suggest the bifaces were reduced on site but most likely at the Obsidian Cliffs quarry or en route to the Willamette Valley where they were cached and never retrieved.

Based on the obsidian hydration results, site 35MA375 had been used by successive groups of Native Americans for thousands of years following the cached obsidian bifaces. The later occupants procured obsidian from waterway sources in the Willamette Valley and undertook a variety of lithic activities. These activities included the manufacture of cores from various toolstone to produce expedient tools and the production and maintenance of arrow points.

Finally, it is hoped this study sheds light on the steps taken during the progression from a flintknapping novice to an expert. Additional to the hand skills required, selection of implements such as hammerstones and billets, and the raw material itself are important.

Taking the time to learn and excel in these choices is a strong determinant in the success of a flintknapper. In the end, finding tools at an archaeological site that were made by flintknappers of differing skill levels hints at the importance of lithic tool manufacture and use within a society.

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Appendix A - Technological Analysis of Cache and Experimental Bifaces

Cache Bifaces	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Length CM	10.86	12.21	10.62	10.4	9.08	10.05	12.21	10.75	10.1	10.45	9.67	9.72	10.95	10.78	10.3
Width CM	7.88	6.81	6.38	6.13	6.29	6.2	7.04	6.67	5.41	6.27	6.2	6.45	7.12	5.3	5.2
Thickness CM	2.74	1.96	2.31	1.81	1.54	1.93	2.1	1.91	2.19	1.73	1.74	2.37	2.33	1.22	1.4
Complete Tool	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cross-Section	Pl	Bi	Pl	Pl	Bi	Bi	Pl	Bi	Pl	Pl	Bi	Bi	Pl	Bi	Pl
Flakes to or Past Mid-line	-	X	X	X	X	X	X	X	X	-	X	X	X	X	X
Thick Patches	X	X	X	X	-	X	X	-	X	-	-	X	X	-	-
Stacked-Step Fractures	2	0	1	2	0	0	1	0	1	1	0	0	1	0	1
Hinge Terminations	5	5	6	8	11	8	3	5	7	4	5	7	6	8	2
Step Terminations	11	15	7	3	7	2	2	5	1	1	4	2	3	1	2
Remnant Surface Dorsal	X	X	X	X	X	X	X	X	X	-	X	X	X	-	-
Remnant Surface Ventral	X	-	-	-	-	-	X	X	X	X	-	X	-	X	-
Original Surfaces Platform	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Platform Preparation	-	-	-	X	X	-	-	-	X	X	X	X	X	-	X

Cache Bifaces	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Inclusions or Cracks	X	X	-	X	X	X	X	X	-	X	-	X	X	X	-
Edges Centered	-	-	-	-	X	-	-	X	-	X	X	X	-	X	X
Cortex	-	-	-	-	PG	PG	PG	PG	PG	PG	PG	PG	PG	PG	-
Episodes of Removal	2	2	3	2	2	2	2-3	2	2	2	2	3	2	2	3
Arris Grinding	-	X	X	X	X	X	X	X	-	X	X	X	X	-	-
Shape	Oval/ Tri	Tri	Tri	Tri	Tri	Tri	Oval	Oval	Oval	Tri	Oval/ Tri	Oval	Oval	Tri	Tri
Tool Weight Grams	192	142	112	118	101	122	166	149	108	116	114	135	164	77	68

Note: An "X" in the box indicates presence of listed attribute on indicated biface.
Cache bifaces from site 35MA375.

Novice #1 Bifaces	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Length CM	10.0	7.5	7.1	9.5	9.7	10.2	10.5	9.1	8.5	12.6	10.0	7.7	8.8	8.1	8.6
Width CM	7.7	7.3	6.0	7.5	6.5	7.5	9.3	5.6	7.2	7.0	9.0	6.1	7.7	6.2	7.3
Thickness CM	2.6	2.3	1.8	2.1	2.2	2.4	3.4	2.3	2.6	1.6	2.6	1.7	4.3	2.1	1.9
Complete Tool	X	X	X	2	X	X	X	X	X	X	X	2	X	X	X
Cross-Section	Bi/Pl	Pl	Pl	Pl	Bi	Pl	Pl	Pl	Pl	Bi	Pl	Bi	Pl	Bi	Pl
Flakes to or Past Mid-line	X	-	X	X	-	X	X	X	-	X	X	X	-	X	-
Thick Patches	X	X	X	X	X	X	X	X	X	-	X	-	X	X	X
Stacked-Step Fractures	3	9	2	7	5	10	5	5	5	4	1	7	0	2	3
Hinge Terminations	4	3	6	4	3	9	9	4	4	6	4	2	1	3	4
Step Terminations	3	2	6	3	5	3	8	9	5	8	11	3	6	3	3
Remnant Surface Dorsal	X	X	X	X	X	X	X	X	X	X	-	X	-	X	X
Remnant Surface Ventral	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Original Surface Platform	-	-	-	X	-	X	-	-	X	-	-	-	-	-	X
Squared Edge/s	-	-	X	X	X	X	X	X	X	X	-	-	-	-	X
Platform Preparation	X	X	X	X	X	X	X	X	-	X	X	X	-	X	X
Inclusions or Cracks	-	-	-	X	X	X	-	-	-	-	-	X	-	-	-
Edges Centered	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cortex	PG	-	PG	PG	PG	-	-	-	PG	PG	PG	PG	PG	-	-
Episodes of Removal	2	2-3	2	2	2	2	2	2-3	2	2-3	3	2	2	2	2
Arris Grinding	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-

Novice #1 Bifaces	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Shape	Oval	Oval	Oval	Oval	Oval/ Tri	Oval/ Tri	Oval/ Tri	Oval	Tri	Oval	Oval	Oval	Oval	Oval/ Squ	Oval/ Squ
Flake Length CM	12.4	11.5	12.0	-	-	-	-	-	-	-	-	-	-	-	-
Flake Width CM	10.5	10.1	9.2	-	-	-	-	-	-	-	-	-	-	-	-
Flake Thickness CM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Debitage Weight Grams	80.4	66.3	57.7	151.2	108.6	344.7	459.8	539.8	222.2	220	337.1	149.5	334.4	102.1	195.2
Tool Weight Grams	182.5	119.4	70.3	191.7	145.3	176.8	268.4	152.5	168	165.7	231.7	143.9	267.4	138.6	140.5
Total Weight Grams	262.9	185.7	128	342.9	253.9	521.5	728.2	692.3	390.2	385.7	568.8	293.4	601.8	240.7	335.7
Time (Min.)	10:35	19:20	21:20	10:20	10:26	19:53	19:00	35:18	17:15	24:44	28:23	41:12	11:23	8:15	14:19

Note: An “X” in the box indicates presence of listed attribute on indicated biface.
IND: Indeterminate shape.
Flintknapper #1 Novice: Technological Analysis.

Novice #2 Bifaces	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Length CM	9.3	5.5	8.2	9.1	7.5	9.7	7.2	9.8	6.5	6.5	6.4	9.0	10.8	9.4	12.2
Width CM	6.2	4.7	5.1	7.5	6.3	8.5	7.1	8.4	5.2	6.0	5.9	5.5	7.0	8.5	6.8
Thickness CM	3.5	1.5	2.6	1.9	1.5	3.5	3.8	3.7	3.1	2.8	3.7	1.0	1.3	2.9	4.5
Complete Tool	X	X	X	2	X	X	X	X	X	X	X	X	X	X	X
Cross-Section	Pl	Pl	Pl	Pl	Pl	Bi	Pl	Bi/Pl	Pl	Pl	Pl	Bi	Bi	Bi	Bi
Flakes to or Past Mid-line	X	X	X	X	-	X	X	X	X	X	X	-	-	X	X
Thick Patches	X	X	X	X	X	X	X	X	X	X	X	-	-	X	X
Stacked-Step Fractures	3	1	2	4	6	3	4	7	0	3	4	2	1	8	7
Hinge Terminations	4	3	7	7	2	10	7	6	3	2	4	2	1	1	10
Step Terminations	2	4	4	5	10	12	8	9	6	8	5	11	8	11	17
Remnant Surface Dorsal	-	-	X	X	X	X	-	X	X	-	-	X	X	X	-
Remnant Surface Ventral	-	-	X	X	X	X	X	-	X	X	X	X	X	X	X
Original Surface Platform	-	-	-	X	X	-	-	-	-	-	X	-	-	-	-
Squared Edge/s	-	X	X	X	X	-	-	-	-	-	X	-	-	-	X
Platform Preparation	X	X	X	X	-	X	X	X	X	X	-	X	X	X	X
Inclusions or Cracks	X	X	X	-	X	X	-	X	X	X	-	X	-	-	X
Edges Centered	-	-	-	-	-	X	-	-	-	-	-	X	X	X	X
Cortex	PG	IC	IC	IC	PG		PG		PG		PG		PG	PG	IC

Novice #2 Bifaces	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Episodes of Removal	2	2	1-2	1-2	2	2	2	2-3	2	1-2	2	1-2	1-2	2	2
Arris Grinding	-	-	X	-	-	-	-	-	-	-	-	--		--	
Shape	Oval	Squ	Oval/ Tri	Tri	Tri	Rect	Oval	Oval	Oval	Oval	Oval	Rect	Oval/ Tri	Tri	Oval
Flake Length CM	-	-	-	-	-	-	-	-	-	-	-	-	-	13.1	15.5
Flake Width CM	-	-	-	-	-	-	-	-	-	-	-	-	-	11.3	13.4
Flake Thickness CM	-	-	-	-	-	-	-	-	-	-	-	-	-	3.4	5.7
Debitage Weight Grams	273.7	72.4	148.1	109.2	230.2	184.2	317.6	398.8	115.3	194	225.2	108.3	41.7	251.5	824
Tool Weight Grams	184.6	48.6	148.5	110.4	64.5	273.7	173.5	307.7	85.4	91.6	105.4	85.7	109.5	234.1	448.5
Total Weight Grams	458.2	121.1	296.5	219.7	294.7	457.9	491.1	706.5	200.7	285.6	330.6	194	151.2	485.6	1272.5
Time (Min.)	59:00	18:00	41:50	43:10	31:45	24:00	25:01	23:25	10:07	11:41	9:53	17:20	9:33	16:08	27:30

Note: An “X” in the box indicates presence of listed attribute on indicated biface.
IND: Indeterminate shape.
Flintknapper #2 Novice: Technological Analysis.

Novice #3 Bifaces	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Length CM	10.3	9.0	11.3	9.1	8.7	8.3	10.1	7.6	9.7	7.8	9.4	9.5	11.5	7.8	9.0
Width CM	8.2	7.3	7.7	6.5	5.7	5.1	6.8	5.0	8.1	5.4	6.1	6.7	6.6	5.6	6.0
Thickness CM	2.6	1.5	3.7	1.9	2.6	1.6	4.9	1.6	2.5	1.8	2.3	5.1	4.0	1.4	1.3
Complete Tool	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cross-Section	Bi	Bi	Bi	Bi	Bi/Pl	Bi	Pl	Bi/Pl	Pl	Pl	Pl	Pl	Pl	Bi	Bi/Pl
Flakes to or Past Mid-line	-	X	X	-	X	-	X	-	X	-	X	X	-	X	X
Thick Patches	X	-	X	-	X	X	X	X	X	X	X	X	X	-	-
Stacked-Step Fractures	2	3	5	1	0	4	2	1	0	0	3	4	8	0	0
Hinge Terminations	2	6	7	3	4	1	5	1	10	4	0	9	7	0	1
Step Terminations	2	6	7	4	5	7	5	4	7	2	4	2	6	3	4
Remnant Surface Dorsal	-	-	X	X	X	X	X	X	X	X	X	X	-	X	X
Remnant Surface Ventral	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Original Surface Platform	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-
Squared Edge/s	X	X	-	-	-	-	-	-	X	-	X	X	X	-	-
Platform Preparation	-	X	X	X	X	X	-	X	X	X	X	X	-	X	X
Inclusions or Cracks	X	-	X	-	-	-	-	-	X	-	-	X	-	-	-
Edges Centered	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-
Cortex	PG	PG	PG	PG	PG	PG	IC	PG	PG	-	-	PG	PG	-	IC
Episodes of Removal	1-2	1-2	2-3	1-2	2	2	2-3	1-2	1-2	2	2	2	2	1-2	1-2
Arris Grinding	-	-	X	-	X	X	X	X	X	X	X	-	X	X	X
Shape	Tri	Oval	Oval	Oval/	Oval/	Oval/	Oval	Oval	Oval	Oval	Oval	Oval	Oval	Oval	Oval

Novice #3 Bifaces	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
				Tri	Tri	Tri									
Flake Length CM	-	-	-	-	-	-	-	-	-	-	16.3	15.3	10.6	11.0	11.0
Flake Width CM	-	-	-	-	-	-	-	-	-	-	10.5	9.9	7.3	1.8	8.3
Flake Thickness CM	-	-	-	-	-	-	-	-	-	-	5.2	4.2	1.7	1.7	2.5
Debitage Weight Grams	69.9	117.7	382	29.9	60.3	91.1	263.8	67.9	95.5	161	149.6	464.6	311.2	47	53.5
Tool Weight Grams	201.2	112.7	305	106.9	115.3	83.8	290.9	74.8	204.4	103.8	133.9	331.5	409.4	74.7	80.4
Total Weight Grams	271.1	230.4	687	136.8	175.6	174.9	554.7	142.7	299.9	264.8	283.4	796.1	720.6	121.6	133.9
Time (Min.)	27:00	48:50	20:00	28:15	44:00	32:47	60:10	60:04	39:19	48:09	40:00	49:10	49:50	27:45	34:02

An “X” in the box indicates presence of listed attribute on indicated biface.
IND: Indeterminate shape.
Flintknapper #3 Novice: Technological Analysis.

Novice #4 Bifaces	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Length CM	7.9	8.3	8.6	8.4	9.1	9.3	7.6	9.6	8.9	NA	7.5	8.0	10.8	8.4	10.2
Width CM	5.7	7.5	7.7	7.5	6.2	7.0	7.8	6.4	7.6	7.0	5.2	6.5	6.2	5.5	6.5
Thickness CM	2.6	2.1	2.6	2.3	1.9	1.7	3.0	1.7	2.1	1.0	2.1	2.7	3.3	3.9	2.8
Complete Tool	X	X	X	X	X	X	X	X	X	4+	X	X	X	X	X
Cross-Section	Pl	Pl	Bi	Pl	Pl	Pl	Pl	Bi	Bi	Bi	Bi	Bi	Pl	Pl	Pl
Flakes to or Past Mid-line	X	X	X	-	X	X	X	X	X	-	-	X	X	-	-
Thick Patches	X	X	X	X	X	X	X	-	X	-	X	X	X	X	X
Stacked-Step Fractures	1	2	2	3	4	1	2	0	1	0	3	6	7	11	7
Hinge Terminations	2	3	2	3	6	2	4	2	0	2	1	3	3	4	4
Step Terminations	6	5	8	4	3	5	4	1	7	2	1	3	3	4	4
Remnant Dorsal Surface	X	X	X	X	X	X	X	X	X	X	X	X	-	X	-
Remnant Ventral Surface	X	X	X	X	X	X	X	X	X	X	X	-	X	-	X
Original Surfaces Platform	-	-	X	-	-	X	-	-	-	-	X	-	-	-	-
Squared Edge/s	-	X	X	X	-	-	-	-	X	X	X	-	-	X	X
Platform Preparation	X	X	X	X	X	X	X	X	X	X	X	-	X	-	-
Inclusions or Cracks	X	X	-	-	X	X	X	-	-	-	X	X	X	X	X
Edges Centered	-	-	-	-	-	-	-	-	-	-	-	--	-	-	-
Cortex	-	PG	PG	IC	PG	PG	-	-	-	PG	PG	-	PG	-	PG
Episodes of Removal	2	2	2	1-2	2-3	1-2	1-2	2	1-2	1	1-2	2	2	2-3	2
Arris Grinding	X	-	X	-	X	X	X	X	X	-	-	-	-	-	-
Shape		Tri	Oval	Oval	Rec	Oval	Oval	Oval	Oval	Und	Oval/	Oval	Und	Tri	Oval/

Novice #4 Bifaces	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Oval										Tri				Tri
Flake Length CM	-	-	-	-	-	-	-	-	-	-	110.3	152	154	113.5	127.3
Flake Width CM	-	-	-	-	-	-	-	-	-	-	88	126.2	104.1	103.1	95.8
Flake Thickness CM	-	-	-	-	-	-	-	-	-	-	20.8	45.8	32.3	46.9	26.1
Debitage Weight Grams	205.4	122.1	198.6	110.76	282.2	77.6	216.3	127.6	95.5	36.3	69.5	550.3	211.7	314.5	187.6
Tool Weight Grams	103.1	130.8	165.7	152.91	118.2	25.8	163.6	132.9	159.9	74.5	76.7	139.1	186.4	153.4	193.4
Total Weight Grams	308.5	253	364.3	263.67	400.4	103.4	379.9	260.5	255.4	110.7	146.1	689.5	398.1	468	381
Time (Min.)	31:45	15:00	15:50	15:50	24:15	12:20	18:04	11:16	9:34	6:30	9:08	15:47	8:57	16:16	11:42

An “X” in the box indicates presence of listed attribute on indicated biface.
IND: Indeterminate shape.
Flintknapper #4 Intermediate: Technological Analysis.

Intermediate #5 Bifaces	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Length CM	10.8	12.8	11.9	15.3	11.8	10.0	12.8	9.8	10.5	10.4	11.6	9.6	11.6	9.3	11.4
Width CM	9.2	8.7	10.1	11.3	9.0	8.9	10.8	9.0	9.0	8.9	9.5	8.5	6.2	8.8	8.4
Thickness CM	3.5	2.3	3.8	4.3	3.6	2.1	2.1	2.6	3.9	4.2	5.6	3.6	2.6	2.5	3.7
Complete Tool	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cross-Section	Pl	Pl	Bi/Pl	Bi	Pl	Pl	Bi	Bi	Pl	Pl	Pl	Pl	Pl	Pl	Pl
Flakes to or Past Mid-line	-	-	X	X	X	-	-	X	X	-	X	X	X	-	X
Thick Patches	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Stacked-Step Fractures	1	2	3	6	1	4	6	3	3	4	3	3	4	3	2
Hinge Terminations	9	3	8	4	4	6	3	2	5	2	5	2	4	5	5
Step Terminations	3	3	4	5	2	5	8	6	2	2	7	4	3	4	3
Remnant Surface Dorsal	X	X	X	-	-	X	X	X	-	-	X	-	X	X	-
Remnant Surface Ventral	X	X	X	X	X	X	X	X	X	X	X	-	-	X	X
Original Surface Platform	-	-	-	-	-	X	X	X	X	-	-	X	-	-	-
Squared Edge/s	-	X	X	X	-	X	X	X	X	-	-	X	-	X	-
Platform Preparation	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Inclusions or Cracks	X	X	X	-	-	X	X	X	X	-	X	-	-	X	X
Edges Centered	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X
Cortex	PG	PG	PG	PG	IC	PG	PG	PG	PG	IC	PG	PG	-	PG	PG
Episodes of Removal	2	1-2	2-3	2-3	2	2	2	2-3	2-3	1-2	2-3	3	2-3	1-2	1-2
Arris Grinding	X	-	-	-	-	-	-	-	-	X	-	-	X	-	-
Shape	Oval	Oval/Tri	Oval	Tri	Oval	Squ	Oval	Oval	Oval	Oval	Oval	Oval	Oval	Oval	Oval

Intermediate #5 Bifaces	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Flake Length CM	15.0	16.0	12.6	15.3	15.1	12.4	14.6	12.2	13.0	10.4	11.7	10.6	45.0	12.5	14.3
Flake Width CM	10.5	10.5	13.9	12.4	11.1	9.2	13.4	12.2	11.1	8.9	11.7	10.2	9.5	10.7	9.4
Flake Thickness CM	3.5	4.5	4.1	5.2	4.2	3.2	5.7	4.2	4.4	4.2	6.9	4.4	4.7	3.4	4.5
Debitage Weight Grams	253.3	229.2	356.9	236.3	217.9	143	381.8	255.6	268.5	116.1	254.1	254.2	474.6	158.7	141.6
Tool Weight Grams	324.4	306.5	449.6	597.3	323.4	314.1	311.9	327.7	373.2	206.6	477.9	279.4	159.5	183.3	302.6
Total Weight Grams	577.7	535.7	806.5	833.6	541.2	457.1	693.7	583.3	641.7	322.7	732	533.6	634.1	342	444.2
Time (Min.)	13:18	11:52	13:51	52:04	11:08	13:18	17:24	12:29	35:26	17:33	22:49	16:37	22:32	14:17	14:34

Note: An “X” in the box indicates presence of listed attribute on indicated biface.
IND: Indeterminate shape.
Flintknapper #5 Intermediate: Technological Analysis

Intermediate #6 Bifaces	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Length CM	8.1	16.4	8.1	12.2	9.8	10.9	7.6	13.3	8.7	11	8.9	9.1	9.7	7.1	9.3
Width CM	7.6	8.1	6.8	7.8	7.5	9	6.6	5.4	6.1	7.4	7.1	5.4	6.2	6.6	5.9
Thickness CM	2.4	2.1	2.3	2.9	2.1	2.3	2.6	1.4	2.2	3.5	1.9	2.9	2.3	2.6	2
Complete Tool	X	2	X	X	X	3	X	X	X	X	X	3	2	X	X
Cross-Section	Bi	NA	Bi/Pl	Bi/Pl	Bi	Bi/Pl	Bi	Bi	Bi	Pl	Bi/Pl	NA	NA	Pl	Bi
Flakes to or Past Mid-line	X	-	X	X	-	X	X	-	-	X	X	X	X	X	-
Thick Patches	X	-	X	X	-	X	X	X	X	X	-	X	X	X	X
Stacked-Step Fractures	2	2	5	6	2	1	1	1	1	7	2	2	1	1	2
Hinge Terminations	2	1	4	7	2	4	2	2	4	7	3	3	1	2	2
Step Terminations	10	1	6	8	3	7	6	4	8	5	9	3	3	4	2
Remnant Surface Dorsal	X	X	X	-	X	X	-	X	X	X	X	-	-	-	X
Remnant Surface Ventral	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Original Surface Platform	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-
Squared Edge/s	X	X	-	X	X	X	X	-	-	-	-	X	X	X	-
Platform Preparation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Inclusions or Cracks	-	X	-	X	X	-	-	-	X	-	-	-	X	-	-
Edges Centered	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
Cortex	PG	PG	-	-	PG	-	PG	-	-	-	PG	-	IC	-	-
Episodes of Removal	2-3	1	2	2-3	1-2	2	2	1-2	1-2	2-3	2-3	NA	1-2	2	2
Arris Grinding	X	-	X	-	X	X	-	-	-	X	-	-	-	X	-
Shape	Oval	IND	Oval	Oval	Oval	IND	Oval	Oval	Oval	Oval	Oval/	IND	Oval	Oval	Tri

Intermediate #6 Bifaces	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
											Tri				
Flake Length CM	15.3	20.3	10.2	20.1	14.9	15.4	9.7	16.3	11.6	13.3	12.6	13.5	11.3	10.3	12
Flake Width CM	14.1	9.3	10.1	11.6	9.6	10.3	9.7	7.5	8.5	12.3	9.6	10	7	7.3	8.6
Flake Thickness CM	4.3	3.2	4.3	5.5	2.4	3	3	1.5	2.8	4.	3.6	4.6	2.4	3.7	2.4
Debitage Weight Grams	301.3	209.1	245	1043.6	170.1	177.4	146.7	71.2	103.4	578.3	307.	407.7	73.1	192.5	115
Tool Weight Grams	173.9	361.5	136.5	285.2	163.2	265.1	125	110	109.9	293.9	241.70	135.1	108.9	99.9	92.7
Total Weight Grams	475.2	570.6	381.5	1328.8	333.3	442.5	271.7	181.3	213.3	872.2	549.5	542.9	181.9	292.3	207.7
Time (Min.)	7:03	8:47	7:49	13:29	6:30	3:21	3:37	7:39	5:16	4:45	3:56	2:27	2:09	3:13	12:32

Note: An “X” in the box indicates presence of listed attribute on indicated biface.
IND: Indeterminate shape.
Flintknapper #6 Intermediate: Technological Analysis.

Expert #7 Bifaces	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Length CM	11.3	11.4	9.2	9.3	10.9	9.0	13.8	8.9	9.6	8.7	8.4	14.7	8.1	9.0	9.1
Width CM	6.3	5.3	6.4	6.6	8.7	5.9	8.9	5.3	7.9	6.1	7.6	11.4	5.2	8.5	6.0
Thickness CM	1.9	2.2	2.5	1.9	2.1	2.1	3.5	1.5	2.5	2.4	2.5	3.8	2.5	1.9	1.5
Complete Tool	X	X	X	X	X	X	X	X	X	2	X	X	X	X	X
Cross-Section	Pl	Pl	Pl	Pl	Pl	Pl	Bi	Bi	Bi/Pl	Bi/Pl	Bi	Bi/Pl	Pl	Bi	Bi
Flakes to or Past Mid-line	-	X	X	X	X	X	X	-	X	X	X	X	-	-	-
Thick Patches	X	X	X	X	-	X	X	-	X	X	X	X	X	X	-
Stacked-Step Fractures	3	2	1	0	0	3	0	1	1	1	6	4	2	2	2
Hinge Terminations	2	4	8	1	0	1	3	4	3	6	1	7	0	3	0
Step Terminations	5	4	4	2	2	3	2	5	4	5	4	3	3	4	2
Remnant Surface Dorsal	X	X	X	X	X	-	X	X	-	X	X	X	-	X	X
Remnant Surface Ventral	X	-	X	X	X	X	X	X	X	-	-	X	X	X	X
Original Surface Platform	X	X	X	X	X	X	X	-	-	-	-	-	-	-	-
Squared Edge/s	X	X	X	X	X	X	X	X	X		X	X	X	X	X
Platform Preparation	X	-	X	X	X	X	X	X	X	X	X	X	X	X	X
Inclusions or Cracks	-	-	X	-	-	X	-	-	-	-	-	X	-	-	-
Edges Centered	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cortex	PG	PG	PG	PG	PG	IC	PG	PG	PG	-	IC	PG	PG	PG	PG
Episodes of Removal	2-3	1-2	1-2	1-2	1-2	1-2	1-2	1-2	2	3	2	1-2	1-2	1-2	1-2
Arris Grinding	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shape	Oval/	Oval	Oval	Rect	Oval	Oval	Oval	Oval	Oval	Oval	Oval	Oval	Oval	Tri	Rect

Expert #7 Bifaces	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	Tri														
Flake Length CM	11.5	12.1	12.2	9.7	12.4	10.7	15.4	13.2	12.1	12.4	9.9	15.1	10	11.66	9.2
Flake Width CM	7.9	9.8	12	7.8	9.6	8.2	12	9.6	10.1	10.2	9.7	13.4	7.4	10.3	6.8
Flake Thickness CM	2.9	3.5	2.9	2.5	3.	2.5	5.2	3	3.5	3.4	3.8	7.4	3.3	2.9	2.6
Debitage Weight Grams	69.1	195	239.4	45.2	123.1	42	250.7	84.7	167.5	194.1	147.5	528.1	61.2	69.6	57.9
Tool Weight Grams	138	145.5	167.5	137.6	227.6	131.1	420	76.3	206.3	220.4	156.9	601.2	126.1	148	100.3
Total Weight Grams	207.1	340.5	406.9	182.7	350.7	173	670.7	161	373.8	414.5	304.4	1129.3	187.3	217.6	158.2
Time (Min.)	8:41	8:14	14:41	3:07	4:06	4:49	3:57	3:59	8:43	6:20	7:50	8:13	3:17	8:31	6:38

Note: An “X” in the box indicates presence of listed attribute on indicated biface.
IND: Indeterminate shape.
Flintknapper #7 Expert: Technological Analysis.

Expert #8 Bifaces	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Length CM	16.1	18.7	13.3	11.6	10.7	11.8	11.5	18.4	15.2	14.1	9.9	8.1	9.0	9.9	9.5
Width CM	12.0	12.2	8.9	9.1	6.2	7.4	8.6	6.3	5.8	9.9	6.7	5.3	4.7	5.7	6.1
Thickness CM	4.2	4.5	3.2	2.6	2.2	1.9	3.8	2.6	2.4	4.0	2.6	1.6	1.8	1.9	2.9
Complete Tool	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cross-Section	Pl	Bi	Bi	Bi	Bi	Bi	Bi	Bi	Bi	Bi	Pl	Bi	Bi	Pl	Bi/Pl
Flakes to or Past Mid-line	-	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Thick Patches	X	X	X	-	-	-	X	X	X	X	X	-	X	X	X
Stacked-Step Fractures	2	2	1	0	3	1	3	1	0	1	0	1	2	0	2
Hinge Terminations	3	3	3	4	2	5	2	4	4	1	3	1	3	3	3
Step Terminations	3	4	3	3	4	4	5	5	2	3	3	1	2	3	5
Remnant Surface Dorsal	X	X	X	-	X	-	-	X	-	-	X	X	X	X	-
Remnant Surface Ventral	X	X	X	X	X	X	X	X	X	X	X	X	X	X	-
Original Surface Platform	X	-	-	-	-	-	-	-	-	X	-	-	X	-	-
Squared Edge/s	X	X	X	X	-	-	X	-	-	-	-	X	X	-	-
Platform Preparation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Inclusions or Cracks	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Edges Centered	X	X	X	X	X	X	-	X	X	X	X	-	-	-	-
Cortex	PG	-	-	PG	-	-	-	-	-	PG	-	-	PG	-	PG
Episodes of Removal	1-2	1-2	2	1-2	2-3	3	2-3	3	2	1-2	1-2	1-2	1-2	1-2	2
Arris Grinding	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Shape	Oval	Oval/	Oval	Oval	Oval	Oval	Oval	Oval	Oval	Oval	Oval	Oval	Oval	Oval	Oval

Expert #8 Bifaces	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
		Tri													
Flake Length CM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17.4
Flake Width CM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10.3
Flake Thickness CM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.2
Debitage Weight Grams	194.4	365.5	163.4	178.9	756.6	282.4	751	686.9	1750.9	647.7	899.7	126.3	81.8	88.3	504.3
Tool Weight Grams	374.9	540.1	372.1	262.6	156.5	202.6	268.5	229.7	522.1	192.0	78.6	81.9	109.2	303.9	126.7
Total Weight Grams	569.3	905.6	535.5	441.5	913.1	485	1019.5	916.6	2273	839.7	978.3	208.2	191	392.2	631
Time (Min.)	1:45	1:56	2:55	5:45	5:21	5:51	2:39	10:36	14:36	3:30	3:17	5:06	3:40	3:50	4:40

Note: An “X” in the box indicates presence of listed attribute on indicated biface.
IND: Indeterminate shape.
Flintknapper #8 Expert: Technological Analysis.

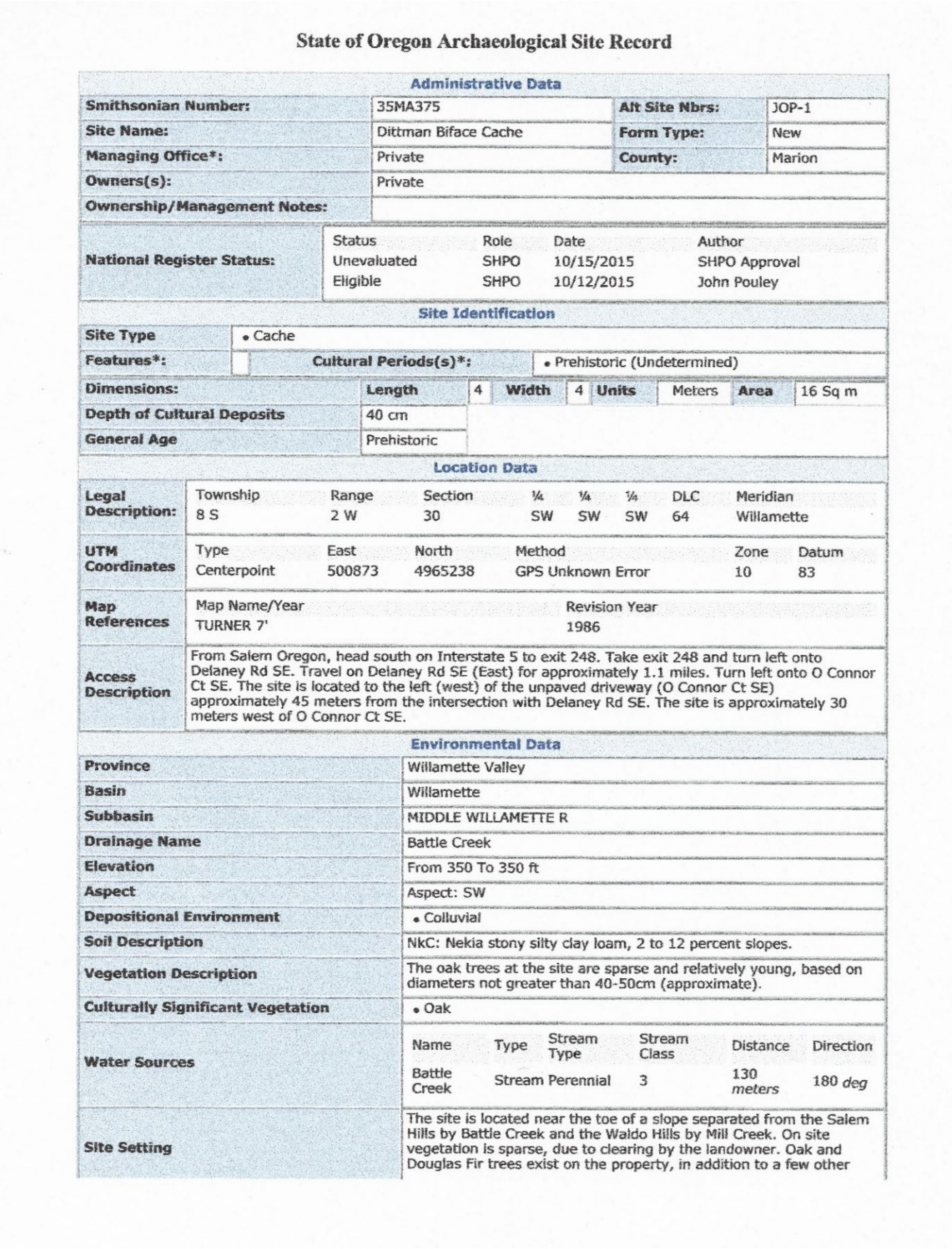
Appendix B – Oregon Cache Sites

Cache Name	Trinomial	Count	Shape	Age	Obsidian Source	Primary Source
Badger Creek Cache	WSIR-14	22 Complete 21 Fragments	Ovate		Obsidian Cliffs	Marschall 2004; Pouley 2019
Benham Falls East	35DS1988	~73	Lanceolate		Newberry Volcano, Cougar Mountain	Marschall 2004; Pouley 2019
Big Babbette Site	35DS799	18*	Lanceolate Ovate (1)		Newberry Volcano, Obsidian Cliffs, Riley	Marschall 2004
Burdick	35JE197		Ovate		Obsidian Cliffs	Marschall 2004; Pouley 2019
Champa	674NA959	14 Complete 21 Fragments	Lanceolate		Tank Creek, Riley, Chickahominy	Pouley 2017, 2019
Delta Power Site	35LA1177	2				Pouley 2019
Dittman Biface Cache	35MA375	15	Ovate	~4000 BP	Obsidian Cliffs	Pouley 2017, 2019
Glade Cache	35GR1311	5	Lanceolate		Whitewater Ridge	Pouley 2017, 2019
Grogan Cache		22	Ovate to Pentagonal	Post-Mazama	Newberry Volcano, Obsidian Cliffs	Marschall 2004; Pouley 2019
**Highway 138 Artifacts	35KL833					Pouley 2019
Jim-Bob	35KL879	11	Lanceolate		Silver Lake/Sycan Marsh, Cougar Mountain, Spode Mountain, Newberry Volcano	Marschall 2004; Pouley 2019
Lava Butte Cache	35DS33	~7	Laurel Leaf	6800-1400 BP	Newberry Volcano	Davis et al. 1991;

Cache Name	Trinomial	Count	Shape	Age	Obsidian Source	Primary Source
						Marschall 2004; Pouley 2017, 2019
Lava Cast Cache	35DS751	~15	Lanceolate		Newberry Volcano, Quartz Mountain, Obsidian Cliffs	Scott et al. 1986; Pouley 2019
Lava Island Rockshelter	35DS86	28	Lanceolate		McKay Butte, Newberry Volcano	Scott et al. 1986; Marschall 2004; Pouley 2019
McKenzie River Cache			Projectile Points			Pouley 2019
Owyhee River Cache		~20	Projectile Points Unfinished			Pouley 2019
Pahoehoe	35DS268	98 Complete 12 Fragments	Lanceolate		Quartz Mountain, McKay Butte	Scott et al. 1986; Pouley 2019
Paul's Fire Cache	35LIN542	33 Complete Unknown number of fragments	Ovate		Obsidian Cliffs	Rogers 1993; Pouley 2017, 2019
Quartz Mountain Biface Cache	35LK5092	25 Complete 19 Fragments			Spodue Mountain, Drews Creek, Butch Flat, Silver Lake/Sycan Marsh	Pouley 2019
Ray Cache		45	Ovate		Silver Lake/Sycan Marsh, Cougar Mountain	Marschall 2004; Pouley 2017, 2019
Spilled Milk Cache	35DO931	13				Pouley 2019
Sugar Cache	35DS752	17 Complete 121 Fragments refit to 32 Bifaces	Ovate	<5800 BP	Cougar Mountain, Newberry Volcano,	Marschall 2004; Pouley 2019

Cache Name	Trinomial	Count	Shape	Age	Obsidian Source	Primary Source
					Silver Lake/Sycan Marsh	
Swamp Wells Cache	35DS65	6	Ovate			Marschall 2004; Pouley 2019
Three Blade Cache	0601031902SI	3	Lanceolate		Newberry Volcano	Pouley 2019
Wickiup Knives	35DS550	2	Ovate			Brogan 1969; Pouley 2017, 2019
1969	35KL36					Pouley 2019
2004	35JE637	7				Pouley 2019
2008	35DS1892	3				Pouley 2019

Appendix C - State of Oregon Archaeological Site Report



State of Oregon Archaeological Site Record

Administrative Data

Smithsonian Number:	35MA375	**Alt Site Nbrs:**	JOP-1
Site Name:	Dittman Biface Cache	**Form Type:**	New
Managing Office*:	Private	**County:**	Marion
Owners(s):	Private		
Ownership/Management Notes:			

National Register Status:

Status	Role	Date	Author
Unevaluated	SHPO	10/15/2015	SHPO Approval
Eligible	SHPO	10/12/2015	John Pouley

Site Identification

Site Type	• Cache		
Features*:		**Cultural Periods(s)*:**	• Prehistoric (Undetermined)

Dimensions:	**Length**	4	**Width**	4	**Units**	Meters	**Area**	16 Sq m
Depth of Cultural Deposits	40 cm							
General Age	Prehistoric							

Location Data

Legal Description:

Township	Range	Section	¼	¼	¼	DLC	Meridian
8 S	2 W	30	SW	SW	SW	64	Willamette

UTM Coordinates

Type	East	North	Method	Zone	Datum
Centerpoint	500873	4965238	GPS Unknown Error	10	83

Map References

Map Name/Year	Revision Year
TURNER 7'	1986

Access Description

From Salem Oregon, head south on Interstate 5 to exit 248. Take exit 248 and turn left onto Delaney Rd SE. Travel on Delaney Rd SE (East) for approximately 1.1 miles. Turn left onto O Connor Ct SE. The site is located to the left (west) of the unpaved driveway (O Connor Ct SE) approximately 45 meters from the intersection with Delaney Rd SE. The site is approximately 30 meters west of O Connor Ct SE.

Environmental Data

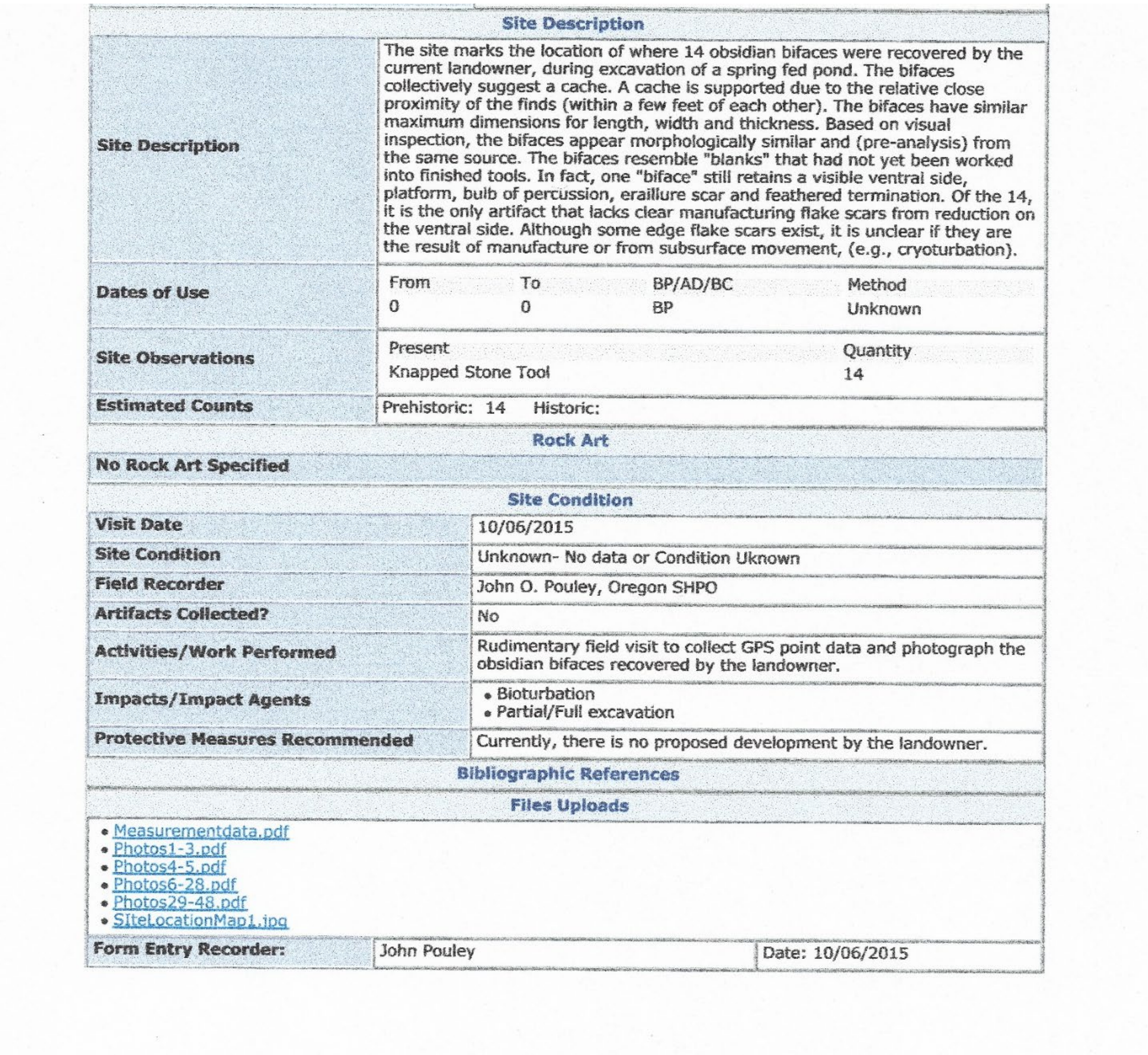
Province	Willamette Valley
Basin	Willamette
Subbasin	MIDDLE WILLAMETTE R
Drainage Name	Battle Creek
Elevation	From 350 To 350 ft
Aspect	Aspect: SW
Depositional Environment	• Colluvial
Soil Description	NkC: Nekia stony silty clay loam, 2 to 12 percent slopes.
Vegetation Description	The oak trees at the site are sparse and relatively young, based on diameters not greater than 40-50cm (approximate).
Culturally Significant Vegetation	• Oak

Water Sources

Name	Type	Stream Type	Stream Class	Distance	Direction
Battle Creek	Stream	Perennial	3	130 *meters*	180 *deg*

Site Setting

The site is located near the toe of a slope separated from the Salem Hills by Battle Creek and the Waldo Hills by Mill Creek. On site vegetation is sparse, due to clearing by the landowner. Oak and Douglas Fir trees exist on the property, in addition to a few other



Site Description

Site Description	The site marks the location of where 14 obsidian bifaces were recovered by the current landowner, during excavation of a spring fed pond. The bifaces collectively suggest a cache. A cache is supported due to the relative close proximity of the finds (within a few feet of each other). The bifaces have similar maximum dimensions for length, width and thickness. Based on visual inspection, the bifaces appear morphologically similar and (pre-analysis) from the same source. The bifaces resemble "blanks" that had not yet been worked into finished tools. In fact, one "biface" still retains a visible ventral side, platform, bulb of percussion, eraillure scar and feathered termination. Of the 14, it is the only artifact that lacks clear manufacturing flake scars from reduction on the ventral side. Although some edge flake scars exist, it is unclear if they are the result of manufacture or from subsurface movement, (e.g., cryoturbation).
Dates of Use	From: 0 To: 0 BP/AD/BC: BP Method: Unknown
Site Observations	Present: Knapped Stone Tool Quantity: 14
Estimated Counts	Prehistoric: 14 Historic:

Rock Art

No Rock Art Specified

Site Condition

Visit Date	10/06/2015
Site Condition	Unknown- No data or Condition Uknown
Field Recorder	John O. Pouley, Oregon SHPO
Artifacts Collected?	No
Activities/Work Performed	Rudimentary field visit to collect GPS point data and photograph the obsidian bifaces recovered by the landowner.
Impacts/Impact Agents	• Bioturbation • Partial/Full excavation
Protective Measures Recommended	Currently, there is no proposed development by the landowner.

Bibliographic References

Files Uploads

- Measurementdata.pdf
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Appendix D - Lithic Technological Analysis of Biface Cache Site 35MA375

Appendix D is the lithic technological analysis report of the cache bifaces prepared for Oregon's SHPO Archaeological Report and is referenced throughout this thesis.

Technological Analysis of the Dittman Biface Cache and Other Lithic Artifacts from 35MA375

by

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with

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January 09, 2019

Introduction

Archaeological Investigations Northwest, Inc. (AINW) volunteered to conduct a lithic technological analysis of the Dittman Biface Cache and other lithic artifacts recovered from pre-contact archaeological site 35MA375. The goals of the analysis were to identify the lithic reduction technologies represented in the cache of 15 obsidian bifaces and other stone tools and flakes recovered from archaeological excavations at the site where the cache was found.

Primary research questions involved whether the bifaces in the cache were manufactured at the site or elsewhere and whether the other artifacts at the site were culturally, temporally, or functionally related to the cache of bifaces. Multiple lines of inquiry were used to address these research questions. Most importantly, these inquiries included characterization of the manufacturing technologies for the bifaces in the cache, and for the other items in the lithic assemblage to identify commonalities or differences between the biface cache and the lithic tools and flakes in the surrounding archaeological site.

Secondary analyses included correlation of obsidian geochemical source identifications to determine whether the artifacts from the site area around the cache were derived from the same geological source as the bifaces in the cache. In addition, obsidian hydration dating was used to evaluate the age and temporal relationships between the biface cache and other obsidian artifacts found in archaeological excavations of test units surrounding the cache find location at 35MA375.

Results of these analyses suggest that the bifaces in the cache were not manufactured at 35MA375 where they were deposited some four thousand years ago. Instead, it seems most likely that they were roughed-out at the Obsidian Cliffs quarries in the Cascade Range and transported to the Willamette Valley where they were left at 35MA375 and never retrieved. Subsequent Native American use of the site area, thousands of years later, involved use of different lithic materials from a variety of toolstone sources to manufacture arrow points, flake tools, and other types of stone tools unrelated to the bifaces in the cache. The reduction technologies employed by later site inhabitants are fundamentally different from the technologies represented in the cache of bifaces. It may be that the later users of site 35MA375 were not even aware of the biface cache buried beneath their feet.

Methods of Technological Analysis

Lithic technological analysis of artifacts from 35MA375 was performed based on identification of technologically distinctive attributes distilled from hundreds of flintknapping experiments conducted by the authors and corroborated by reference to the lithic technological literature (e.g., Crabtree 1982). Constellations of diagnostic attributes were used to identify reduction strategies and techniques used to produce the tools and debitage. Stone tools were assigned technological and functional classes based on attributes such as character of flake scars, breakage patterns, use wear, and overall form. In manufacturing stone tools, many flakes are produced that are discarded without further use or modification. This debris constitutes debitage that is useful for understanding manufacturing processes. For this analysis, debitage was tabulated by size, raw material type, reduction technology, and reduction stage.

In total, 101 pieces of lithic debitage and 39 tools were recovered from site 35MA375. All of the debitage and 25 of the tools, including one of the obsidian bifaces considered to be part of the cache, were recovered from six 1x1 meter excavation units at site 35MA375. The remaining 14 tools, all obsidian bifaces considered part of the cache, had been collected by the landowner prior to archaeological excavations.

Lithic Debitage from Excavation Units

Lithic debitage recovered from excavation units at 35MA375 included 101 flakes and flake fragments (Table 1). Of these, 73 were identified to a specific reduction technology and stage of reduction. These flakes represent 72.3% of the debitage assemblage and are considered diagnostic of specific reduction technologies used to shape stone tools at the site. The remaining 28 pieces of debitage are percussion (PERC) flake fragments that could not be identified more specifically due to absence of diagnostic attributes lost to damage or breakage.

The diagnostic debitage at 35MA375 (n=73) includes four types of raw materials. The most abundant raw material is cryptocrystalline silicate (CCS) that represents 47.9% of the diagnostic debitage, followed by obsidian that represents 37% of the diagnostic debitage, fine-grained volcanic (13.7%) and petrified wood (1.4%).

The diagnostic debitage predominantly represents core reduction (67.2%). Percussion core reduction technology produces flakes for use as tools or flake blanks for further reduction into formed tools. The early-stage percussion core reduction technology is most abundant and is represented by CCS (n=21), fine-grained volcanic (n=9), obsidian (n=7), and petrified wood (n=1). Late-stage percussion core reduction technology is represented by relatively few flakes including CCS (n=7), obsidian (n=3), and fine-grained volcanic (n=1) raw materials.

Bipolar reduction is an effective method for producing flakes from small, rounded pebbles such as the obsidian present in local alluvial gravels. There were five obsidian bipolar reduction flakes representing 6.7% of the diagnostic debitage recovered at 35MA735.

Percussion biface reduction flakes represent 24.7% of the diagnostic debitage, indicating that the manufacture of bifacial tools was secondary to core reduction at 35MA375. There are 14 early-stage percussion biface reduction flakes composed of obsidian (n=8) and CCS (n=6). Late-stage percussion biface reduction technology is represented by relatively fewer flakes composed of obsidian (n=3) and CCS (n=1).

Only one early-stage obsidian pressure flake was present at 35MA375 and constitutes 1.4% of the diagnostic debitage. The presence of a pressure flake at 35MA375 indicates that pressure biface reduction was conducted at the site but relatively rarely. However, it should be noted that most pressure flakes, especially those used in the manufacture of arrow points are quite small and unlikely to be recovered in standard archaeological dry screening (Ozbun 2011). Pressure flaking is probably significantly underrepresented in the recovered archaeological assemblage.

The presence of cortex and the type of cortex on flakes provides information about the source of the raw material. Cortex of two types was noted during the analysis of the debitage from site 35MA375: incipient cone and primary geological. Incipient cone cortex consists of rounded exterior surfaces formed by numerous overlapping cones of percussion on raw material that has been transported down slope, usually by a stream. Nodules of raw material that exhibit incipient cone cortex are often obtained from secondary alluvial deposits in gravel bars. On the other hand, primary geological cortex consists of raw material with angular exterior surfaces that may exhibit evidence of chemical weathering typical of bedrock formations that usually occur in upland sources.

Of the 101 flakes and flake fragments from site 35MA375, cortex was noted on 35, representing 34.7% of the debitage assemblage. Thirty-four of these were incipient cone cortex and one was primary geological cortex. The predominance of incipient cone cortex indicates that, for the most part, alluvial sources provided the bulk of the toolstone used at the site. Upland bedrock was a secondary and minor source of toolstone.

Heat-treatment is an intentional application of heat to siliceous stone for the purpose of improving its flakability. When heat-treatment is successful tensile strength of the raw material is reduced and the flakes become easier to remove. Intentional heat-treatment of CCS is evident by the presence of differential color and/or luster between flake scars on the same flake. After heat-treatment, the original surface exhibits a dull surface while a subsequently flaked surface is more lustrous and sometimes of a different color than the un-flaked surface. Differential luster and/or color were noted on three flakes (2.97%) of the 101 pieces of debitage from site 35MA375. This attribute was noted on one early-stage percussion biface reduction flake and two percussion flake fragments of indeterminate technologies. The presence of differential color and luster on CCS flakes indicates that CCS toolstone was occasionally heat-treated prior to percussion flaking. The percussion biface reduction flake indicates that an early-stage percussion biface blank was heat-treated prior to subsequent systematic thinning.

Heat damage to CCS can be distinguished from intentional heat-treatment by the presence of potlidding, crenated breaks, and crazing of the stone that makes controlled flaking difficult or impossible. Heat damage was noted on 20 pieces of debitage, totaling 19.8% of the total assemblage. The presence of heat damage suggests that some of the heat-treatment attempts were unsuccessful or that some of the flakes and tools were discarded in hearths or were otherwise exposed to fires after being deposited at the site.

Remnant ventral surface is a portion of the original detachment scar of a flake and can be identified as a positive flake scar on the dorsal surface of a flake removed from a flake blank. Two CCS early-stage percussion biface reduction flakes, two obsidian early-stage percussion biface reduction flakes, and one petrified wood early-stage core reduction flake retained small patches of remnant ventral surface. This attribute indicates that flake blanks served as the basis to produce at least two bifaces, and that one flake served as a core at 35MA375.

Lithic Tools from Excavation Units

The analysis of the artifacts recovered from site 35MA375, not counting the obsidian bifaces recovered by the landowner prior to archaeological excavations, identified 24 tools (Table 1). Most of these 24 archaeologically excavated tools represent an emphasis on percussion reduction of cores, production of flakes for expedient use, and use of hunting tools. To further interpret activities occurring at the site, the tools were grouped into three categories: core reduction; expedient tools (flake tools and worked flakes); and hunting tools.

Core Reduction (n=12)

Of the 24 tools recovered during excavation, 12 were cores representing 50% of the tool assemblage. This high percentage of cores corresponds well with the high proportion of core reduction debitage in the assemblage. A core is an artifact from which flakes are removed to provide useful flake tools or flake blanks. Cores take many forms that can be classified according to the predominant orientation of the flake scars and reduction techniques. Core types identified based on the orientation and direction of flake scars included bifacial, multidirectional, and bipolar cores.

Of the seven obsidian cores, three had been reduced by bipolar reduction. All three bipolar cores exhibited incipient cone cortex. Two of the obsidian cores had been reduced by multidirectional percussion. One of the multidirectional cores had been reduced from a pebble and exhibited incipient cone cortex. Two of the obsidian cores had been reduced by bifacial reduction. One of the bifacial reduction cores exhibited incipient cone cortex.

All five of the CCS cores were reduced by employing a multidirectional percussion technique. Four of the multidirectional percussion CCS cores exhibited evidence of intentional heat-treatment that was expressed by the presence of differential luster (n=4) and differential color (n=1), and three of the four heat-treated cores retained incipient cone cortex. Although a low number of flakes exhibited evidence of intentional heat-treatment (n=3), the presence of differential luster and/or color on cores indicates that CCS nodules were heat treated at the site.

Expedient Tools (n=6)

Flake tools and worked flakes recovered from 35MA375 are included in the expedient tools category. Flake tools are flakes that exhibit edge wear indicative of use in some processing activity, most likely of organic materials. Flake tools (n=5) represent 20.8% of the tool assemblage at 35MA375. Of the five flake tools, three are of obsidian and two are of CCS. Early-stage percussion bifacial reduction flakes were used for two of the flake tools, and the other three were fragments of percussion flakes of indeterminate percussion reduction technologies. Use wear on the five flake tools was represented by micro-flaking on the lateral margins (n=4) and distal edge (n=1). One of the obsidian early-stage percussion biface reduction flakes (Catalog # 064) exhibited a patch of remnant ventral surface indicating it was derived from a flake core or flake blank.

Worked flakes are flakes that have been intentionally altered at their margins to create a tool or to modify the edge of the flake for use as an expedient tool. There was one CCS worked flake (Catalog # 069-1) recovered from 35MA375. The worked flake exhibited percussion flake scars and micro-flaking on the lateral margin, and differential luster between flake scars indicating intentional heat treatment.

Hunting Tools (n=6)

This category includes pressure-shaped bifacial preforms (n=2) and projectile points (n=4) that are used for hunting and processing of animals. Preforms are unfinished pressure flaked bifacial tools, commonly discarded during the manufacturing process because of a deleterious break. The two CCS preform fragments recovered from site 35MA375 both exhibited bending breaks that occurred during manufacture. One CCS preform was manufactured on a minimally bifacially worked flake blank. A flake blank is a piece of lithic material modified to a particular stage of reduction and intended for further reduction. In this analysis, blanks were distinguished from preforms on the basis of manufacturing techniques as exhibited by negative flake scars. Percussion flake scars are evident on blanks, and pressure flake scars are evident on preforms. Blanks are usually identified from fragments broken and discarded during the manufacturing process. The CCS preform fragment (Catalog # 026) made on a flake blank was used as a flake tool, heat treated, and then pressure flaked. The bending break occurred during pressure flaking. The other CCS preform (Catalog # 057-1) was manufactured on a flake blank and exhibits evidence of post-depositional heat damage by the presence of potlidding.

Projectile points are artifacts manufactured to tip weapons such as spears, darts, and arrows. Spear and dart points are generally distinguished from arrow points on the basis of form, size, and technological attributes. In general, arrow points tend to be roughly triangular in outline form, much smaller than spear and dart points, and manufactured from thin flakes. Arrow points were distinguished from dart points using a Dart-Arrow Index (Hildebrandt and King 2012). By adding the neck width to maximum thickness, a single index value is produced. Points with a threshold value of less than 11.8 mm are considered to be arrow points and points with a value greater than 11.8 mm are considered to be dart points.

There were fragments of four projectile points recovered from 35MA375, representing 16.7% of the tool assemblage. Based on the Dart-Arrow Index and technological criteria, all four projectile points were arrow-sized. Three of the four arrow points were comprised of obsidian and one of petrified wood. All four projectile points were small, serrated arrow points with narrow stems and exhibited either a bending break or a burination break, all of which occurred during use. The projectile points are technologically similar to projectile points commonly found in late pre-contact sites in traditional territories of the Kalapuya. Three of the arrow points exhibited use-wear in the form of micro-flaking on the lateral margins. The petrified wood arrow point exhibited use-wear on the tip in the form of rounding and was possibly recycled and reused as a drill.

Summary of Lithic Artifacts from Excavation Units at 35MA375

The technological analysis of the flaked stone artifacts from site 35MA375 reflects an overwhelming emphasis on percussion reduction of alluvial pebbles for the production of flake tools and flake blanks for other tools. Diagnostic lithic debitage indicates that both core and biface percussion reduction technologies were employed; however, the emphasis was on core reduction for the production of expedient flake tools. Lithic raw materials used at the site reflected a narrow range of material types with an emphasis on locally available alluvial cobbles and pebbles

Bipolar debitage at site 35MA375 included five obsidian flakes. Bipolar technology was likely used only for the initial splitting of pebbles and nodules that were subsequently reduced using percussion and pressure reduction techniques.

The presence of early-stage percussion biface reduction flakes indicates that the production of biface blanks occurred at the site, but only as a secondary activity. Likewise, the relatively small number of late-stage percussion biface thinning flakes and one early-stage pressure flake suggests that the production and maintenance of projectile points and flake tools occurred at the site, but only as an activity of relatively minor importance, or an activity represented by flakes that were not recovered during screening of the excavated sediments.

Intentional heat-treatment was occasionally employed to facilitate the reduction of CCS alluvial nodules and in the production of early-stage bifaces. Heat-treating may have been done in tandem with the use of thermal features for processing foodstuffs but does not appear to have been an important activity at the site.

The large number of expedient flake tools suggests that the focus of the activities at the site was the working and processing of organic materials. A fragile, extremely sharp cutting edge on expediently produced flakes is useful in the preparation of plant resources, such as basketry materials, and cutting through soft animal flesh. In contrast, a bifacial tool edge is stronger, more durable, and appropriate for heavy duty tasks, such as sawing, piercing, and cutting wood, bone, leather, or raw hide.

The site appears to be a temporary and likely seasonally used area, possibly associated with harvesting and processing of plant resources and/or game. While arrow points were present, hunting does not appear to have been a primary activity at the site.

Biface Cache Technological Observations

The following descriptions of the 15 obsidian bifaces representing the cache, characterize the basic technological attributes observed. Measurements and summary attribute data are presented in Table 2. Attachment B contains photographs of all 15 bifaces.

Biface #1

This obsidian biface has a plano-convex cross-section and is made on a large percussion flake. Two negative percussion scars cross the bulbar portion of the original flake blank. Most of the ventral surface of the original flake remains visible on the biface. Two patches of flat weathered surfaces from the original blocky core are evident on the dorsal surface. There are two episodes of percussion flake scars on the dorsal surface. A crack and a series of step terminations are evident near the edge on the dorsal surface of the biface.

Biface #2

Biface #2 has a bi-convex cross-section. Small patches of weathered surfaces are present on both faces suggesting that the original piece of obsidian raw material was a thick tabular blocky piece with weathered concave surfaces. One surface exhibits a concave potlid surface with compression rings emanating from a central area. There are two episodes of percussion flake removals. The first removals were larger and widely spaced. The second removals were smaller and placed roughly between the larger negative scars, but were not systematically spaced. There are numerous step terminations on the short secondary removals on both faces. One face exhibits a thick central area that would be difficult to remove or correct for during systematic thinning or reduction.

Biface #3

Biface #3 has a plano-convex cross-section. Thick edges with remnant square/weathered surfaces from the original blocky piece of obsidian raw material are evident. One wide overshot scar is present on the flat to concave surface of the biface. Several percussion scars near the narrow tip terminated in hinges that left a concave surface. There are three episodes of flake removals including one early overshot removal followed by flake removals that left several large hinge terminations. Edges are thick and rounded, especially at the narrow tip end and would be difficult to thin.

Biface #4

Biface #4 is roughly plano-convex in cross-section with remnant square edges on both lateral margins and at the base of the roughly triangular shaped obsidian biface. A patch of phenocrysts at the tip adjacent to a square edge would be problematic for further flake removals. There are several good platforms for removing flakes from this biface. There have been two episodes of percussion flake removals. The first was the widely spaced removal of a few large flakes from both faces. A second episode of percussion flake removals consisted of short flakes removed from square edges that appeared to have been done to prepare platforms. Edges are thick and rounded, and square remnant edges of the original tabular piece of raw material are present.

Biface #5

Biface #5 has a bi-convex cross-section, smooth faces, and platform preparation flake scars along the lateral margins (except in an area of recent damage). The obsidian biface is roughly triangular in shape with an exposed crack and a weathered surface at the base of the triangle that could cause minor thinning problems. Overall, this is a very well prepared biface blank suitable for thinning. Two episodes of percussion flake removals are evident. Large widely spaced flake scars are present on both faces with shorter and more numerous secondary percussion flake scars used to form bifacial edges around the biface. A few patches of flat weathered surfaces and concave weathering scars (potlids) associated with small patches of phenocrysts (freeze/thaw weathering) are evident.

Biface #6

Biface #6 is roughly bi-convex, thick and uneven in cross-section. The obsidian biface has thick crushed edges and patches of step terminations and phenocrysts. Patches of flat, concave, and convex weathered surfaces are evident on both faces. Two episodes of percussion flake removals are evident on both faces. The earlier removals were large and left concave surfaces and hinge terminations. The edges are not centered and the biface is very uneven and lumpy. Patches of phenocrysts would be problematic in systematically thinning this biface. As a core, several flakes could be produced from this biface.

Biface #7

Biface #7 is plano-convex in cross-section. This obsidian biface is made on a thick flake removed from a large blocky core by a heavy bipolar percussion force that created the flat sheared cone that exhibits several bipolar percussion reduction attributes, tightly spaced concentric compression rings, a flat surface, and numerous radial striations. There is a layer of phenocrysts near one edge of the biface that would likely impede systematic thinning of the biface. Several patches of flat weathered surfaces are present on the dorsal surface of the flake and on the termination of the flake blank that indicates that the core from which the flake blank was struck was a large block of obsidian with square edges. Two to three episodes of percussion flake removals are evident on the thick dorsal surface of the biface. Large negative percussion scars are widely spaced, some of which reach and pass over the midline, however, several terminated in hinges that have left thick patches near the tip and middle of the biface.

Biface #8

Biface #8 is bi-convex in cross-section with well centered margins, smooth faces, very few step terminations and minor hinge terminations near the midpoint on the ventral surface. Small patches of weathered flat surfaces on the dorsal surface and around the edges and remnant platform suggest that the flake blank was a large percussion flake removed from an angular blocky obsidian core. The patch of phenocrysts near one edge would likely impede systematic thinning of the blank. However, the blank is well made. Two episodes of percussion flake removals are evident on the dorsal surface, and one episode on the ventral surface of the large flake blank.

Biface #9

Biface #9 is plano-convex in cross-section and made on a thick obsidian flake fragment that retains a prominent square edge from the original flake blank. The original flake blank was removed from a blocky core. The biface is not well shaped but is of high quality obsidian with no visible phenocrysts. Percussion flakes have been removed from both faces, but only a few from the ventral surface and only from the thin edge on the dorsal surface.

Biface #10

Biface #10 is plano-convex in cross-section. Its margins are well centered and there is a large concave patch of weathered surface from the original blocky obsidian core. A large phenocryst is evident on the ventral surface, and a seam of phenocrysts is present near the base of the roughly oval to triangular biface. Only a few percussion flakes have been removed from the ventral surface of the flake blank. Multiple percussion flake removals are evident on the dorsal surface with most flake scars not reaching the midline. The edge of the biface exhibits overlapping step flake scars that appear to have been purposefully created, possibly for platform preparation.

Biface #11

Biface #11 is bi-convex in cross-section. The margins are fairly well centered but rather sinuous. Both faces are well flaked and relatively smooth. Flake scars reach or extend to and over the midline. Patches of smooth weathered surfaces are evident on one face. Two episodes of percussion flake removals are evident on both faces, and the obsidian biface blank is oval and somewhat triangular in overall shape.

Biface #12

Biface #12 is bi-convex in cross-section and was reduced from a thick obsidian flake blank. The margins are centered and multiple percussion flake removals are evident on both faces. There are several hinge terminations on both faces and overlapping step terminations near the platform end of the flake blank. Both faces are rough and there are several phenocrysts. Some of the platforms are heavily ground.

Biface #13

Biface #13 is bi-convex in cross-section. Square edges and flat weathered surfaces indicate that the raw material was a thick flake from a blocky obsidian core. There are several hinge and step terminations on the flat/concave surface. The percussion flake removals on the convex surface reach the midline and were widely spaced. Most of the edges have been ground as a form of platform preparation. The obsidian is of a relatively high quality with no large phenocrysts. A few knapping errors need to be corrected before the biface can be systematically thinned.

Biface #14

Biface #14 is bi-convex in cross-section and nicely thinned with step terminations on thin lateral margins, and otherwise smooth faces. The obsidian is of relatively high quality and the biface exhibits very good percussion thinning. Post depositional damage is evident on the lateral edges. This biface is more refined than most of the others from the cache.

Biface #15

Biface #15 is plano-convex in cross section, longitudinally curved and slightly twisted. In plan view, it is roughly triangular in shape. A small patch of a square edge is present at the base and a negative flake scar left a square edge on one side of the tip. There are at least two episodes of flake removals on the plano side/face of the biface, and several slight hinge terminations are present near the centerline. The convex side/face exhibits three flake removal episodes and there are remnants of the dorsal surface and flake scars on the high points. There are only minor hinge terminations. Margins are relatively sharp, there are a few slight step terminations on the edges and some crushing along the edges (possible platform preparation) and short expanding scars from wide platforms. This obsidian biface seems to have been refined more-so than most of the other bifaces and is similar to Biface #14.

Summary of Cache Observations

Prior to field excavations at site 35MA375, the landowner uncovered a cache of fourteen obsidian bifaces. During subsequent archaeological test excavations, a fifteenth obsidian biface was found. Caches are defined as a collection of similar items stored for later use and are relatively rare in the archaeological record since they were generally intended for retrieval (Carpenter and Fisher 2014). For this analysis all fifteen bifaces are considered to be part of the cache.

At least seven of the fifteen bifaces were clearly produced on thick flake blanks removed from large blocky cores. Of the fifteen bifaces, ten exhibited primary geologic cortex. Chemically weathered surfaces are flat, roughened surfaces that exhibited concave scars (potlids) associated with freeze/thaw weathering, generally located near patches of phenocrysts. This chemical weathering is typical of bedrock formations that usually occur in upland locations. Additionally, eleven bifaces retained either square edges or thick areas suggesting they were produced on large, thick flake blanks removed from blocky cores. The presence of primary geologic cortex suggests that at least ten of the bifaces were produced at or near the quarry site.

Remnant surfaces were observed on all of the bifaces in the form of dorsal, ventral, and/or platform surfaces. These remnant surfaces are portions of the original detachment scar or other parts of a flake and indicate that flake blanks were used for the production of several of the bifaces found at site 35MA375. The flake blanks exhibiting remnant surfaces were removed from blocky cores by using direct freehand percussion reduction, except for Biface #7, which exhibits evidence for heavy bipolar percussion. The bipolar percussion reduction produced a flat sheared cone, tightly spaced concentric compression rings, a flat surface, and numerous pronounced radial striations, all attributes of bipolar reduction. Bipolar reduction may have been used as a thinning method in this case.

There was a continuum of morphological variation between the individual bifaces, but as a whole, the biface plan view shapes could be classified as oval (n=5), triangular (n=8), and two were roughly oval to triangular in shape. The cross-sections of the bifaces consisted of eight that were bi-convex and seven that were plano-convex in cross section. The margins of the bifaces ranged from relatively straight, thin, and well-centered to thick and uneven.

The bifaces exhibited two to three episodes of flake removals on either one or both surfaces of the biface. The first episode of flake removal produced larger flakes spaced widely apart, while the second and third episodes removed smaller flakes and were placed roughly between the larger negative flake scars. One exception is Biface #1, which exhibits only two percussion scars on the ventral surface and two episodes of flake removal on the dorsal surface.

Of the fifteen obsidian bifaces, fourteen were made from obsidian with phenocrysts present throughout the raw material. Phenocrysts can hinder the reduction process as they can cause hinge and step terminations, and difficulty in removing flakes past the midline. All fifteen of the bifaces exhibited hinge terminations, step terminations, and/or stacked step terminations. These flake terminations are considered to be errors in the manufacturing process which, in some cases could be due to the presence of phenocrysts. Flaking to or past the midline of the biface is a critical step in the manufacturing process of thinning a biface. However, if these bifaces were intended to serve as cores for the production of flake blanks, then the phenocrysts and flaws would not have been a major problem. Of the fifteen bifaces, eight exhibited flake scars that traveled to or past the midline.

Platform preparation techniques employed in the production of the bifaces involved removal of short flakes from the biface margins to strengthen striking platforms for subsequent reduction. Arris grinding can be used in flintknapping to facilitate flaking and to prepare bifaces for transport. Of the fifteen bifaces, eleven exhibited evidence of arris grinding, and eight retained evidence of platform preparation that included grinding, rounding of margins, and removal of several short flakes from square edges.

Obsidian Sourcing

Obsidian x-ray fluorescence geochemical analyses were conducted by Craig Skinner and Alex Nyers of Northwest Research Obsidian Studies Laboratory. All 15 of the cache bifaces were identified as Obsidian Cliffs geochemical type (Table 3), tracing them to a source on the northwestern flank of Middle Sister Mountain in the Cascade Range of Oregon. Although Obsidian Cliffs material is available from secondary geological sources, the cortex and other attributes of the cache bifaces indicate they were procured from the primary geological (bedrock) source. In a direct line, this obsidian source is approximately 118 kilometers (73 miles) southeast of 35MA375, and much farther if transported along typical foot trails that follow ridges or stream valleys. The Obsidian Cliffs source area ranges in elevation from about 1,800 meters (6,000 feet) to about 2,100 meters (7,000 feet), and is therefore much higher than the Willamette Valley floor at 35MA375, which is about 91 meters (300 feet) in elevation. Substantial effort was required to transport the cache bifaces from the Obsidian Cliffs toolstone source to site 35MA375.

Other obsidian artifacts (flakes and tools) recovered from the archaeological excavations at site 35MA375 were characterized as geochemical types from Cascade Range sources (Table 4). These geochemical types are Inman Creek A (n=15), Inman Creek B (n=19), Obsidian Cliffs (n=3), Devil Point (n=1), Butte Creek (n=1), and Unknown B (n=1). The most abundant of these, Inman Creek A and Inman Creek B, occur in Willamette River gravels much closer to 35MA375 than the Obsidian Cliffs primary geological source. The cortex observed on several of these artifacts indicates that they were procured from alluvial gravel sources, most likely along the Willamette River that is about 8 km (5 miles) west of site 35MA375. The variety of obsidian geochemical types and the close proximity of the secondary geological source for the most abundant obsidian (Inman Creek A and B) reflects a very different obsidian procurement process for the artifacts recovered from the excavations as compared with the obsidian bifaces in the cache.

One obsidian flake (Catalog #40) was originally sourced to Inman Creek B. Geochemically, Inman Creek B and Obsidian Cliffs obsidian are very similar (See XRF Report # 2017-08b). After additional analysis, it was determined that flake #40 re-fit to biface #15. Flake #40 and biface #15 were excavated from the same unit and level (Unit 2, Level 6). The biface exhibited a fresh flake scar and the attributes on the dorsal surface of the flake aligned with the attributes adjacent to the flake scar on the biface. The flake was then re-evaluated by Alex Nyers who confirmed the flake correlated with the Obsidian Cliffs obsidian source. Similarly, an additional flake (Catalog #35) exhibited attributes technologically distinctive of bifacial reduction. Like flake #40, flake #35 was also a small sample size, sourced to Inman B, and exhibited a fresh ventral surface. Flake #35 did not re-fit to any of the bifaces from the cache. However, flake #35 had the same hydration reading as flake #40 (4.4 microns) and could potentially be from the Obsidian Cliffs source. If flake #35 was from the Obsidian Cliffs source it would be closer in age to the bifaces recovered from the cache. Further analysis is need to determine if flake #35 is from the Obsidian Cliffs source.

Obsidian Hydration Dating

Jennifer Thatcher of Willamette Analytics, LLC, measured obsidian hydration rims. Samples from the cache bifaces were prepared by AINW prior to sending them to Willamette Analytics, LLC, for obsidian hydration analysis. The AINW preparation involved removing small pressure flakes from the edges of the bifaces in order to avoid the standard procedure of sawing notches to remove thin sections for microscopic measurement. The pressure flakes were removed from technologically distinctive surfaces (See Attachment B for the locations of pressure flake sample removals). Two or three pressure flakes were removed from each cache biface and attempts were made to sample technologically early and late surfaces in the sequence of flake removals. This sampling strategy was designed to detect differences in the age of flake removals that might represent scavenging of materials from older archaeological sites or significant gaps in time from when the initial reduction occurred to when later reduction occurred. The pressure flakes from the cache bifaces were then sent to Willamette Analytics, LLC, for thin-sectioning. The non-cache artifacts, flakes and tools from archaeological excavations at the site, were prepared by Willamette Analytics, LLC, using the standard lapidary saw thin-sectioning method.

In total, 75 samples were measured for obsidian hydration rims or rinds (Figure 1). These included 34 samples from the 15 cache bifaces. The rind measurements from the cache bifaces, all of Obsidian Cliffs geochemical type, were strikingly consistent with 30 measuring 4.2 microns, 2 measuring 4.3 microns, 1 measuring 6.1 microns, and 1 that could not be measured (Table 3). The estimated age of the most frequent rind measurement, 4.2 microns, was calculated to be 4175 +/- 1075 years before present (BP) on the basis of hydration rates established for Obsidian Cliffs and controlling for effective hydration temperatures in the archaeological deposits at site 35MA375 (Cowan 2017 and Attachment C). The two slightly thicker rinds (4.3 microns) are within the error range of the measurement technique and are assumed to represent the same age. The substantially thicker rind (6.1 microns) from Biface #11 is one of two samples taken from the biface. It was taken from a naturally weathered surface that exhibited a small fracture likely caused by freeze/thaw processes. Therefore, the thicker rind measurement likely represents an older, probably geological, crack in the obsidian raw material. The other sample from Biface #11 was measured at 4.2 microns, representing the same age as the other bifaces. The thicker rind is assumed to represent an older surface, naturally exposed at the Obsidian Cliffs quarry and retained on the biface during manufacturing, transportation, and deposition at 35MA375.

The non-cache obsidian artifacts (flakes and tools from the archaeological excavations) produced a total of 25 hydration rind measurements (Table 4). Of these, 24 or all but one, were from obsidian geochemical types with known hydration rates – Inman Creek A (n=9); Inman Creek B (n=12); and Obsidian Cliffs (n=3). The ages of these artifacts were estimated using the same method as for the cache bifaces. However, distribution of age estimates shows the majority to be much younger than the cache bifaces. The age distribution appears to be normally distributed around a peak in the range of 1000 to 2000 years BP (n=13). Two of the artifacts from the site excavations appear to be about the same age as the cache bifaces, and one appears to be much older (Catalog #35). The oldest date may represent an older, scavenged artifact or an anomaly related to a geological surface like that found on cache Biface #11. However, the sample size was small and the flake could possibly be sourced to Obsidian Cliffs similar to flake #40. If that were the case, the estimated age would be closer to that of the bifaces in the cache. One obsidian flake (#59) from Obsidian Cliffs exhibited a square edge and primary geologic cortex with a hydration rim value of 3.0 microns. This flake is much more recent than the flakes from the cache bifaces and suggests that at least one biface from the primary Obsidian Cliffs geologic source was initially flaked at the site much more recently than the bifaces from the cache.

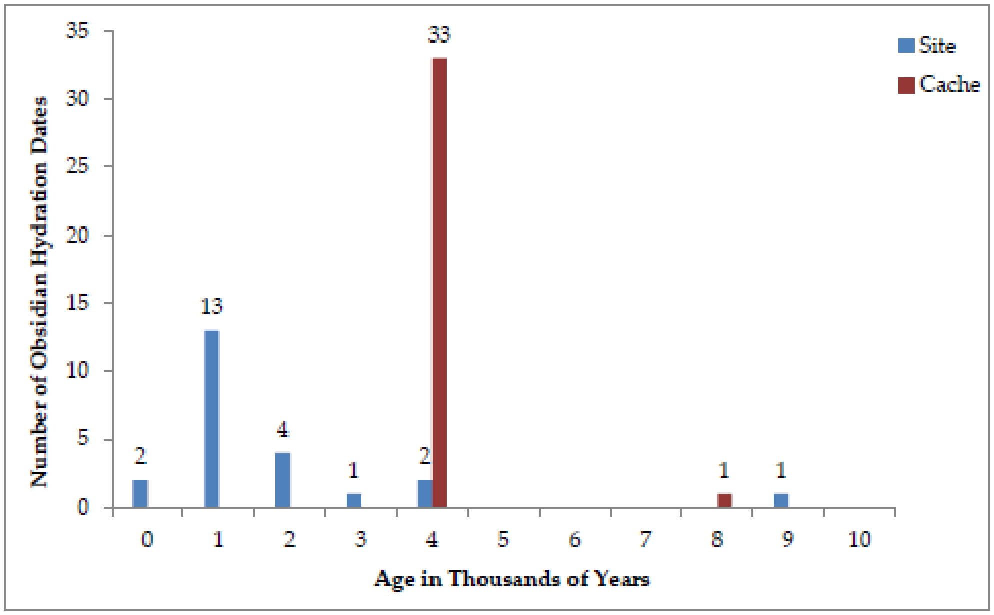

Figure 1: Frequency distribution of hydration dates grouped in 1,000 year increments for artifacts from 35MA375.

Conclusions

Technological analysis and obsidian sourcing and hydration dating results have lead us to conclude that the cached bifaces at 35MA375 likely represent a single caching event at an estimated age of 4,175 years ago and that the bifaces were not further reduced at the site. The cached bifaces are much older than most of the obsidian tools and flakes recovered from the archaeological excavations surrounding the cache location. Additionally, the reduction technologies employed by later site inhabitants are fundamentally different from the technologies represented in the cache of bifaces and involved the use of different lithic materials from a variety of toolstone sources for the manufacturing of arrow points, flake tools, and other types of stone tools unrelated to the bifaces in the cache. It is likely that the later users of site 35MA375 were not even aware of the biface cache buried beneath their feet.

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TABLE 1

SITE 35MA375 TECHNOLOGICAL ANALYSIS SUMMARY OF DEBITAGE AND TOOLS*

Diagnostic Debitage	**CCS**	**Fine-Grained Volcanic**	**Obsidian**	**Petrified Wood**	**Total**	**%**
Bipolar			5		5	6.7%
Core Reduction, Early	21	9	7	1	38	52.1%
Core Reduction, Late	7	1	3		11	15.1%
Biface Percussion, Early	6		8		14	19.2%
Biface Percussion, Late	1		3		4	5.5%
Pressure, Early			1		1	1.4%
Pressure, Late						
TOTAL	*35*	*10*	*27*	*1*	*73*	*100%*
%	*47.9%*	*13.7%*	*37%*	*1.4%*	*100%*	
Undiagnostic Debitage						
Percussion	24	2	1	1	28	100%
Thermal						
Undetermined						
TOTAL	*24*	*2*	*1*	*1*	*28*	*100%*
%	*85.7%*	*11.9%*	*27.7%*	*2%*	*100%*	
TOTAL – DEBITAGE	*59*	*12*	*28*	*2*	*101*	100%
%	*58.4%*	*11.9%*	*27.7%*	*2%*	*100%*	
Stone tools						
Core	5		7		12	50%
Flake Tool	2		3		5	20.8%
Projectile Point –Arrow Sized			3	1	4	16.7%
Preform	2				2	8.3%
Worked Flake	1				1	4.2%
TOTAL – STONE TOOLS	*10*		*13*		*24*	100%
%	*41.6%*		*54.2%*	*4.2%*	*100%*	

* This summary of technological attributes for flakes and tools does not include the 15 bifaces considered to be items from a buried cache of obsidian biface blanks.

TABLE 2
35MA375 OBSIDIAN BIFACE CACHE

TABLE 2
35MA375 OBSIDIAN BIFACE CACHE
TECHNOLOGICAL OBSERVATIONS

Bifaces	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Length (mm)	109	122	106	104	91	101	122	108	101	105	97	97	109	108	103
Width (mm)	79	68	62	61	63	62	70	67	54	63	62	65	71	53	52
Thickness (mm)	27	20	23	18	15	19	21	19	22	17	17	24	23	12	14
Plano Convex	X		X	X			X		X	X			X		X
Bi-Convex		X			X	X		X			X	X		X	
Flakes to or Past Mid-line		X	X	X	X	X	X	X	X		X	X	X	X	X
Stacked-Step Fractures	X			X	X	X	X					X			
Thick Patches	X	X	X	X		X	X		X			X	X		
Hinge/Step Terminations	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
RVS	X						X	X	X	X		X		X	
Original Surfaces	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Squared Edge/s			X	X		X	X	X	X				X		
Platform Preparation				X	X				X	X	X	X	X		X
Inclusions or Cracks	X	X		X	X	X	X	X		X		X	X	X	
Edges Centered					X			X		X	X	X		X	X
Cortex					X	X	X	X	X	X	X	X	X	X	
Episodes of Removals	2	2	3	2	2	2	2-3	2	2	2	2	3	2	2	3
Arris Grinding		X	X	X	X	X	X	X		X	X	X	X		
Shape	Oval Tri	Tri	Tri	Tri	Tri	Tri	Oval	Oval	Oval	Tri	Oval Tri	Oval	Oval	Tri	Tri

Note: An "X" in the box indicates presence of listed attribute on indicated biface.

TABLE 3

Obsidian Sourcing (XRF) and Hydration Results for Cache Bifaces

Biface Number	Sample Number*	Comment	Source	Hydration Rim (μ)	AINW Hydration Date** (Years BP)	Standard Deviation +/-
1	1-1	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
1	1-2	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
2	2-1	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
2	2-2	Flake Removed From Biface	Obsidian Cliffs	NA	-	-
3	3-1	Flake Removed From Biface	Obsidian Cliffs	4.3	4375	1125
3	3-2	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
3	3-3	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
4	4-1	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
4	4-2	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
5	5-1	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
5	5-2	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
6	6-1	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
6	6-2	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
7	7-1	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
7	7-2	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
8	8-1	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
8	8-2	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075

9	9-1	Eraillure Flake From Biface	Obsidian Cliffs	4.2	4175	1075
9	9-2	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
9	9-3	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
9	9-4	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
10	10-1	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
10	10-2	Flake Removed From Biface	Obsidian Cliffs	4.3	4375	1125
11	11-1	Flake Removed From Biface	Obsidian Cliffs	6.1	8875	2275
11	11-2	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
12	12-1	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
12	12-2	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
12	12-3	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
13	13-1	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
13	13-2	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
14	14-1	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
14	14-2	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
15	15-1	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075
15	15-2	Flake Removed From Biface	Obsidian Cliffs	4.2	4175	1075

*The first number in the Sample Number denotes to the biface and the second number signifies the sample removed from that biface. See Attachment B.

**Information on estimated age calculations can be found in Attachment C.

TABLE 4

Obsidian Sourcing (XRF) and Hydration Results for Site Artifacts

Catalog Number	Excavation Unit	Excavation Level	Source	Hydration Rim (μ)	AINW Hydration Date* (Years BP)	Standard Deviation +/-
30	Unit 1	Level 5	Inman Creek A	1.6	2225	NA
33	Unit 2	Level 2	Inman Creek B	NA	-	-
34	Unit 2	Level 2	Inman Creek A	1.4	1600	NA
35	Unit 2	Level 3	Inman Creek B	4.4	9875	4225
40**	Unit 2	Level 6	Obsidian Cliffs	4.4	4875	1250
42	Unit 3	Level 2	Inman Creek A	1.3	1375	NA
43	Unit 3	Level 3	Inman Creek B	1.5	1100	500
46	Unit 3	Level 4	Inman Creek B	NA	-	-
47	Unit 3	Level 4	Devil Point	2.5	-	-
48	Unit 3	Level 4	Too Small for XRF	NA	-	-
54	Unit 3	Level 7	Inman Creek B	3.0	4725	2025
55	Unit 4	Level 2	Inman Creek B	1.7	1375	600
58	Unit 4	Level 3	Inman Creek B	2.0	1975	875
59	Unit 4	Level 4	Obsidian Cliffs	3.0	2175	575
61	Unit 5	Level 1	Inman Creek B	1.9	1650	725
63	Unit 5	Level 2	Obsidian Cliffs	2.6	1550	425
64	Unit 5	Level 2	Inman Creek B	NA	-	-
65	Unit 5	Level 2	Inman Creek A	1.3	1375	NA
68	Unit 5	Level 4	Inman Creek B	2.0	2000	875
70	Unit 5	Level 5	Inman Creek A	1.1	1025	NA
71	Unit 5	Level 6	Inman Creek A	1.2	1250	NA
75	Unit 6	Level 2	Inman Creek B	1.4	925	425
76	Unit 6	Level 2	Inman Creek B	3.1	4750	2050
79	Unit 6	Level 4A	Inman Creek A	1.9	3125	NA
82	Unit 6	Level 5A	Inman Creek B	1.4	975	450
83	Unit 6	Level 5A	Inman Creek B	NA	-	-
84	Unit 6	Level 5A	Inman Creek B	2.4	2950	1275
85	Unit 6	Level 5A	Inman Creek A	1.1	1025	NA

21	Unit 1	Level 2	Inman Creek A	NA	-	-
44-S1	Unit 3	Level 3	Inman Creek A	NA	-	-
44-S2	Unit 3	Level 3	Unknown B	NA	-	-
49-S1	Unit 3	Level 4	Inman Creek A	NA	-	-
49-2	Unit 3	Level 4	Inman Creek A	1.1	1000	NA
50-S1	Unit 3	Level 5	Butte Creek	NA	-	-
52-S1	Unit 3	Level 6	Inman Creek B	NA	-	-
52-S2	Unit 3	Level 6	Inman Creek B	NA	-	-
52-S3	Unit 3	Level 6	Inman Creek B	NA	-	-
56-S1	Unit 4	Level 2	Inman Creek A	NA	-	-
66-S1	Unit 5	Level 2	Inman Creek A	NA	-	-
78-S1	Unit 6	Level 3	Inman Creek B	1.7	1425	625
81-S1	Unit 6	Level 4B	Inman Creek A	NA	-	-

* Information on estimated age calculations can be found in Attachment C.

** Catalog # 40 is an obsidian flake that re-fits to Biface #15.

ATTACHMENTS

The Dittman Biface Cache Site 35MA375

Attachment A: Technological Data

Tool Catalog
Debitage Catalog
Lithic Technology Abbreviations
Lithic Technology Glossary

Attachment B

Biface Photographs

Attachment C: Obsidian Studies

XRF Reports
Hydration Rim Measurements
Hydration Age Estimate Methods
Hydration Age Estimate Data Sheets

Attachment A:
Technological Data

Tool Catalog
Debitage Catalog
Lithic Technology Abbreviations
Lithic Technology Glossary

TOOL ANALYSIS DATA FOR SITE 35MA375

Catalog #	Unit	Level	Composition	Cortex	Reduction	RemnSurf	PrevState	Function	UseWear	Wear Location	Style	Maintenance	Element	Break	Break Stage	Thermal	Length(mm)	Width (mm)	Thick (mm)	Notes
026	1	3	CCS		BPRES	V	BLK	PRE	MF	LAT			FRAG	BEND	MANU	DIFLUS/ DIFCOL	12	13	6	MIN.BIFACIALLY WORKLED FLAKE BLANK, USED AS FTOL, HEAT TREATED, THEN PRESSURE FLAKED
027-1	1	3	CCS		MPERC			FTOL	MF	LAT			FRAG	BEND			9.3	23.3	4.7	
030	1	5	OBS	IC	BPO		PEB	COR					COMP				18.2	16.1	6.4	
034	2	2	OBS	IC	MPERC		PEB	COR					FRAG	UND			14.1	9.2	9	POOR QUALITY OBSIDIAN: PHENOCRYSTS AND OTHER INCLUSIONS
046	3	4	OBS		BPRES	V	FLK	PPTA	MF	LAT	KAL	RESHARP	COMP	BEND/BURIN	USE		10	10	3	SLIGHT CURVATURE TO FLAKE
049-1	3	4	CCS	IC	MPERC			COR					COMP			DIFLUS	26.1	21.7	17.8	
049-2	3	4	OBS		BPERC			FTOL	MF	LAT			COMP				19	16.3	3	BIFE FLAKE
049-3	3	4	CCS		BPERC			FTOL	MF	DIST			FRAG	BEND			21.9	12.8	3.8	BIFE FLAKE
050-1	3	5	CCS	IC	MPERC			COR					FRAG			DIFLUS	15.9	11.7	7.5	
052-1	3	6	CCS	IC	MPERC			COR	MF				COMP			DIFLUS	22.7	17.7	10.1	
055	4	2	OBS	IC	BPO			COR					COMP				16.4	16.5	10.3	
057-1	4	3	CCS		BPRESS		FLK	PRE					FRAG	BEND	MANU	PTLD	11.9	8.1	1	POTLIDDING OCCURRED POST-DEPOSITIONAL
058	4	3	OBS		BPRES	V	FLK	PPTA			KAL	REWORK/RESHARP	COMP	BEND	USE		13	12	2	FLAT FLAKE, POSS. BPO FLAKE BLANK
059	4	4	OBS		BPERC		FLK	FTOL	MF	LAT			COMP				11.2	9.9	1.7	
062-1	5	1	CCS		MPERC		UND	COR					COMP				23.9	17.1	10.1	
063	5	2	OBS	IC	BPO		PEB	COR					COMP				20.6	10	6.8	

NOTES: DOES NOT INCLUDE BIFACES FROM CACHE. SEE LIST OF ABBREVIATIONS AND LITHIC TECHNOLOGY GLOSSARY.

Catalog #	Unit	Level	Composition	Cortex	Reduction	RemnSurf	PrevState	Function	UseWear	Wear Location	Style	Maintenance	Element	Break	Break Stage	Thermal	Length(mm)	Width (mm)	Thick (mm)	Notes
064	5	2	OBS		BPERC	V	FLK	FTOL	MF	LAT			COMP				16.1	10.5	4.2	
068	5	4	OBS		MPERC		UND	COR	MF	LAT			FRAG	UND			10	5.9	3.2	
069-1	5	4	CCS		BPERC		FLK	WFL	MF	LAT			COMP			DIFLUS	18.6	13.2	4	LUSTROUS ON FLAKE SCARS
075	6	2	OBS		BPRES			PPTA	MF	LAT	KAL	RESHARP	COMP	BEND/BURIN	USE		14	11	3	BARD AND TIP EXHIBIT BENDING BREAKS, STEM EXHIBITS BURIN BREAK
082	6	5A	OBS	IC	BPERC		PEB	COR					COMP				30.1	22.3	12.6	
084	6	5A	OBS		BPERC		UND	COR	MF	LAT			FRAG	UND			10.4	9.7	3.7	
086-1	6	5A	CCS		MPERC		UND	COR					COMP			DIFCOL	35.7	15.5	10.5	FLAKE SCARS EXHIBIT DIFCOL
087	6	5B	PET		BPRES			PPTA	RO/MF	TIP/LAT		REWORK/RESHARP	TIP	BURIN	USE		12	5	2	PPTA POSS. RECYCLED/USED AS DRILL

TOTAL: 24

NOTES: DOES NOT INCLUDE BIFACES FROM CACHE. SEE LIST OF ABBREVIATIONS AND LITHIC TECHNOLOGY GLOSSARY.

DEBITAGE ANALYSIS DATA FOR SITE 35MA375

Catalog #	Unit	Level	Composition	Technology	Operation	RVS	Cortex None	Cortex Some	Cortex All	Cortex Type	Heat Alteration Damage	Heat Alteration Diflus	Heat Alteration Difcol	Size 2	Size 3	Size 4	Size 5	Size 6	Size 7	Total	Notes
021	1	2	OBS	CORE				1		IC						1				1	
027	1	3	PET	CORE		1	1										1			1	
027	1	3	CCS	PERC				1		IC		1	1			1				1	
027	1	3	CCS	PERC			2									2				2	
033	2	2	OBS	BIFE			1									1				1	
035	2	3	OBS	BIFE	PLP		1									1				1	FRESH FLAKE FROM A SQUARE EDGE
036	2	3	CCS	PERC			1				1	1					1			1	
036	2	3	CCS	PERC	PTLD		1						1			1				1	FLAKE IS A POTLID: DIFCOL ON A BREAK
038	2	4	FGV	CORE					1	IC								1		1	
039	2	5	CCS	CORE				1		IC	1						1			1	
039	2	5	FGV	CORE				1		IC	1						1			1	
040	2	6	OBS	BIFE	PLP	1	1									1				1	FITS TO BIFACE # 15
042	3	2	OBS	CORE	PLP				1	IC					1					1	
043	3	3	OBS	BPO			1										1			1	RECYCLED FROM A PERCUSSION FLAKE
044	3	3	CCS	CORE				4		IC						1	1	2		4	
044	3	3	CCS	PERC			1									1				1	
044	3	3	CCS	BIFE			1					1				1				1	LUSTROUS ON VENTRAL SIDE, DULL ON DORSAL
044	3	3	CCS	CORL			1									1				1	
044S1	3	3	OBS	CORE				1		IC							1			1	
044S2	3	3	OBS	CORE				1		IC						1				1	
047	3	4	OBS	BIFL			1									1				1	
048	3	4	OBS	BIFL	MRF		1								1					1	
049	3	4	CCS	PERC			1									1				1	
049	3	4	CCS	PERC			1					1				1				1	
049	3	4	CCS	PERC			1				1	1					1			1	
049	3	4	CCS	BIFE	PLP	1	1									1				1	
049	3	4	CCS	CORE				3		IC	2					1	2			3	
049	3	4	CCS	CORL			1									1				1	

NOTES: SEE LIST OF ABBREVIATIONS AND LITHIC TECHNOLOGY GLOSSARY

Catalog #	Unit	Level	Compo-sition	Tech-nology	Oper-ation	RVS	Cortex				Heat Alteration			Size						Total	Notes
							None	Some	All	Type	Damage	Diflus	Difcol	2	3	4	5	6	7		
049S1	3	4	OBS	BIFE			1									1				1	
050	3	5	CCS	CORE	PLP		1									1				1	
050	3	5	FGV	PERC			1										1			1	
050	3	5	CCS	BIFL			1									1				1	
050	3	5	CCS	BIFE		1	1										1			1	
050	3	5	CCS	CORE			1				1					1				1	
050	3	5	CCS	PERC			1				1					1				1	
050	3	5	CCS	BIFE			1											1		1	
050S1	3	5	OBS	CORE				1		PG							1			1	
052	3	6	CCS	BIFE			1										1			1	
052S1	3	6	OBS	BIFE	PLP		1									1				1	
052S2	3	6	OBS	BIFE	PLP		1									1				1	
052S3	3	6	OBS	BIFE	PLP		1								1					1	
053	3	7	CCS	CORL			1										1			1	
053	3	7	CCS	CORL			1										1			1	
054	3	7	OBS	BIFE	PLP	1	1									1				1	
056	4	2	CCS	PERC			1				1	1				1				1	
056S1	4	2	OBS	CORL			1										1			1	
057	4	3	CCS	BIFE			1				1	1				1				1	
057	4	3	FGV	PERC			1										1			1	
060	4	4	FGV	CORE			1										1			1	
060	4	4	CCS	CORE				1		IC							1			1	
061	5	1	OBS	CORE				1		IC							1			1	
062	5	1	CCS	PERC			1				1					1				1	POTLIDDING ON VENTRAL AND DORSAL SIDES
062	5	1	CCS	CORE			1				1							1		1	EXTENSIVE HEAT DAMAGE
062	5	1	CCS	CORE			1										1			1	
065	5	2	OBS	BPO				1		IC							1			1	
066	5	2	FGV	CORE				2		IC							2			2	
066	5	2	CCS	CORE				1		IC							1			1	
066	5	2	CCS	PERC			1				1						1			1	
066	5	2	CCS	PERC			1				1						1			1	
066	5	2	CCS	CORL			1									1				1	
066S1	5	2	OBS	CORL				1		IC							1			1	

NOTES: SEE LIST OF ABBREVIATIONS AND LITHIC TECHNOLOGY GLOSSARY

Catalog #	Unit	Level	Composition	Technology	Operation	RVS	Cortex				Heat Alteration			Size						Total	Notes
							None	Some	All	Type	Damage	Diflus	Difcol	2	3	4	5	6	7		
067	5	3	CCS	CORE					1	IC							1			1	
067	5	3	CCS	PERC			1				1						1			1	
067	5	3	CCS	CORE				1		IC							1			1	
067	5	3	CCS	CORE				1		IC							1			1	
067	5	3	FGV	CORE				1		IC							1			1	
069	5	4	CCS	CORL			1						1			1				1	DIFCOL ON DISTAL END/BREAK
069	5	4	FGV	CORL			1										1			1	
070	5	5	OBS	CORE				1		IC						1				1	
071	5	6	OBS	BPO			1									1				1	
072	5	6	PET	PERC			1									1				1	
074	6	1	CCS	PERC			1				1						1			1	
076	6	2	OBS	BPO					1	IC							1			1	
077	6	2	CCS	PERC			1				1					1				1	
078	6	3	CCS	CORE				1		IC						1				1	CTX ON PLATFORM ONLY
078	6	3	CCS	CORE			1									1				1	
078S1	6	3	OBS	CORL			1									1				1	
079	6	4A	OBS	BPO			1									1				1	
080	6	4A	CCS	CORL			1									1				1	
080	6	4A	CCS	PERC			1				1	1				1				1	
080	6	4A	CCS	PERC			2									1	1			2	
080	6	4A	CCS	PERC				1		IC	1	1				1				1	
081	6	4B	CCS	CORE			1										1			1	
081S1	6	4B	OBS	PREE			1									1				1	
083	6	5A	OBS	PERC			1									1				1	
085	6	5A	OBS	BIFL			1									1				1	
086	6	5A	FGV	CORE					1	IC							1			1	COBBLE CHOPPER FLAKE
086	6	5A	CCS	CORE			1								1					1	
086	6	5A	CCS	PERC				1		IC							1			1	
086	6	5A	FGV	CORE					2	IC						1		1		2	
088	6	5B	CCS	PERC			1									1				1	
089	6	6A	CCS	PERC			1				1					1				1	
														TOTAL:						101	

NOTES: SEE LIST OF ABBREVIATIONS AND LITHIC TECHNOLOGY GLOSSARY

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AINW ABBREVIATIONS FOR LITHIC ANALYSIS

ABR = ABRADER OR REDUCTION BY ABRASION
ADZ = ADZE
ALT = ALTERNATE FLAKE
ANV = ANVIL
BAS = BASALT
BAT - BATTERING
BEAD = BEAD
BEND = BENDING FRACTURE
BIF = BIFACE
BIFE = BIFACE PERCUSSION EARLY FLAKE
BIFL = BIFACE PERCUSSION LATE FLAKE
BKN = BROKEN
BLB = BULB REMOVAL FLAKE
BLD = BLADE AND BLADE TECHNOLOGY
BLK = BLANK
BLKA = ARROW-SIZED BLANK
BLKD = DART-SIZED BLANK
BLKU = BLANK OF UNKNOWN BIFACIAL TOOL TYPE
BLKP = PESTLE BLANK
BNO = BASAL-NOTCHED
BOUL = BOULDER
BOWL = STONE BOWL
BPERC = BIFACIAL PERCUSSION REDUCTION
BPRES = BIFACIAL PRESSURE REDUCTION
BPO = BIPOLAR FLAKE, BIPOLAR CORE, OR BIPOLAR REDUCTION
BTOL = BIFACIAL TOOL
BURIN = BURIN/BURIN SPALL
CCS = CRYPTOCRYSTALLINE SILICATE
CGV = COARSE-GRAINED VOLCANIC LITHIC MATERIAL
CHP = CHOPPER
CNO = CORNER-NOTCHED
COB = COBBLE
COMP = COMPOSITION
CONT = CONTRACTING
CONV = CONVEX
COR = CORE
CORE = CORE PERCUSSION EARLY FLAKE
CORL = CORE PERCUSSION LATE FLAKE
CRBR = CRENATED BREAK
CTOL = COBBLE TOOL
CTX = CORTEX
CYC = CYLINDRICAL
CZ = CRAZING

D = DORSAL
DEB = DEBITAGE
DIST = DISTAL FRAGMENT OR DISTAL MARGIN
DIFCOL = DIFFERENTIAL COLOR
DIFLUS = DIFFERENTIAL LUSTER
DRI = DRILL OR REDUCTION BY DRILLING
DSN = DESERT SIDE-NOTCHED
EDG = EDGE PREPARATION FLAKE
EGC = EDGE GROUND COBBLE
ERL = ERRAILURE FLAKE
EXPN = EXPANDING
FLK = FLAKE
FC = FLAKED COBBLE
FGV = FINE-GRAINED VOLCANIC LITHIC MATERIAL
FRAG = FRAGMENT
FTOL = FLAKE TOOL
GDS = GROUND OR PECKED STONE
GGL = GREEN OR GRAY GLASSY LITHIC MATERIAL (vitrophyre)
GND = GRINDING OR ABRASION
GLA = GLASS
GRA = GRANITE
GRV = GRAVER
HAM = HAMMERSTONE
IC = INCIPIENT CONE CORTEX
KNI = KNIFE
LANCE = LANCEOLATE
LAT = LATERAL MARGIN
MAINT = MAINTENANCE
MANU = MANUFACTURING
MANO = MANO
MAR = MARBLE
MAUL = MAUL
MED = MEDIAL
MET = METAMORPHIC ROCK
MF = MICROFLAKING
MORT = MORTAR
MPERC = MULTIDIRECTIONAL PERCUSSION REDUCTION
MPORT = MANUPORT
MPRES = MULTIDIRECTIONAL PRESSURE REDUCTION
MRF = MARGIN REMOVAL FLAKE
MTE = METATE
NA = NOT APPLICABLE
NC = NONCULTURAL
NET = NET WEIGHT
NO = NOTCH OPENING ANGLE
NTC = NOTCH OR NOTCHING FLAKE

OBS = OBSIDIAN
OTH = OTHER
OVT = OVERSHOT (outrepasse [French]) OR OVERSHOT FLAKE
P = PLATFORM
PEB = PEBBLE
PEBT = PEBBLE TOOL
PECK = PECKED OR REDUCTION BY PECKING
PERC = UNDETERMINED PERCUSSION FLAKE
PERV = PERVERSE FRACTURE
PEST = PESTLE
PET = PETRIFIED WOOD
PG = PRIMARY GEOLOGICAL CORTEX
PHAM = PECKING HAMMERSTONE (USED IN MANUFACTURE)
PLP = PLATFORM PREPARATION (FLAKE)
PO = POLISH
PPT = PROJECTILE POINT
PPTA = ARROW POINT
PPTD = DART POINT
PPTU = PROJECTILE POINT OF UNDETERMINED TYPE
PRE = PREFORM
PREA = ARROW POINT-SIZED PREFORM
PREB = PRESSURE BLADE MICROBLADE
PRED = DART POINT-SIZED PREFORM
PREE = PRESSURE EARLY FLAKE
PREL = PRESSURE LATE FLAKE
PREU = PREFORM OF UNKNOWN BIFACIAL TOOL SIZE
PROX = PROXIMAL FRAGMENT OR PROXIMAL MARGIN
PTLD = POTLID OR POTLIDDED
PY = PYROCLASTIC CORTEX
QTZ = QUARTZITE
QUA = QUARTZ
RBR = RADIAL BREAK OR RADIAL BREAK REDUCTION
RD = ROUNDING
RDS = REMNANT DORSAL SURFACE
REJ = REJUVENATION
RESH = RESHARPEN
REWO = REWORK
RHO = RHYOLITE
RM = RAW MATERIAL
RVS = REMNANT VENTRAL SURFACE
SCR = SCRAPER
SERR = SERRATION OR SERRATED
SIL = SILTSTONE
SLA - SLATE
SNO = SIDE-NOTCHED
SAN = SANDSTONE

SHEAR = SHEARING FRACTURE
SPALL = HAMMERSTONE SPALL
SS = SOIL SHEEN CORTEX
ST = STRIATIONS
STEM = STEM OR STEMMED
SZ 1 = <1/16 inch (<1.6 mm), DEBITAGE SIZE CLASS
SZ 2 = >1/16 - <1/8 inch (1.6 - 3.2 mm), DEBITAGE SIZE CLASS
SZ 3 = >1/8 - <1/4 inch (3.2 - 6.4 mm), DEBITAGE SIZE CLASS
SZ 4 = >1/4 - <1/2 inch (6.4 - 12.7 mm), DEBITAGE SIZE CLASS
SZ 5 = >1/2 - <1 inch (12.7 - 25.4 mm), DEBITAGE SIZE CLASS
SZ 6 = >1 - <2 inches (25.4 - 50.8 mm), DEBITAGE SIZE CLASS
SZ 7 = >2 - <4 inches (50.8 - 101.6 mm), DEBITAGE SIZE CLASS
TAB = TABULAR
THE = THERMAL FLAKE (POTLID) OR THERMAL BREAK (CRAZING OR CRENATED)
TERM = TERMINATION
TRM = TESTED RAW MATERIAL
UND = UNDETERMINED OR INDETERMINATE FLAKE, PERCUSSION OR PRESSURE
UNI = UNIFACE
UPERC = UNIFACIAL PERCUSSION REDUCTION
UPRES = UNIFACIAL PRESSURE REDUCTION
V = VENTRAL
VQU = VEIN QUARTZ
Wb = WIDTH OF STEM AT BASE
Wn = WIDTH OF STEM BETWEEN NOTCHES OR BELOW SHOULDERS
Wt = WEIGHT IN GRAMS
WFL = WORKED FLAKE

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AINW LITHIC TECHNOLOGY GLOSSARY

ABRADER (ABR): Abraders are typically gritty, friable stones such as sandstone or pumice used to shape, sharpen, or dull other objects through grinding. Abraders are used to work a variety of materials including wood, bone, antler, and stone. In flintknapping, abraders are used to prepare stone tool edges for use as platforms to facilitate flake removal.

ALTERNATE FLAKE (ALT): Alternate flakes are the byproduct of creating a bifacial (beveled) edge using a technique called alternate flaking. Alternate flaking involves removing a flake through a square or thick edge and then turning over the piece being worked and using the previous flake scar as a platform for the next flake off of the opposing face. This process begins at one end of a square or thick edge and proceeds on alternate faces into the unbeveled edge. Beveling an edge prepares it for bifacial thinning or shaping by producing edge angles appropriate for use as platforms. Alternate flaking can be done by percussion or by pressure and is a common technique used to prepare edges of tabular or angular materials, the thick margins of flake blanks (especially at the proximal end), margins with stacked step terminations, and broken flakes or bifaces. Alternate flakes are often triangular in cross section and retain a portion of the original square or thick edge on the dorsal surface near the platform. The contact point is usually skewed toward one side of the platform. The orientation of the flake reflects the angle of applied force in the direction of the adjacent edge rather than perpendicular to the edge being worked as is most common in percussion bifacial thinning.

ANVIL (ANV): A stone block used as a rest or support on which materials are hammered usually with another stone, such as for splitting long bones to extract marrow or for making radial breaks on lithic artifacts. Also used in the bipolar technique of lithic reduction, the artifact to be flaked is held with one end firmly against a stone anvil then struck with the hammerstone on the opposite end. Bipolar reduction anvils are identified by the pock marks and crushing scars left where the impact is absorbed. When small rounded pebbles are reduced, the pock marks generally form a circular pattern that is deepest in the center and is located near the middle of the anvil surface. The anvil stone must be massive enough to absorb the shock of bipolar hammering and have flat or slightly convex upper and lower surfaces but are of various sizes and shapes.

ARRIS: A ridge formed by the intersection between two flake scars on an artifact.

ARROW-SIZED (BLKA; PREA; PPTA): Generally smaller than dart-sized and associated with bow-and-arrow technologies and the manufacturing technologies associated with production of arrow points (blanks, preforms, and projectile points).

BASAL-NOTCHED (BNO): A method of notching into the proximal edge of a projectile point to facilitate hafting and retention of the point in a wound.

BASALT (BAS): An igneous volcanic rock, with a grain size of less than 1 millimeter, and generally low in silica dioxide content (approximately 50%), although basalts used in flaked stone technologies may be selected for their higher silica contents. Basalt's basic chemistry, composed predominantly of ferromagnesian minerals (especially pyroxene) and feldspar (calcic plagioclase), distinguishes it from other fine-grained volcanic rocks such as rhyolite (acidic) which is composed predominantly of feldspar and quartz, and from andesite (intermediate) which is composed predominantly of feldspar. Basalt is usually black or gray and darker colored than other volcanic rocks.

BENDING FRACTURE (BEND): A non-concoidal fracture caused by flexing that exceeds the elasticity of the material. The fracture is characterized by the lack of a bulb of force, fracture initiation near the center of an artifact's face rather than at the margin, and fracture plane propagation oriented nearly perpendicular to the initiation face. The fracture exhibits compression rings, radial striations, and often a distinctive finial termination. Bending fractures occur during stone tool manufacture as a result of percussive shock waves (end shock) or from bending thin items in the hand during pressure flaking, during stone tool use such as from impact on projectile points, and from post-depositional effects like trampling.

BIFACE (BIF): A lenticular or plano-convex artifact with flakes removed from two opposing sides. Bifaces are operationally distinguished from other tools with partial bifacial edges (such as worked flakes) by being flaked all or most of the way around the margin and having flake scars that extend across the faces toward the center of the piece.

BIFACIAL THINNING FLAKE, EARLY STAGE (BIFE): Percussion flakes with multi-faceted platforms, relatively acute platform angles, relatively small but thick platforms, a simple dorsal flake scar pattern, curved and thin longitudinal section, slightly curved and thin cross section, and parallel to expanding margins. May exhibit evidence for edge preparation, alternate, or bulb removal flaking. May retain remnants of ventral surface from flake blank.

BIFACIAL THINNING FLAKE, LATE STAGE (BIFL): Percussion flakes with same attributes as BIFE but with more complex dorsal flake scar patterns (some scars from previous flakes originating from the opposite margin of the biface), thinner, sometimes lipped and isolated platforms, thinner and more uniform cross-sections, more pronounced curvature, and usually expanding margins.

BIPOLAR REDUCTION / BIPOLAR FLAKE (BPO): This reduction technique involves holding a core, or item to be flaked on an anvil and then striking that core with a hammerstone, using necessary force to split the parent piece or detach flakes. Bipolar fractures are initiated by wedging, propagate under compressive force, and terminate axially. These fractures are characterized by a lack of bulbs of force, crushed platforms and terminations, pronounced compression rings and radial striations, and a relatively flat fracture plane oriented perpendicular to the initiation surface. Flake scars on cores and the dorsal surface of flakes often are oriented parallel to each other and initiate from opposite directions. Bipolar technologies are frequently employed to reduce small rounded lithic materials such as alluvial pebbles and in the lateral cycling of bifaces.

BLADE/BLADE TECHNOLOGY (BLD): A specialized percussion or pressure flake manufactured with parallel or sub-parallel lateral edges; the length being equal to, or more than, twice the width. Made from a prepared core, blades possess one or more arrises parallel to the lateral margins and prepared platforms that often exhibit grinding. A true blade technology is based on the use of a *specialized* and *maintained* blade core. This technique is intentional and distinctly different from other flake reduction processes that produce an occasional linear flake.

BLANK (BLK): A piece of lithic material modified to a particular stage of reduction and intended for further reduction. In analysis of artifacts, blanks are distinguished from preforms on the basis of manufacturing technique such that the negative flake scars indicate percussion reduction for the blanks and pressure reduction for the preforms. Blanks are usually identified from fragments broken and discarded during the manufacturing process.

BOULDER (BOUL): A rock size greater than 256 millimeters in diameter with shapes varying from angular to well-rounded.

BULB OF FORCE: This feature can be found on the ventral surface of a concoidal flake, towards the proximal end, below the platform. It appears as a dome-like form created as a partial Hertzian cone expanding from the ring crack around the contact point on the platform. Although the bulb of force is the hallmark attribute of concoidal (literally "shell-like" meaning curved with concentric ribs) fractures, its size and distinctiveness varies with technique and magnitude of force application as well as with characteristics of the lithic material.

BULB REMOVAL FLAKE (BLB): A flake that removes part or all of the bulb of force from a flake blank, usually in the early stages of percussion bifacial thinning. In addition to a portion of the bulb of force, the dorsal surface of this flake frequently exhibits other distinctive features of the ventral surface of the original flake blank including the contact point, ring crack, eraillure scar, or part of the platform. This flake is a classic example of Remnant Ventral Surface (RVS).

BURIN/BURIN SPALL (BURIN): Burin is a term that refers to a technique used to remove the edge of a tool or flake parallel to the long axis. A burin spall is the specialized flake removed that generally forms a right angle edge on one or both lateral margins. Burin spalls are distinctly narrow and thick in relation to their length and are usually triangular or rectangular in cross-section. The obtuse edges formed on the burin spalls and burins are ideal for engraving or carving wood or bone.

CHATOYANT: Sheen or "cat's eye" effect of reflected light created in obsidian from tiny gas bubbles stretched in the viscous lava during formation of the volcanic glass.

CHOPPER (CHP): A heavy core tool manufactured by percussion flaking of restricted areas along the sides or ends of a cobble. These tools were probably used for a variety of tasks that required a heavy-duty work edge, including cutting, crushing, pulping, scraping, and chopping.

CORE (COR): An artifact from which flakes are removed, in order to provide useful flake tools or flake blanks. Cores take many forms described according to predominant orientation of the flake scars and reduction techniques (e.g., unidirectional, multidirectional, bifacial, bipolar).

COARSE-GRAINED VOLCANIC LITHIC MATERIAL (CGV): Igneous rock in which the mineral crystals are visible to the unaided eye.

COBBLE (COB): A rock size from 64 to 256 millimeters in diameter with shapes varying from angular to well-rounded.

CORE BLANK: A core (often the remnant of a core left after some initial flake blank production) that is worked into a blank (usually a bifacial blank) through percussion flaking. Also referred to as a blank produced from a core nucleus reduction trajectory. In analysis, core blank (or core nucleus) reduction can be distinguished from flake blank reduction by the locations of cortex remnants, absence of remnant ventral, dorsal, or platform surfaces, debitage attributes, and other contextual information. Core blank or core nucleus reduction commonly occurs when bifaces are produced from tabular materials or when the sizes of available materials are only minimally adequate for tool size requirements.

CORE REDUCTION FLAKE, EARLY STAGE (CORE): Percussion flakes with cortical or single facet platforms, relatively wide (nearly 90°) platform angles, relatively large, thick platforms, dorsal cortex (usually present), few dorsal flake scars, dorsal flake scars oriented parallel to the margins of the flake and initiated from the same platform area, roughly parallel margins, longitudinal section straight or slightly curved, and triangular or blocky cross-section. Attributes of core reduction flakes are highly dependent on the nature of the raw material, method of reduction, and intended product.

CORE REDUCTION FLAKE, LATE STAGE (CORL): Percussion flakes with same attributes as CORE but with evidence of platform preparation, thinner platforms, more dorsal flake scars, expanding margins, and usually lacking cortex.

CORNER-NOTCHED (CNO): A method of notching into the proximal corners of a triangular shaped projectile point. This type of notching generally creates two barbs and an expanding stem used to facilitate hafting and retention of the point in a wound.

CORTEX (CTX): This refers to the outer surface or "rind" of a naturally occurring piece of lithic raw material. Cortex may be part of the matrix in which the material is formed (e.g., chalky material surrounding chert nodules in marine deposits), or a weathering or erosional surface. Three different types of cortex are identified for our purposes: primary geological (PG), incipient cone (IC), and pyroclastic (PY).

CRENATED BREAK (CRBR): A thermally initiated break that follows a wavy line, to form rounded teeth that would fit together on the two fragments formed by the break.

CRYPTOCRYSTALLINE SILICATE (CCS): A term used by archaeologists to refer to microcrystalline varieties of quartz that exhibit brittle, homogeneous, and isotropic qualities conducive to concoidal flaking. These include cherts, flints, jaspers, chalcedonies, and agates.

CRAZING (CZ): Thermal damage caused by differential expansion in CCS materials. The damage consists of a network of small intersecting cracks in the artifact.

DART-SIZED (BLKD; PRED; PPTD): Generally larger than arrow-sized and associated with spear and atlatl technologies and the manufacturing technologies associated with production of dart points (blanks, preforms, and projectile points).

DEBITAGE (DEB): In manufacturing stone tools, flakes are produced that are discarded without use or modification. This debris constitutes debitage, commonly referred to as waste flakes. Debitage is produced at every stage of the lithic reduction sequence, from the first flakes removed from the unaltered raw material to flakes produced in rejuvenating broken or dulled tools. All flakes, unless too broken or damaged, exhibit attributes identifiable to a specific technology and/or stage of reduction.

DESERT SIDE-NOTCHED (DSN): Small, triangular arrow-sized projectile points notched on the lateral margins near the proximal end; frequently with a concave or notched proximal margin and sometimes serrated on the lateral margins. Desert Side-notched points appear during the Late Prehistoric period and persist into the Historic Period. Desert Side-notched points were used over most of the western United States including the Great Basin and California; in the Plains and Southwest; they commonly go by other names.

DIFFERENTIAL COLOR (DIFCOL): A change in color to CCS lithic material caused by controlled thermal alteration. After heat-treatment, the original surface exhibits a dull color while the subsequently flaked surfaces exhibit a different, typically brighter, color and a more lustrous surface than the un-flaked surface.

DIFFERENTIAL LUSTER (DIFLUS): Luster refers to the light reflective qualities of fracture surfaces on CCS materials. Microscopically smoother or flatter fracture surfaces reflect light more brightly and appear more vitreous than microscopically rough surfaces which appear more dull. Smoother fracture surfaces are often produced on thermally altered or heat-treated CCS artifacts. Heat treatment is an intentional alteration of the material to improve its flakability. Flakes removed from an artifact prior to heat alteration will exhibit the materials "natural" luster, not only on the flakes but also in the scars left on the parent artifact. After heat alteration, flakes removed will reveal more vitreous fracture surfaces on the interior of the artifact. When these flake scars exist on an artifact side by side, or the ventral surface of a flake exhibits more vitreous luster than its dorsal surface, this is considered good evidence for intentional heat treatment. Differential luster observed in thermal damage features, such as in a potlid scar, or on the interior of a crazed break are not attributable to intentional heat treatment and are not recorded.

DISTAL (DIST): Orientation term that refers to the termination end of a flake, working end of a tool, or tip of biface (especially a projectile point).

DORSAL SURFACE (D): The dorsal surface of a flake is that face which corresponds to the exterior of the artifact from which it was detached.

DRILL (DRI): A tool (usually bifacial), with a worked projection presumably used for perforating materials such as stone, wood, bone, or antler.

EDGE GROUND COBBLE (EGC): Usually a flat cobble or pebble with a squared off edge exhibiting polish and rounding.

EDGE PREPARATION FLAKE (EDG): A flake removed from a margin in order to change the angle of the edge to facilitate flaking. Usually to bevel an edge in preparation for bifacial reduction. These flakes usually have thick and wide multifaceted platforms and are short in length.

ERRAILLURE FLAKE (ERL): A flake formed between the bulb of force and the bulbar scar on the ventral surface of a flake. The dorsal side bares no compression rings, but the ventral side of the flake does exhibit compression rings that match the scar on the bulb of force. The eraillure flake is typically concavo-convex and oval in shape similar to a contact lens. It does not have a platform or point of contact.

FINE-GRAINED VOLCANIC LITHIC MATERIAL (FGV): Igneous rock in which the crystals are too small to be seen by the unaided eye.

FLAKE (FLK): Any piece detached from a core that retains a platform and/or ventral surface. See Debitage.

FLAKE TOOL (FTOL): Flake tools have one or more edges that are suitable for use (for scraping or cutting, for example) without further modification. In use, working edges acquire a polish or tiny flake scars (micro-flaking) and may exhibit breaks or other damage.

FLAKED COBBLE (FC): The general category of "flaked cobble" is used for fragmentary artifacts for which a more specific function or form cannot be determined.

GLASS (GLA): Modern or historic manufactured (from quartz sand) material suitable for flintknapping.

GRAVER (GRV): Gravers are stone tools typically made by pressure flaking and intentionally designed to have a functional point or points. It is generally assumed that gravers are used to incise soft stone or organic materials such as bone, shell, wood, or antler.

GROUND ARRIS: An arris that has been ground or abraded. Arris grinding is used in flintknapping to facilitate flaking and to prepare artifacts for transportation.

GROUND STONE (GDS): Ground stone artifacts have been modified by pecking and grinding rather than by flaking. The general category of "ground stone" is used for fragmentary artifacts that exhibit pock marks from pecking or striations from grinding and for which a more specific function or form cannot be determined.

HAMMERSTONE (HAM): Lithic percussion indenter or percussor used as a flintknapping tool to detach flakes.

HAMMERSTONE SPALL (SPALL): An unintentional flake produced from a hammerstone. The flake is characterized by battering on the platform and dorsal surface.

INCIPIENT CONE CORTEX (IC): A cortex type that occurs on alluvial (and sometimes colluvial) gravels as a result of surface erosion caused by natural battering of gravels against one another. Battering occurs from tumbling in the traction load of streams as materials are transported. The battering causes Hertzian cone fractures to be set into the surface, making it weak and susceptible to further erosion. Incipient cone cortex exhibits ring cracks and cone fractures initiated on flat surfaces and extending perpendicularly into the stone without detaching, a rounded surface topography, and often a smooth finish.

KNIFE (KNI): Typically a bifacially worked tool made for cutting or sawing and identified by the location of wear and edge damage patterns. The tool is usually thick in cross-section to provide support and strength. The motion of use is usually lengthwise and evidence of this can be seen in the patterns of re-sharpening, orientation and location of use-wear striations parallel to the edge, and damage in the form of burin-like scars and/or micro-flaking, rounding, and polish along the lateral margins.

LANCEOLATE (LANCE): A projectile point that expands from the distal tip into a curved form and gradually converges towards the proximal base or corners.

MANO (MANO): "Hand" stone used with a metate for grinding or pulverizing food stuffs such as wild seeds or nuts, or other materials such as hematite for powdered pigment. Manos are usually cylindrical or ovoid in shape.

MANUPORT (MPORT): Unmodified objects that have been transported to an archaeological site from their areas of natural occurrence.

MARGIN: Edge of an artifact (tool or flake).

MARGIN REMOVAL FLAKE (MRF): Half-moon or semi-circular fragment of a biface or flake blank edge produced from a bending fracture initiated near the edge. These flakes result from flintknapping errors (application of force at an inappropriate angle and too far from the edge) or from inadvertent or careless reduction of a thin edge.

MAUL (MAUL): A large ground stone tool used to drive wedges to split wood for planks and other purposes.

MEDIAL (MED): Orientation term that refers to the midsection or middle of an artifact.

METAMORPHIC ROCK (MET): Metamorphic rocks have been modified by heat, pressure, and chemical processes, while buried deep below Earth's surface (e.g., schist, slate, marble, and quartzite).

METATE (MTE): A stone used for grinding grains, seeds, and other organic materials; sometimes also called a grinding slab.

MICRO-FLAKING (MF): Scars left by small flakes removed from the working edge of a stone tool during use. The use-edge is modified by contact with the worked material and can also often appear shiny or polished and rounded.

MORTAR (MORT): A ground stone or wooden receptacle with a cup-shaped depression usually used with a pestle for processing foods items.

MULTIDIRECTIONAL: Core type with flakes removed in more than one direction or from more than one platform, or both.

NOTCH/NOTCHING FLAKE (NTC): A specialized technique of pressure flaking that repeatedly removes flakes from opposite sides of a biface at one location along the margin to create an indentation in the margin. Frequently done near the basal end of a projectile point for hafting or used to produce serration along the margins of a projectile point.

OBSIDIAN (OBS): A dense volcanic glass containing over 70% silicon dioxide (SiO_2), obsidian is generally rich in iron and magnesium. Microscopic iron oxide crystals finely dispersed in the glass usually give obsidian a dark or black color. Red or green hues sometimes result from variation in the oxidation state of the iron minerals. Color banding or flow banding is caused by oxidation of flow surfaces subsequently folded into the viscous melt as the lava moves (http://volcanoes.usgs.gov/images/pglossary/obsidian.php). Obsidian has a non-crystalline (amorphous solid) structure well-suited for flaked-stone tool manufacture and fractures at a molecular level to create edges sharper than ground surgical steel scalpel edges. However, obsidian is relatively soft (5.0 to 5.5 on Mohs' hardness scale) and thin edges are brittle compared with steel and most other rocks commonly used in stone tool manufacture.

OVERSHOT FLAKE (OVT): A flake with a reverse hinge termination that removes part of the core or biface on the opposite margin from which it is initiated. Usually considered a flintknapping error. Also outrepasse (French), overpass, or plunging flake. If complete, such flakes provide evidence for the length or width or bifaces and may also indicate platform preparation techniques used and sequence of flake removals.

PEBBLE (PEB): A rock size from 4 to 64 millimeters in diameter with shapes varying from angular to well-rounded.

PECKED OR REDUCTION BY PECKING (PECK): A percussion battering technique used to remove material by initiation of overlapping superimposed cones with a hammerstone; commonly used in the shaping of ground stone tools.

PECKING HAMMERSTONE (PHAM): A pecking hammerstone is used in manufacture of "ground" or pecked stone tools such as pestles and mortars. Typically, pecking hammerstones are flaked to form a sharp edge or bit on a hard igneous or metamorphic cobble. The sharpened bit is then used to batter the "ground" stone tool blank to shape or roughen the surface as needed.

PERCUSSION FLAKE, INDETERMINATE (PERC): Flake fragment with attributes of percussion reduction (discriminate ventral features and remnant percussion scars on dorsal surface) but lacking distinctive characteristics indentifiable to a particular technology or reduction stage.

PERVERSE FRACTURE (PERV): Concoidal fracture initiated at the margin of a biface usually by a misdirected percussion blow. The fracture propagates diagonally through the biface along a twisting path.

PESTLE (PEST): Oblong cylindrical shaped ground stone tool used for pounding, crushing, or grinding substances in a mortar.

PETRIFIED WOOD (PET): Stone produced by siliceous replacement of organic material.

PLATFORM (P): Surface of a flake which contains the contact point of force applied to initiate the fracture for its detachment. The surface of a core, biface, or other piece on which force is applied to initiate a fracture to detach a flake.

PLATFORM PREPARATION FLAKE (PLP): A short flake removed from the platform end of a core face to strengthen the platform for subsequent reduction. These flakes usually have thick and wide platforms and vary in shape depending on the configuration of the core. Platform preparation flakes are diagnostic of certain types of core maintenance.

POLISH (PO): A shiny surface luster produced on or near the use-edge or on the surface of a tool; usually a consequence of cutting or grinding organic materials.

POTLID/POTLIDDING (PTLD): A flake or the scar from detachment of a flake, usually on CCS materials, caused by thermally induced differential expansion. The flake usually initiates near a flaw beneath the surface of the material and propagates under Hertzian principles toward the surface. The flake has a circular planview outline and leaves a shallow, smooth depression. The flake exhibits a shape resembling that of a lid of a pot. Potlids are usually the result of accidental, incidental, or postdepositional damage to lithic materials in a fire. Although potlidding may occur as the result of mistakes in heat treatment, they do not usually reflect heat treating of materials where they are found.

PREFORM (PRE): An unfinished pressure flaked tool, usually arrested in the manufacturing process because of a deleterious break.

PRESSURE FLAKE, EARLY STAGE (PREE): Flakes with small isolated platforms oriented to one side of the flake, acute platform angles, remnant ventral surface or remnants of percussion scars on dorsal surface (arrises oriented in varying directions), margins are generally parallel to one another, and the flake is usually curved and twisted in longitudinal section.

PRESSURE FLAKE, LATE STAGE (PREL): Flakes with same attributes as Pressure Flake, Early Stage (PREE) but with remnants of previous pressure scars on dorsal surface (arrises oriented parallel to flake margins) and may exhibit attributes of final edge shaping such as for serrations or notches.

PRIMARY GEOLOGICAL CORTEX (PG): Natural exterior rind produced as a result of formation processes or weathering of lithic materials at or near the location of their flow or bed (outcrop). Examples include the chalky exterior of marine chert nodules, the crystalline cavity lining of hydrothermal cherts, the frothy exterior of an obsidian flow, and the smooth to scratched or pitted weathering of a naturally fractured outcrop.

PROJECTILE POINT (PPT): A specific biface, made for use with a lance (Lance), dart (PPTD), or arrow (PPTA).

PROXIMAL (PROX): Orientation term that refers to the platform end of flake or the base of tool, especially a projectile point.

PYROCLASTIC CORTEX (PY): Rind that occurs on obsidian or other volcanic rock that has been explosively (within an ash flow) or aerially ejected as lava from a volcanic vent. The cortex visually suggests its molten genesis with a mildly undulating rounded shape and wrinkled (as a result of contraction during cooling) texture. This type of cortex may visually resemble incipient cone cortex, but lacks the overlapping ring cracks characteristic of IC cortex.

QUARTZ (QUA): Macrocrystalline silicate, usually monocrystalline quartz or metamorphosed (massive) quartz.

QUARTZITE (QTZ): Metamorphosed sandstone.

RADIAL BREAK (RBR): Fracture caused by applying force (percussion) to the middle of a flake or tool, on an anvil. The resulting fragments are pie shaped and exhibit square or obtuse edges along the broken surfaces.

RAW MATERIAL (RM): Unmodified toolstone.

REMNANT DORSAL SURFACE (RDS): A portion of the dorsal surface of the flake blank from which a flaked stone artifact is made. This surface may survive as a depression or a protrusion surrounded by flake scars removed in subsequent reduction. The surface exhibits cortex or negative flake scar attributes that are larger than the same attributes of surrounding flake scars and signifies a flake blank reduction trajectory. A remnant dorsal surface is difficult to identify on flakes but may be readily apparent on tools that have been minimally reduced from flake blanks.

REMNANT PLATFORM SURFACE (RPS): A portion of the original platform of a flake or flake blank which usually exhibits a single facet. This attribute is sometimes found at the base of projectile points such as Cascade and Coquille Broad-stemmed types. This attribute can indicate a particular manufacturing sequence involving linear flake blanks.

REMNANT VENTRAL SURFACE (RVS): A portion of the original detachment scar of a flake or flake blank. This attribute can be identified as a positive flake scar on the dorsal surface of a flake or on a tool and signifies a flake blank reduction trajectory. This surface may survive as a depression or a protrusion surrounded by flake scars removed in subsequent reduction. RVS is distinguished from other flake scars by relatively disproportionate (larger) attributes such as radial striations and compression rings. Since the remnant is only a portion of a larger surface, it often appears flat and featureless (because the features are widely spaced).

RHYOLITE (RHO): An igneous volcanic rock, with a fine ground mass (grain size of less than 1 millimeter), and often larger phenocrysts. Rhyolite's acidic chemistry is composed predominantly of potassium feldspar and quartz. Rhyolite is usually white, yellow, brown, or red and often flow banded or streaked. Most obsidians are glassy rhyolites.

ROUNDING (RD): An attribute of use-wear on sharp edges of stone tools caused by attrition through micro-flaking and grinding.

SANDSTONE (SAN): A sedimentary rock consisting primarily of cemented sand-size quartz grains.

SCRAPER (SCR): A uniface with a bit that exhibits use wear or rejuvenation. Presumably used for scraping organic materials, such as animal hides, which will give it a characteristic polish.

SERRATION (SERR): A series of small notches along the lateral margins of a tool (usually a projectile point).

SHEARING FRACTURE (SHEAR): Usually a result of impact and producing fractures primarily oriented longitudinally. These fractures can result from the splitting of the cone of force and leave a flake scar that forms a right angle edge on both faces. These breaks differ from bending breaks in that the force is initiated at the margin, as opposed to on the face. Shear breaks seldom reveal a bulb of force or a hinged or lipped termination.

SIDE-NOTCHED (SNO): Notching on a projectile point initiated on the lateral margins.

SILTSTONE (SIL): A sedimentary rock consisting primarily of consolidated silt particles.

SOIL SHEEN CORTEX (SS): A natural weathering of the exterior surface of a stone that is caused by chemical dissolution of minerals in the stone forming a shiny luster. Soil sheen cortex typically forms over a long period in acidic soils.

STRIATIONS (ST): An attribute of use wear on stone tools formed by scratches on or near the used edge or surface of a tool.

TERMINATION (TERM): The edge or margin of a flake or flake scar where the fracture ends (leaves the parent artifact).

TESTED RAW MATERIAL (TRM): Tested raw material is not a tool in the conventional sense, but represents pebbles or cobbles that have been split or from which flakes have been removed in order to determine whether the raw material is suitable for use.

UNIFACE (UNI): An artifact with flakes removed from one surface.

UNIDIRECTIONAL: Core type with flakes removed in one direction or from one platform, or both.

VEIN QUARTZ (VQU): A lithic material from a hydrothermal CCS deposit formed in a crack or cavity of another rock.

VENTRAL SURFACE (V): The face or side of a flake that corresponds to interior of the artifact from which it was detached.

WORKED FLAKE (WFL): A flake intentionally altered at its margin, usually by pressure flaking, to create a tool or to resharpen the edge for use as a tool.

Attachment B:
Biface Photos

Biface #1

*Numbers indicate catalog number of flake removed for hydration rim reading

Biface #2

*Numbers indicate catalog number of flake removed for hydration rim reading

Biface #3

*Numbers indicate catalog number of flake removed for hydration rim reading

Biface #4

*Numbers indicate catalog number of flake removed for hydration rim reading

Biface #5

*Numbers indicate catalog number of flake removed for hydration rim reading

Biface #6

*Numbers indicate catalog number of flake removed for hydration rim reading

Biface #7

Numbers indicate catalog number of flake removed for hydration rim reading

Biface #8

*Numbers indicate catalog number of flake removed for hydration rim reading

Biface #9

*Numbers indicate catalog number of flake removed for hydration rim reading

Biface #10

*Numbers indicate catalog number of flake removed for hydration rim reading

Biface #11

*Numbers indicate catalog number of flake removed for hydration rim reading

Biface #12

*Numbers indicate catalog number of flake removed for hydration rim reading

Biface #13

*Numbers indicate catalog number of flake removed for hydration rim reading

Biface #14

*Numbers indicate catalog number of flake removed for hydration rim reading

Biface #15

*Numbers indicate catalog number of flake removed for hydration rim reading

**Catalog #40. Flake detached during excavation and re-fit to biface during analysis

Attachment C:
Obsidian Studies

XRF Reports
Hydration Rim Measurements
Hydration Age Estimate Methods
Hydration Age Estimate Data Sheets

Results of X-Ray Fluorescence Analysis

Craig E. Skinner

2015

Northwest Research Obsidian Studies Laboratory

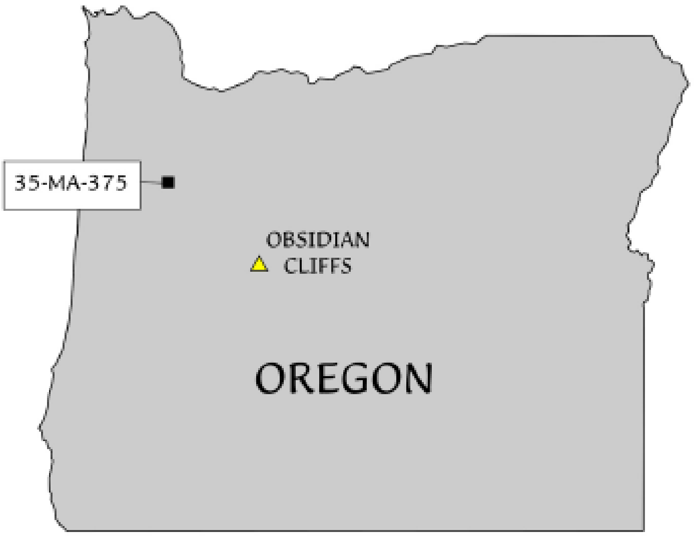

Figure 1. Locations of the Dittman Biface Cache and the source of the artifacts.

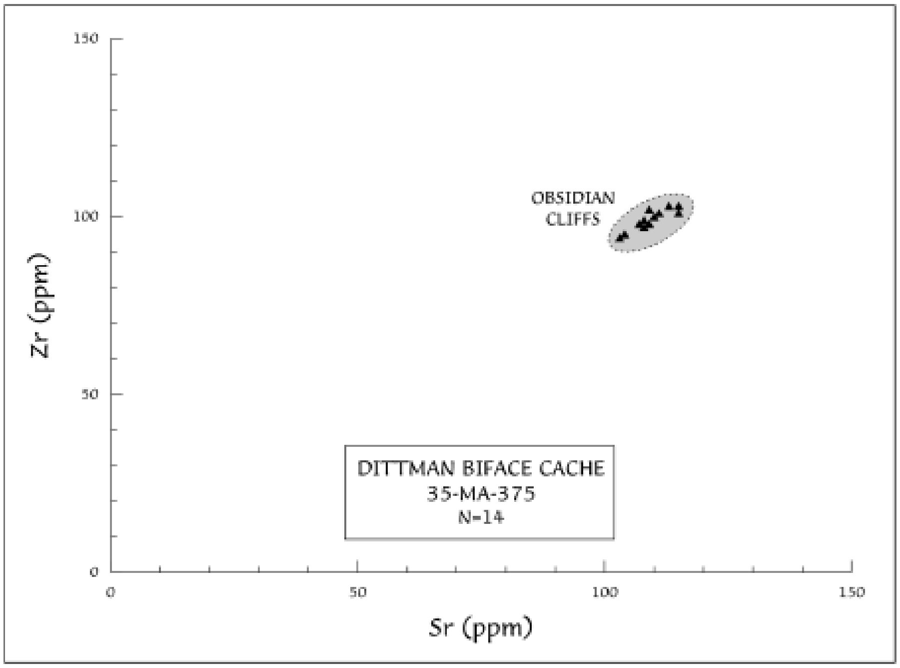

Figure 2. Scatterplot of strontium (Sr) plotted versus zirconium (Zr) for all analyzed artifacts.

Northwest Research Obsidian Studies Laboratory

Table A-1. Results of XRF Studies: Dittman Biface Cache (35-MA-375), Marion County, Oregon

				Trace Element Concentrations									Ratios		
Site	Specimen No.	Catalog No.		Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	Fe^2 O^{3T}	Fe:Mn	Fe:Ti	Geochemical Source
35-MA-375	1	1		72	104	16	95	6	NM	NM	806	NM	NM	NM	Obsidian Cliffs
			±	1	1	1	1	1	NM	NM	22	NM			
35-MA-375	2	2		83	115	17	103	9	NM	NM	863	NM	NM	NM	Obsidian Cliffs
			±	2	2	1	1	1	NM	NM	22	NM			
35-MA-375	3	3		81	109	16	102	7	NM	NM	923	NM	NM	NM	Obsidian Cliffs
			±	2	1	1	1	1	NM	NM	21	NM			
35-MA-375	4	4		79	108	14	99	7	NM	NM	911	NM	NM	NM	Obsidian Cliffs
			±	2	1	1	1	1	NM	NM	21	NM			
35-MA-375	5	5		80	111	18	101	8	NM	NM	858	NM	NM	NM	Obsidian Cliffs
			±	2	2	1	1	1	NM	NM	22	NM			
35-MA-375	6	6		73	103	13	94	6	NM	NM	847	NM	NM	NM	Obsidian Cliffs
			±	1	1	1	1	1	NM	NM	21	NM			
35-MA-375	7	7		78	107	16	98	8	NM	NM	932	NM	NM	NM	Obsidian Cliffs
			±	1	1	1	1	1	NM	NM	21	NM			
35-MA-375	8	8		80	115	16	101	7	NM	NM	872	NM	NM	NM	Obsidian Cliffs
			±	2	2	1	1	1	NM	NM	23	NM			
35-MA-375	9	9		77	109	17	98	7	NM	NM	822	NM	NM	NM	Obsidian Cliffs
			±	2	1	1	1	1	NM	NM	22	NM			
35-MA-375	10	10		75	108	15	97	6	NM	NM	827	NM	NM	NM	Obsidian Cliffs
			±	2	2	1	1	1	NM	NM	23	NM			
35-MA-375	11	11		75	108	15	97	7	NM	NM	855	NM	NM	NM	Obsidian Cliffs
			±	1	1	1	1	1	NM	NM	21	NM			
35-MA-375	12	12		75	107	15	98	7	NM	NM	850	NM	NM	NM	Obsidian Cliffs
			±	1	1	1	1	1	NM	NM	22	NM			

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

Northwest Research Obsidian Studies Laboratory

Table A-1. Results of XRF Studies: Dittman Biface Cache (35-MA-375), Marion County, Oregon

			Trace Element Concentrations									Ratios		
Site	Specimen No.	Catalog No.	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	$Fe^{2}O^{3T}$	Fe:Mn	Fe:Ti	Geochemical Source
35-MA-375	13	13	79	110	16	100	7	NM	NM	899	NM	NM	NM	Obsidian Cliffs
			± 1	1	1	1	1	NM	NM	21	NM			
35-MA-375	14	14	84	113	18	103	7	NM	NM	840	NM	NM	NM	Obsidian Cliffs
			± 2	2	1	1	1	NM	NM	21	NM			
NA	RGM-1	RGM-1	152	109	24	217	6	NM	NM	770	NM	NM	NM	RGM-1 Reference Standard
			± 2	2	1	2	1	NM	NM	23	NM			

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

X-Ray Fluorescence Analysis of Obsidian Artifacts from The Dittman Biface Cache, Site 35-MA-375, Marion County, Oregon

Alex J. Nyers
Northwest Research Obsidian Studies Laboratory

Forty-one artifacts from the Dittman Biface Cache, Site 35-MA-375 (N = 41), Marion County, Oregon, were submitted for energy dispersive X-ray fluorescence trace element provenance analysis. The samples were prepared and analyzed at the Northwest Research Obsidian Studies Laboratory under the accession number 2017-08b.

Analytical Methods

X-Ray Fluorescence Analysis. Nondestructive trace element analysis of the samples was completed using a Thermo NORAN QuanX-EC energy dispersive X-ray fluorescence (EDXRF) spectrometer. The analyzer uses an X-ray tube excitation source and a solid-state detector to provide spectroscopic analysis of elements ranging from sodium to uranium (atomic numbers 11 to 92) and in concentrations ranging from a few parts per million to 100 percent. The system is equipped with a Peltier-cooled Si(Li) detector and an air-cooled X-ray tube with a rhodium target and a 76 micron Be window. The tube is driven by a 50 kV 2mA high voltage power supply, providing a voltage range of 4 to 50 kV. During operation, the tube current is automatically adjusted to an optimal 50% dead time, a variable that is significantly influenced by the varying physical sizes of the different analyzed samples. Small specimens are mounted in 32 mm-diameter sample cups with mylar windows on a 20-position sample tray while larger samples are fastened directly to the surface of the tray.

For the elements that are reported in Table A-1, we analyzed the collection with a 3.5 mm as well as an 8.8 mm beam collimator installed with tube voltage and count times adjusted for optimum results. Instrument control and data analysis are performed using WinTrace software (version 7) running under the Windows 7 operating system.

The diagnostic trace element values used to characterize the samples are compared directly to those for known obsidian and fine-grained volcanic (FGV) sources reported in the literature and with unpublished trace element data collected through analysis of geologic source samples (Northwest Research 2018a). Artifacts are correlated to a parent obsidian, FGV, or basalt source (or geochemical 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.

Results of Analysis

X-Ray Fluorescence Analysis. The obsidian artifacts analyzed by X-ray fluorescence methods were correlated with five known obsidian sources. Additionally, a single artifact, specimen 33 (catalog number 44-S2) was correlated with the Unknown B source which has been seen archaeologically within Linn County but who's geologic source remains unknown. The locations of the site and the identified sources are shown in Figure 1. Analytical results are presented in Table A-1 in the Appendix and are summarized in Table 1 and Figure 2.

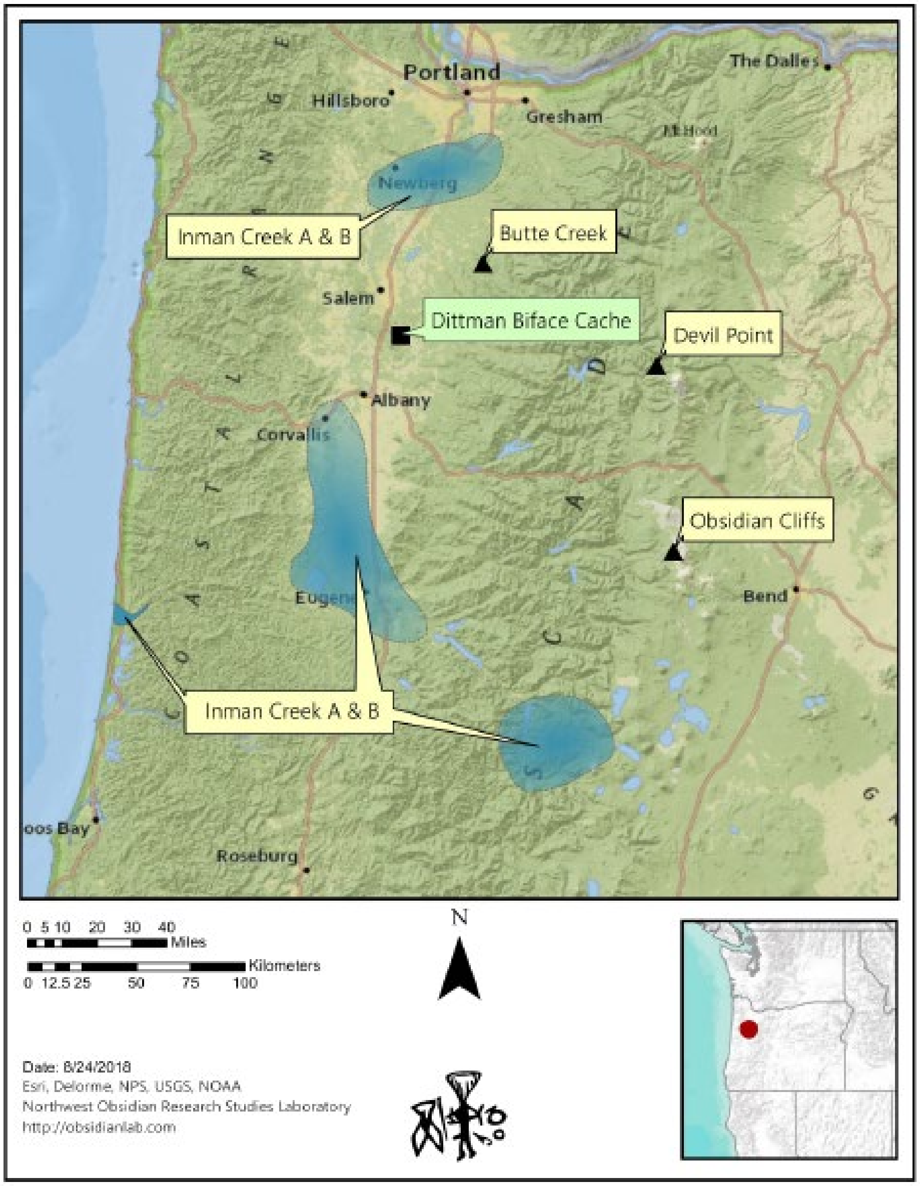

Figure 1. Locations of the project site and sources of the analyzed obsidian artifacts.

Table 1. Summary of results of trace element analysis of the project specimens.

GEOCHEMICAL SOURCE	N=	PERCENTAGE
Butte Creek	1	2.4
Devil Point	1	2.4
Inman Creek A	15	36.6
Inman Creek B	19	46.3
Obsidian Cliffs	4	9.8
Unknown B	1	2.4
TOTAL	**41**	**100.0**

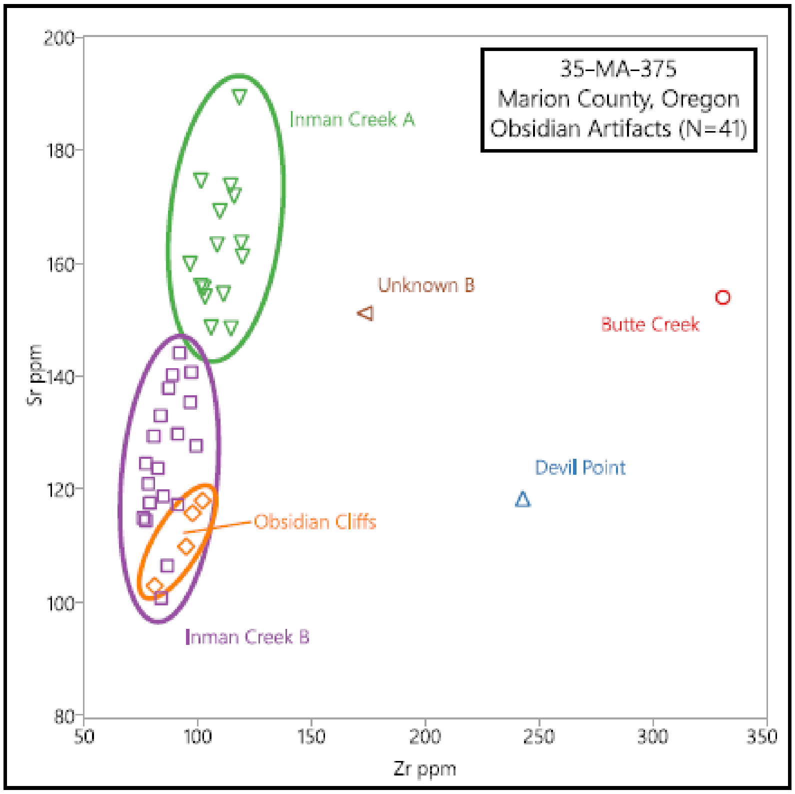

Figure 2 - Scatterplot of zirconium (Zr) plotted versus strontium (Sr) for analyzed artifacts.

Information concerning the location, geologic setting, and prehistoric use of obsidian sources identified in the current investigation may be found at www.sourcecatalog.com (Northwest Research 2018b).

References Cited

Northwest Research Obsidian Studies Laboratory
2018a Northwest Research Obsidian Studies Laboratory World Wide Web Site (www.obsidianlab.com).

2018b Northwest Research U. S. Obsidian Source Catalog (www.sourcecatalog.com).

Appendix

Results of X-Ray Fluorescence Analysis

Northwest Research Obsidian Studies Laboratory

Table A-1. Results of XRF Studies: 35-MA-375, Marion County, Oregon

			Trace Element Concentrations									Ratios		
Site	Specimen No.	Catalog No.	Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	Fe^2O^{3T}	Fe:Mn	Fe:Ti	Geochemical Source
35MA375	1	30	85	161	22	120	9	NM	NM	681	NM	NM	NM	Inman Creek A
			± 3	3	2	3	2	NM	NM	23	NM			
35MA375	2	33	68	129	15	81	6	NM	NM	NM	NM	NM	NM	Inman Creek B *
			± 3	3	2	3	3	NM	NM	NM	NM			
35MA375	3	34	84	155	20	111	12	NM	NM	NM	NM	NM	NM	Inman Creek A *
			± 3	3	2	3	2	NM	NM	NM	NM			
35MA375	4	35	94	128	17	99	10	NM	NM	NM	NM	NM	NM	Inman Creek B *
			± 3	3	2	3	3	NM	NM	NM	NM			
35MA375	5	40	83	103	14	81	0	NM	NM	NM	NM	NM	NM	Obsidian Cliffs *
			± 3	3	2	2	2	NM	NM	NM	NM			
35MA375	6	42	93	154	16	103	10	NM	NM	NM	NM	NM	NM	Inman Creek A *
			± 3	3	2	3	2	NM	NM	NM	NM			
35MA375	7	55	95	135	20	97	9	NM	NM	764	NM	NM	NM	Inman Creek B
			± 3	3	2	3	2	NM	NM	30	NM			
35MA375	8	43	117	138	21	87	6	NM	NM	561	NM	NM	NM	Inman Creek B
			± 3	3	2	2	2	NM	NM	36	NM			
35MA375	9	46	92	115	17	76	7	NM	NM	679	NM	NM	NM	Inman Creek B
			± 3	3	2	2	2	NM	NM	31	NM			
35MA375	10	47	116	118	26	243	13	NM	NM	NM	NM	NM	NM	Devil Point *
			± 3	3	2	3	2	NM	NM	NM	NM			
35MA375	12	54	74	101	14	84	5	NM	NM	NM	NM	NM	NM	Inman Creek B *
			± 3	3	2	3	3	NM	NM	NM	NM			
35MA375	13	58	81	141	17	97	7	NM	NM	NM	NM	NM	NM	Inman Creek B *
			± 3	3	2	3	2	NM	NM	NM	NM			
35MA375	14	59	91	118	16	102	9	NM	NM	NM	NM	NM	NM	Obsidian Cliffs *
			± 3	3	2	3	2	NM	NM	NM	NM			
35MA375	15	61	79	130	18	91	0	NM	NM	652	NM	NM	NM	Inman Creek B
			± 3	3	2	3	2	NM	NM	29	NM			

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

Northwest Research Obsidian Studies Laboratory

Table A-1. Results of XRF Studies: 35-MA-375, Marion County, Oregon

				Trace Element Concentrations									Ratios		
Site	Specimen No.	Catalog No.		Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	Fe^{2}O^{3T}	Fe:Mn	Fe:Ti	Geochemical Source
35MA375	16	63		81	110	17	95	7	NM	NM	677	NM	NM	NM	Obsidian Cliffs
			±	3	3	2	3	2	NM	NM	34	NM			
35MA375	17	64		98	119	18	85	8	NM	NM	537	NM	NM	NM	Inman Creek B
			±	3	3	2	3	2	NM	NM	25	NM			
35MA375	18	65		84	149	17	106	8	NM	NM	NM	NM	NM	NM	Inman Creek A *
			±	3	3	2	3	2	NM	NM	NM	NM			
35MA375	19	68		104	133	21	84	6	NM	NM	NM	NM	NM	NM	Inman Creek B *
			±	3	2	2	2	2	NM	NM	NM	NM			
35MA375	20	70		95	164	19	119	10	NM	NM	NM	NM	NM	NM	Inman Creek A *
			±	3	3	2	3	2	NM	NM	NM	NM			
35MA375	21	71		88	149	22	115	10	NM	NM	NM	NM	NM	NM	Inman Creek A *
			±	3	3	2	3	3	NM	NM	NM	NM			
35MA375	22	75		94	115	12	77	0	NM	NM	615	NM	NM	NM	Inman Creek B
			±	5	4	3	4	4	NM	NM	36	NM			
35MA375	23	76		111	124	16	82	9	NM	NM	609	NM	NM	NM	Inman Creek B
			±	3	3	2	2	2	NM	NM	32	NM			
35MA375	24	79		90	163	17	109	10	NM	NM	NM	NM	NM	NM	Inman Creek A *
			±	3	3	2	3	2	NM	NM	NM	NM			
35MA375	25	82		65	117	13	91	7	NM	NM	725	NM	NM	NM	Inman Creek B
			±	3	3	2	3	2	NM	NM	31	NM			
35MA375	26	83		77	107	15	87	7	NM	NM	NM	NM	NM	NM	Inman Creek B *
			±	3	2	2	2	2	NM	NM	NM	NM			
35MA375	27	84		98	118	19	79	9	NM	NM	NM	NM	NM	NM	Inman Creek B *
			±	3	3	2	2	2	NM	NM	NM	NM			
35MA375	28	85		98	160	21	97	9	NM	NM	NM	NM	NM	NM	Inman Creek A *
			±	3	3	2	3	2	NM	NM	NM	NM			
35-MA-375	30	Biface_15		84	116	19	98	8	NM	NM	755	NM	NM	NM	Obsidian Cliffs
			±	3	3	2	3	2	NM	NM	25	NM			

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

Northwest Research Obsidian Studies Laboratory

Table A-1. Results of XRF Studies: 35-MA-375, Marion County, Oregon

				Trace Element Concentrations									Ratios		
Site	Specimen No.	Catalog No.		Rb	Sr	Y	Zr	Nb	Ti	Mn	Ba	Fe^2O^{3T}	Fe:Mn	Fe:Ti	Geochemical Source
35-MA-375	31	21		81	156	19	103	9	NM	NM	NM	NM	NM	NM	Inman Creek A *
			±	3	3	2	2	2	NM	NM	NM	NM			
35-MA-375	32	44-S1		86	169	20	110	8	NM	NM	654	NM	NM	NM	Inman Creek A
			±	3	3	2	2	2	NM	NM	47	NM			
35-MA-375	33	44-S2		80	151	19	174	9	NM	NM	NM	NM	NM	NM	Unknown B? *
			±	3	3	2	3	2	NM	NM	NM	NM			
35-MA-375	34	49-S1		90	156	16	101	7	NM	NM	NM	NM	NM	NM	Inman Creek A *
			±	3	3	2	2	2	NM	NM	NM	NM			
35-MA-375	35	49-2		89	172	20	116	10	NM	NM	723	NM	NM	NM	Inman Creek A
			±	3	3	2	3	2	NM	NM	37	NM			
35-MA-375	36	50-S1		98	154	39	331	15	NM	NM	538	NM	NM	NM	Butte Creek
			±	3	3	2	4	2	NM	NM	37	NM			
35-MA-375	37	52-S1		70	140	16	89	5	NM	NM	NM	NM	NM	NM	Inman Creek B? *
			±	3	4	2	3	0	NM	NM	NM	NM			
35-MA-375	38	52-S2		60	125	13	77	6	NM	NM	NM	NM	NM	NM	Inman Creek B? *
			±	3	3	2	3	2	NM	NM	NM	NM			
35-MA-375	39	52-S3		73	144	14	92	0	NM	NM	NM	NM	NM	NM	Inman Creek B? *
			±	3	3	2	3	2	NM	NM	NM	NM			
35-MA-375	40	56-S1		107	189	20	118	9	NM	NM	548	NM	NM	NM	Inman Creek A
			±	3	3	2	3	2	NM	NM	46	NM			
35-MA-375	41	66-S1		94	174	20	114	7	NM	NM	636	NM	NM	NM	Inman Creek A
			±	3	3	2	3	2	NM	NM	37	NM			
35-MA-375	42	78-S1		59	121	11	78	6	NM	NM	NM	NM	NM	NM	Inman Creek B? *
			±	3	3	2	3	2	NM	NM	NM	NM			
35-MA-375	43	81-S1		99	175	18	101	9	NM	NM	NM	NM	NM	NM	Inman Creek A *
			±	3	3	2	3	2	NM	NM	NM	NM			
NA	RGM-1	RGM-1		145	114	28	227	9	NM	NM	795	NM	NM	NM	RGM-1 Reference Standard
			±	3	3	2	3	2	NM	NM	30	NM			

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

Obsidian Hydration Analysis of Artifact Obsidian from the Dittman Biface Cache (35-MA-375), Marion County, Oregon

Jennifer J. Thatcher
Willamette Analytics Report 2017-15
Prepared for John Pouley,
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Willamette Analytics Report 2017-15

Obsidian Hydration Analysis of Artifact Obsidian from the Dittman Biface Cache (35-MA-375), Marion County, Oregon

Jennifer J. Thatcher
Willamette Analytics, LLC

Introduction

Thirty-four obsidian artifacts from the Dittman Biface Cache (35-MA-375), Marion County, Oregon, were submitted for obsidian hydration analysis. The samples were prepared and analyzed at Willamette Analytics, LLC in Corvallis, Oregon, under the accession number 2017-15.

Analytical Methods

An appropriate section of each artifact is selected for hydration slide preparation. The location of the section is determined by the morphology and the perceived potential of the location to yield information on the manufacture, use, and discard of the artifact. Two parallel cuts are made into the edge of the artifact using a lapidary saw equipped with 100 millimeter diameter diamond-impregnated .100 millimeter thick blades. These cuts produce a cross-section of the artifact approximately one millimeter thick which is removed from the artifact and mounted on a petrographic microscope slide with Lakeside thermoplastic cement. The mounted specimen slide is ground in a slurry of 600 grade optical-quality corundum abrasive on a plate glass lap. This initial grinding of the specimen reduces its thickness by approximately one half and removes any nicks from the edge of the specimen produced during cutting. The specimen is then inverted and ground to a final thickness of 30-50 microns, removing nicks from the other side of the specimen. The result is a thin cross-section of the surfaces of the artifact.

The prepared slide is measured using an Olympus BHT petrographic microscope fitted with a video micrometer unit and a digital imaging video camera. When a clearly defined hydration rim 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. Narrow rims (under approximately two microns) are usually examined under a higher magnification. Hydration rims smaller than one micron often cannot be resolved by optical microscopy.

Hydration rims are reported to the nearest 0.1 micron and represent the mean value for all readings. Standard deviation values for each measured surface indicate the variability for hydration rim 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 (Meighan 1981, 1983; Liritzis 2015). Any attempts to convert rim measurements to absolute dates should be approached with great care and considerable skepticism, particularly

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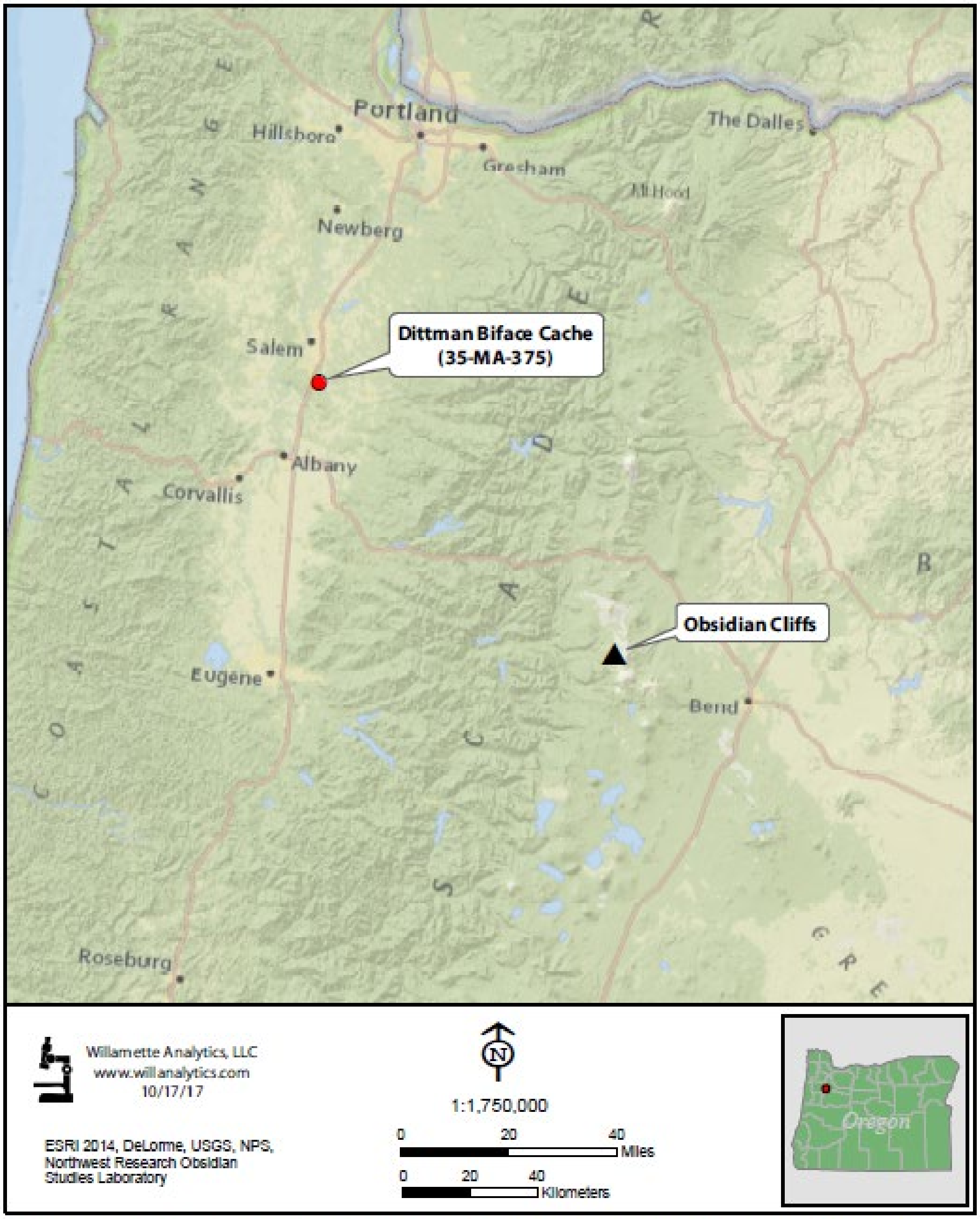

Figure 1. Locations of the project site and the obsidian source identified in the current study.

when rates are borrowed from existing literature sources. When considered through temporal periods, the variables affecting the development of hydration rims are complex (Anovitz et al. 1999; Skinner 1995; Rogers 2008, 2010; Liritzis and Laskaris 2011), and there is no assurance that artifacts recovered from similar provenances or locales have shared thermal and cultural histories.

Results

The 34 flakes that were prepared for obsidian hydration analysis were removed from 15 large bifaces by lithic technologists at Archaeological Investigations Northwest, Inc. (AINW) in Portland, Oregon. In an attempt to identify early and late surfaces with the goal of understanding how the obsidian was selected and reduced, at least two flakes were removed from each of the 15 bifaces.

The bifaces were previously submitted for X-ray fluorescence (XRF) trace element analysis at Northwest Research Obsidian Studies Laboratory in Corvallis, Oregon (Skinner 2015; Nyers 2017). The results of those studies are summarized in Table 1 and in Table A-1 in the Appendix. The locations of the geochemical obsidian source and the project site are shown in Figure 1.

Table 1. Summary of results of hydration analysis of the obsidian artifacts from the project site.

OBSIDIAN SOURCE	**HYDRATION RIM MEASUREMENTS (MICRONS)**	**TOTAL**
Obsidian Cliffs	4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.2, 4.3, 4.3 6.1	**33**
TOTAL	--	**33**

Hydration rims were identified and measured on the dorsal surfaces of all but one very small flake, Specimen # 4 (Catalog # 002-2). This sample did not yield a successful rim measurement due to its small physical size and resultant limitations in the thin section preparation process. One of the artifacts, an eraillure flake, Specimen # 18 (Catalog # 009-1), yielded a hydration rim on both the dorsal and ventral surfaces.

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Appendix

Results of Obsidian Hydration Analysis

Table A-1. Obsidian Hydration Results and Sample Provenience: Artifacts from 35-MA-375, Marion County, Oregon

Site	Specimen No.	Catalog No.	Unit	Depth	Artifact Type [A]	Artifact Source [B]	Hydration Rims		Comments [C]
							Rim 1	Rim 2	
35-MA-375	1	1-1	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	DS only
35-MA-375	2	1-2	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	DS only
35-MA-375	3	2-1	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	DS only
35-MA-375	4	2-2	--	--	DEB	Obsidian Cliffs	NA ± NA	NM ± NM	REC; UNR, DES
35-MA-375	5	3-1	--	--	DEB	Obsidian Cliffs	4.3 ± 0.1	NM ± NM	BEV, DFV, DS only
35-MA-375	6	3-2	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	DS only
35-MA-375	7	3-3	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	DS only
35-MA-375	8	4-1	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	DS only
35-MA-375	9	4-2	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	DS only
35-MA-375	10	5-1	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	REC; BEV, DS only
35-MA-375	11	5-2	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	DS only
35-MA-375	12	6-1	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	DS only
35-MA-375	13	6-2	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	BEV, DS only
35-MA-375	14	7-1	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	BEV, DFV, DS only
35-MA-375	15	7-2	--	--	DEB	Obsidian Cliffs	4.2 ± 0.0	NM ± NM	REC; BEV, DS only

[A] DEB = Debitage
[B] Obsidian Source Data: Northwest Research Obsidian Studies Laboratory
[C] See Abbreviations and Definitions
NA = Not Available; NM = Not Measured; * = Small XRF sample

Table A-1. Obsidian Hydration Results and Sample Provenience: Artifacts from 35-MA-375, Marion County, Oregon

Site	Specimen No.	Catalog No.	Unit	Depth	Artifact Type[A]	Artifact Source[B]	Hydration Rims		Comments[C]
							Rim 1	Rim 2	
35-MA-375	16	8-1	--	--	DEB	Obsidian Cliffs	4.2 ± 0.0	NM ± NM	DS only
35-MA-375	17	8-2	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	DS only
35-MA-375	18	9-1	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	Same rim on DS and VS
35-MA-375	19	9-2	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	BEV, DFV, DS only
35-MA-375	20	9-3	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	REC; DS only
35-MA-375	21	9-4	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	REC; DS only
35-MA-375	22	10-1	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	DS only
35-MA-375	23	10-2	--	--	DEB	Obsidian Cliffs	4.3 ± 0.0	NM ± NM	DS only
35-MA-375	24	11-1	--	--	DEB	Obsidian Cliffs	6.1 ± 0.1	NM ± NM	DS only
35-MA-375	25	11-2	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	REC; BEV, DS only
35-MA-375	26	12-1	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	DS only
35-MA-375	27	12-2	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	DS only
35-MA-375	28	12-3	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	DS only
35-MA-375	29	13-1	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	DS only
35-MA-375	30	13-2	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	DS only

[A] DEB = Debitage

[B] Obsidian Source Data: Northwest Research Obsidian Studies Laboratory

[C] See Abbreviations and Definitions
NA = Not Available; NM = Not Measured; * = Small XRF sample

Willamette Analytics, LLC

Table A-1. Obsidian Hydration Results and Sample Provenience: Artifacts from 35-MA-375, Marion County, Oregon

Site	Specimen No.	Catalog No.	Unit	Depth	Artifact Type [A]	Artifact Source [B]	Hydration Rims Rim 1	Hydration Rims Rim 2	Comments [C]
35-MA-375	31	14-1	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	DS only
35-MA-375	32	14-2	--	--	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	DS only
35-MA-375	33	15-1	TU 2	Level 6	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	DS only
35-MA-375	34	15-2	TU 2	Level 6	DEB	Obsidian Cliffs	4.2 ± 0.1	NM ± NM	DS only

---

[A] DEB = Debitage

[B] Obsidian Source Data: Northwest Research Obsidian Studies Laboratory

[C] See Abbreviations and Definitions
NA = Not Available; NM = Not Measured; * = Small XRF sample

Abbreviations and Definitions

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.

D/V - (Dorsal/Ventral). In most cases both the dorsal and ventral surfaces of an artifact are measured for hydration rim values. The D/V designation is used in some cases to specify rim locations. Likewise, "**DS**", "**DM**" or "**VS**", "**VM**" may be used indicate the dorsal or ventral surfaces or margins.

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 rim was observed on the thin section.

HV - (Highly Variable). The hydration rim 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.

IF - (Internal Fracture). In some cases, especially with weathered samples, rim measurements are taken from internal fractures or cracks. See also **SF** (Step Fracture).

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

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

NVH - (No Visible Hydration). No hydration rim 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 rims 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 rim, 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.

R1, R2, R3 - (Rim 1, Rim 2, Rim 3). Often used when multiple cut locations are specified.

RVS - (Remnant Ventral Scar).

SF - (Step Fracture). In some cases, especially with weathered samples, rim measurements are taken from step fractures. See also **IF** (Internal Fracture).

UNR - (UNReadable). The optical quality of the hydration rim 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.

Obsidian Hydration Analysis of Artifact Obsidian from the Dittman Biface Cache (35-MA-375), Marion County, Oregon

Jennifer J. Thatcher
Willamette Analytics Report 2017-08b
Prepared for John Pouley,
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September 12, 2018

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Willamette Analytics Report 2017-08b

Obsidian Hydration Analysis of Artifact Obsidian from the Dittman Biface Cache (35-MA-375), Marion County, Oregon

Jennifer J. Thatcher
Willamette Analytics, LLC

Introduction

Thirty-eight obsidian artifacts from the Dittman Biface Cache (35-MA-375), Marion County, Oregon, were submitted for obsidian hydration analysis. The samples were prepared and analyzed at Willamette Analytics, LLC in Corvallis, Oregon, under the accession number 2017-08b.

Analytical Methods

An appropriate section of each artifact is selected for hydration slide preparation. The location of the section is determined by the morphology and the perceived potential of the location to yield information on the manufacture, use, and discard of the artifact. Two parallel cuts are made into the edge of the artifact using a lapidary saw equipped with 100 millimeter diameter diamond-impregnated .100 millimeter thick blades. These cuts produce a cross section of the artifact approximately one millimeter thick which is removed from the artifact and mounted on a petrographic microscope slide with Lakeside thermoplastic cement. The mounted specimen slide is ground in a slurry of 600 grade optical-quality corundum abrasive on a plate glass lap. This initial grinding of the specimen reduces its thickness by approximately one half and removes any nicks from the edge of the specimen produced during cutting. The specimen is then inverted and ground to a final thickness of 30-50 microns, removing nicks from the other side of the specimen. The result is a thin cross-section of the surfaces of the artifact.

The prepared slide is measured using an Olympus BHT petrographic microscope fitted with a video micrometer unit and a digital imaging video camera. When a clearly defined hydration rim 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. Narrow rims (under approximately two microns) are usually examined under a higher magnification. Hydration rims smaller than one micron often cannot be resolved by optical microscopy.

Hydration rims are reported to the nearest 0.1 micron and represent the mean value for all readings. Standard deviation values for each measured surface indicate the variability for hydration rim 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 (Meighan 1981, 1983; Liritzis 2015).

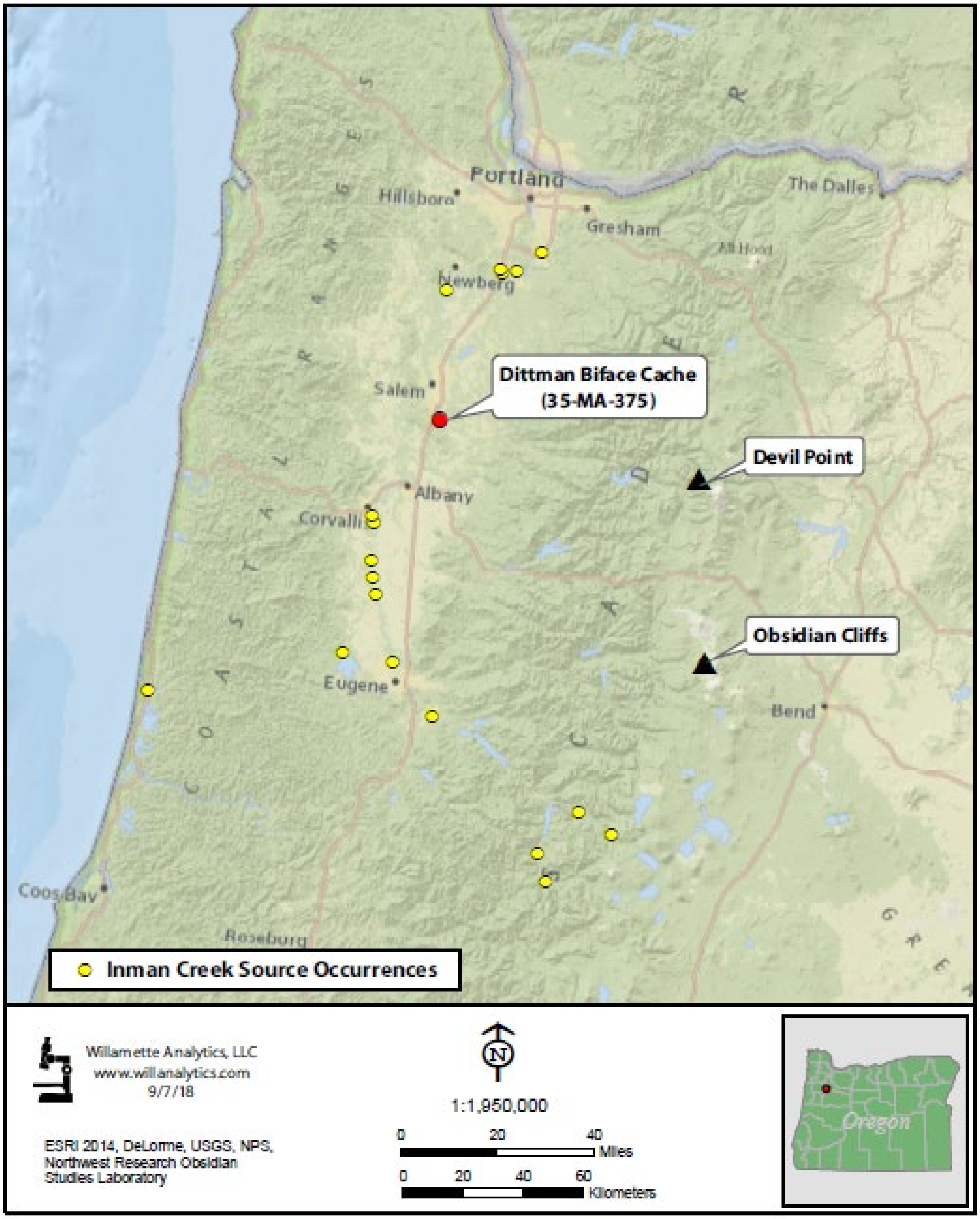

Figure 1. Locations of the project site and the obsidian sources identified in the current study.

Any attempts to convert rim measurements to absolute dates should be approached with great care and considerable skepticism, particularly when rates are borrowed from existing literature sources. When considered through temporal periods, the variables affecting the development of hydration rims are complex (Anovitz et al. 1999; Skinner 1995; Rogers 2008, 2010; Liritzis and Laskaris 2011), and there is no assurance that artifacts recovered from similar provenances or locales have shared thermal and cultural histories.

Results

The obsidian artifacts that were prepared for obsidian hydration analysis were also submitted for X-ray fluorescence (XRF) trace element analysis at Northwest Research Obsidian Studies Laboratory in Corvallis, Oregon (Nyers 2018). The results of that study are summarized in tables 1 and 2, and are presented in Table A-1 in the Appendix. The locations of the geochemical obsidian sources and the project site are shown in Figure 1.

Table 1. Summary of total obsidian hydration (OH) samples from the project site.

OBSIDIAN SOURCE	SAMPLES WITH MEASURABLE OH RIMS (N =)	SAMPLES WITH NO MEASURABLE OH RIMS (N =)	TOTAL
Devil Point	1	--	**1**
Inman Creek A	9	6	**15**
Inman Creek B	12	7	**19**
Obsidian Cliffs	3	--	**3**
TOTAL	**25**	**13**	**38**

Hydration rims were identified and measured on 25 of the 38 artifacts that were submitted for hydration analysis. Six of the Inman Creek A and B samples did not yield measurable hydration rims due to a high crystalline content present in these specimens. The dense configuration of micro-phenocrysts, a characteristic sometimes observed in the Inman Creek source material, tends to obscure rim visibility and can render the reliable measurement of observed rims difficult or impossible. An additional 6 samples from the Inman Creek A and B sources did not yield visible hydration rims, either because rims had not developed or because they were too small to be seen by optical microscopy. A specimen that was correlated with the Inman B source did not yield a measurable hydration rim due to heavy surface weathering.

Table 2. Summary of results of hydration analysis of the obsidian artifacts from the project site.

OBSIDIAN SOURCE	**HYDRATION RIM MEASUREMENTS (MICRONS)**	**TOTAL**
Devil Point	2.5	**1**
Inman Creek A	1.1, 1.1, 1.1, 1.2, 1.3, 1.3, 1.4, 1.6, 1.9	**9**
Inman Creek B	1.4, 1.4, 1.5, 1.7, 1.7, 1.9 2.0, 2.0, 2.4 3.0, 3.1 4.4	**12**
Obsidian Cliffs	2.6 3.0 4.4	**3**
TOTAL	--	**25**

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Appendix

Results of Obsidian Hydration Analysis

Willamette Analytics, LLC

Table A-1. Obsidian Hydration Results and Sample Provenience: Artifacts from 35-MA-375, Marion County, Oregon

Site	Specimen No.	Catalog No.	Unit	Depth (cm)	Artifact Type[A]	Artifact Source[B]	Hydration Rims Rim 1	Hydration Rims Rim 2	Comments[C]
35-MA-375	1	30	Unit 1	Level 5	DEB	Inman Creek A	1.6 ± 0.1	NM ± NM	--
35-MA-375	2	33	Unit 2	Level 2	DEB	Inman Creek B	NM ± NM	NM ± NM	NVH
35-MA-375	3	34	Unit 2	Level 2	DEB	Inman Creek A	1.4 ± 0.0	NM ± NM	--
35-MA-375	4	35	Unit 2	Level 3	DEB	Inman Creek B	4.4 ± 0.1	NM ± NM	Rim on DM only
35-MA-375	5	40	Unit 2	Level 6	DEB	Obsidian Cliffs	4.4 ± 0.0	NM ± NM	NVH on VS; BEV
35-MA-375	6	42	Unit 3	Level 2	DEB	Inman Creek A	1.3 ± 0.1	NM ± NM	--
35-MA-375	7	55	Unit 4	Level 2	DEB	Inman Creek B	1.7 ± 0.1	NM ± NM	REC
35-MA-375	8	43	Unit 3	Level 3	DEB	Inman Creek B	1.5 ± 0.1	NM ± NM	--
35-MA-375	9	46	Unit 3	Level 4	PPT	Inman Creek B	NM ± NM	NM ± NM	NVH
35-MA-375	10	47	Unit 3	Level 4	DEB	Devil Point	2.5 ± 0.1	NM ± NM	--
35-MA-375	12	54	Unit 3	Level 7	DEB	Inman Creek B	3.0 ± 0.1	NM ± NM	--
35-MA-375	13	58	Unit 4	Level 3	PPT	Inman Creek B	2.0 ± 0.1	NM ± NM	--
35-MA-375	14	59	Unit 4	Level 4	DEB	Obsidian Cliffs	3.0 ± 0.1	NM ± NM	--
35-MA-375	15	61	Unit 5	Level 1	DEB	Inman Creek B	1.9 ± 0.1	NM ± NM	--
35-MA-375	16	63	Unit 5	Level 2	DEB	Obsidian Cliffs	2.6 ± 0.1	NM ± NM	DS = cortex

[A] DEB = Debitage; EMF = Edge Modified Flake; PPT = Projectile Point

[B] Obsidian Source Data: Northwest Research Obsidian Studies Laboratory

[C] See text for explanation of comment abbreviations
NA = Not Available; NM = Not Measured * = Small XRF sample

Table A-1. Obsidian Hydration Results and Sample Provenience: Artifacts from 35-MA-375, Marion County, Oregon

Site	Specimen No.	Catalog No.	Unit	Depth (cm)	Artifact Type [A]	Artifact Source [B]	Hydration Rims Rim 1	Hydration Rims Rim 2	Comments [C]
35-MA-375	17	64	Unit 5	Level 2	DEB	Inman Creek B	NM ± NM	NM ± NM	NVH
35-MA-375	18	65	Unit 5	Level 2	DEB	Inman Creek A	1.3 ± 0.1	NM ± NM	--
35-MA-375	19	68	Unit 5	Level 4	DEB	Inman Creek B	2.0 ± 0.1	NM ± NM	--
35-MA-375	20	70	Unit 5	Level 5	DEB	Inman Creek A	1.1 ± 0.1	NM ± NM	--
35-MA-375	21	71	Unit 5	Level 6	DEB	Inman Creek A	1.2 ± 0.1	NM ± NM	--
35-MA-375	22	75	Unit 6	Level 2	PPT	Inman Creek B	1.4 ± 0.1	NM ± NM	REC, WEA
35-MA-375	23	76	Unit 6	Level 2	DEB	Inman Creek B	3.1 ± 0.1	NM ± NM	--
35-MA-375	24	79	Unit 6	Level 4A	DEB	Inman Creek A	1.9 ± 0.1	NM ± NM	--
35-MA-375	25	82	Unit 6	Level 5A	DEB	Inman Creek B	1.4 ± 0.1	NM ± NM	--
35-MA-375	26	83	Unit 6	Level 5A	DEB	Inman Creek B	NA ± NA	NM ± NM	UNR, WEA
35-MA-375	27	84	Unit 6	Level 5A	DEB	Inman Creek B	2.4 ± 0.1	NM ± NM	--
35-MA-375	28	85	Unit 6	Level 5A	DEB	Inman Creek A	1.1 ± 0.1	NM ± NM	--
35-MA-375	31	21	Unit 1	Level 2	DEB	Inman Creek A *	NA ± NA	NM ± NM	UNR (crystalline)
35-MA-375	32	44-S1	Unit 3	Level 3	DEB	Inman Creek A	NA ± NA	NM ± NM	UNR (crystalline)
35-MA-375	34	49-S1	Unit 3	Level 4	DEB	Inman Creek A *	NA ± NA	NM ± NM	UNR (crystalline)

[A] DEB = Debitage; EMF = Edge Modified Flake; PPT = Projectile Point

[B] Obsidian Source Data: Northwest Research Obsidian Studies Laboratory

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Table A-1. Obsidian Hydration Results and Sample Provenience: Artifacts from 35-MA-375, Marion County, Oregon

Site	Specimen No.	Catalog No.	Unit	Depth (cm)	Artifact Type[A]	Artifact Source[B]	Hydration Rims		Comments[C]
							Rim 1	Rim 2	
35-MA-375	35	49-2	Unit 3	Level 4	EMF	Inman Creek A	1.1 ± 0.1	NM ± NM	--
35-MA-375	37	52-S1	Unit 3	Level 6	DEB	Inman Creek B? *	NA ± NA	NM ± NM	UNR (crystalline)
35-MA-375	38	52-S2	Unit 3	Level 6	DEB	Inman Creek B? *	NA ± NA	NM ± NM	REC, UNR (crystalline)
35-MA-375	39	52-S3	Unit 3	Level 6	DEB	Inman Creek B? *	NM ± NM	NM ± NM	NVH (crystalline); DES
35-MA-375	40	56-S1	Unit 4	Level 2	DEB	Inman Creek A	NM ± NM	NM ± NM	NVH (crystalline)
35-MA-375	41	66-S1	Unit 5	Level 2	DEB	Inman Creek A	NM ± NM	NM ± NM	NVH (crystalline)
35-MA-375	42	78-S1	Unit 6	Level 3	DEB	Inman Creek B? *	1.7 ± 0.1	NM ± NM	BEV, DFV (crystalline)
35-MA-375	43	81-S1	Unit 6	Level 4B	DEB	Inman Creek A *	NA ± NA	NM ± NM	UNR (crystalline)

[A] DEB = Debitage; EMF = Edge Modified Flake; PPT = Projectile Point
[B] Obsidian Source Data: Northwest Research Obsidian Studies Laboratory
[C] See text for explanation of comment abbreviations
NA = Not Available; NM = Not Measured * = Small XRF sample

Abbreviations and Definitions

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.

D/V - (Dorsal/Ventral). In most cases both the dorsal and ventral surfaces of an artifact are measured for hydration rim values. The D/V designation is used in some cases to specify rim locations. Likewise, "**DS**", "**DM**" or "**VS**", "**VM**" may be used indicate the dorsal or ventral surfaces or margins.

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 rim was observed on the thin section.

HV - (Highly Variable). The hydration rim 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.

IF - (Internal Fracture). In some cases, especially with weathered samples, rim measurements are taken from internal fractures or cracks. See also **SF** (Step Fracture).

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

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

NVH - (No Visible Hydration). No hydration rim 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 rims 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 rim, 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.

R1, R2, R3 - (Rim 1, Rim 2, Rim 3). Often used when multiple cut locations are specified.

RVS - (Remnant Ventral Scar).

SF - (Step Fracture). In some cases, especially with weathered samples, rim measurements are taken from step fractures. See also **IF** (Internal Fracture).

UNR - (UNReadable). The optical quality of the hydration rim 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.

Archaeological Investigations Northwest, Inc.

AINW OBSIDIAN HYDRATION AGE ESTIMATE ANALYSIS METHODS AND PROCEDURES

Atmospheric water diffuses into volcanic glass or obsidian over time to form a rind or rim that thickens with age. Chronological assessment of obsidian through hydration dating provides a way to date artifacts directly rather than associated deposits, albeit with less accuracy and precision than radiocarbon ages and some other archaeological dating methods. Obsidian hydration age estimate analysis performed by Archaeological Investigations Northwest, Inc. (AINW), uses optical measurements of geochemically sourced obsidian hydration rims in conjunction with high-resolution meteorological data, and source specific hydration rates created using hydration rim thickness paired with temporally sensitive projectile point typologies or dated radiocarbon material to estimate the age of obsidian artifacts. This age estimation technique was developed to date obsidian artifacts found in the desert areas of eastern California and Nevada (Halford 2008; Rogers 2007, 2010a, 2012; Rogers and Duke 2014). This method minimizes age calculation error caused by differences in ambient temperature experienced by flaked obsidian surfaces as they naturally hydrate when exposed to air. This method also allows for the creation of hydration rates using artifacts collected from disparate sites, and successfully estimates artifact ages from sites not directly associated with the calculation of the source's hydration rate. While other modern hydration analysis techniques (secondary ion mass spectrometry [SIMS] and infrared photoacoustic spectroscopy [IR-PAS]) can be used to effectively estimate artifact ages (Liritzis and Laskaris 2012, Stevenson et al. 2001), the optical microscopy method does not require expensive or bulky equipment, is relatively fast, and provides archaeologically valid chronological assessments.

EFFECTIVE HYDRATION TEMPERATURE (EHT) CALCULATION

The ambient temperature of an artifact undergoing hydration greatly alters the speed of the hydration process; if artifacts with different ambient temperature histories are compared to one another or are used to create a single hydration rate, the results will be highly variable. To compensate for this variability, the ambient temperature history of an artifact with a measured hydration rim must be calculated, and measured rim values must be transformed to an established rate's temperature constant prior to determining a chronological age.

The ambient temperature experienced by any artifact is constantly changing due to daily and yearly temperature fluctuations. Effective hydration temperature is a proxy measurement defined as a constant temperature that yields the same hydration results as an actual location's fluctuating ambient temperature. EHT values will always be greater than the mean annual temperature at a location due to the effect temperature extremes have on the hydration process. Annual and diurnal temperature fluctuations lead to thermal expansion and compression, which allows for faster penetration into the artifact by atmospheric water than if the temperature were constantly at the mean. The EHT captures the constant temperature needed to achieve the same rate of hydration that fluctuating temperatures would cause.

AINW's obsidian age estimate analysis uses a simplified algebraic equation developed to fit Fourier series temperature variation modeling to determine an artifact's EHT (Rogers 2007, 2010a). This method requires knowledge of the artifact's location where hydration occurred, including its depth below surface and several meteorological values such as mean annual temperature, maximum annual variation in temperature, and maximum diurnal variation in temperature at the artifact's location.

Effective Hydration Temperature Equation (Rogers 2007, 2010a)

$$\mathrm{EHT} = T_a \times (1 - Y \times 3.8 \times 10^{-5}) + .0096 \times Y^{0.95}$$

$Y = V_a{}^2 + V_d{}^2$

$V_a = V_{a0}e^{-0.44z}$

$V_d = V_{d0}e^{-8.5z}$

T_a = Mean annual temperature

V_{a0} = Annual temperature variation at surface

V_{d0} = Mean annual diurnal temperature variation at surface

z = Artifact's depth below surface in meters

To determine these meteorological values, high-resolution raster maps were created using 30-year average temperature data (Normals) from weather stations located throughout Oregon and nearby states (U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Climatic Data Center [NOAA NCDC] 2016). Data gathered from these stations was measured daily between 1981 and 2010 and includes minimum, average, and maximum temperature readings on monthly and yearly scales.

This data and the location data for of each of these weather stations was entered into Arc-GIS and standardized to values at sea-level by using a temperature lapse rate of 5.0 Kelvin (K) Celsius (C)/1,000 meters (2.74° Fahrenheit [F] or 1.52 K (C)/1,000 feet). This step is performed to account for temperature variability due to differences in elevation on the landscape between the weather stations. Temperature lapse rate has been shown to vary considerably over geographic areas. While the chosen rate is less than the international standard atmosphere (ISA) temperature lapse rate of 6.5 K (C)/1,000 m, the rate of 5.0 K is likely higher than the average terrestrial lapse rate for the area (Minder et al. 2010, Wolfe 1964).

Once all data had been corrected to sea level, Gaussian process regression (Kriging) was performed on the data set to create raster maps of values for all areas between the weather stations (Conolly and Lake 2006). Interpolated raster maps were created of average annual temperature and the average, minimum, and maximum monthly temperatures for January and July. Data in these raster maps was then readjusted for elevation variability using the temperature lapse rate and landscape elevation data taken from available 30-m resolution DEM-raster maps of the interpolated area (Figure 1).

These maps, along with provenience data from the obsidian artifact under investigation, contain all the information needed to calculate an artifact's EHT value. Annual temperature variation is calculated by subtracting the average January temperature map from the average July temperature map. Mean annual diurnal temperature variation is found by determining the monthly diurnal temperature variation for January and July and then averaging these two values. Monthly diurnal temperature variation is determined by subtracting the minimum monthly temperature from the maximum monthly temperature. Because ground cover insulates artifacts from temperature extremes, the artifact's depth below ground surface is necessary to calculate EHT. In instances where the depth of the artifact is known, that value was used for the calculation. If the depth of an artifact is recorded to a specific level of a unit, the average depth of that level is used in the EHT calculation.

Sources of error in determining the EHT include the accuracy of the interpolation of weather station readings, normal fluctuations in the annual average temperature, and long-term climatic variation. By collecting data averaged over the last 30 years, errors in the annual fluctuation of average temperature are minimized. Using modern temperature data as a proxy for modeling the climate over archaeological time spans is another source of error. When the model estimates ages, a second EHT transformation can be implemented to adjust the mean estimated age based on paleo climatic data; however, it has been found that the difference in uncorrected and corrected ages is minimal during the Holocene and is only needed for ages greater than 13,000 years before present (BP) (Rogers 2015; Viau et al. 2006). These sources of error mean that EHT measurements can be no more accurate than 0.5° to 1.0° C (0.9° to 1.8° F) no matter how rigorous the computation method used in the creation of EHT (Rogers 2007).

SOURCE-SPECIFIC HYDRATION RATE CALCULATIONS

Water diffuses into obsidian, like all glass, at a consistent rate, which can be expressed as time (*t*) multiplied by a constant (*k*) equals the square of the hydration rim thickness (*r*). The constant k is the hydration rate.

Hydration Rate Formula (Friedman and Smith 1960)

$$r^2 = kt$$

Many different methods have been used over the years to calculate *k*. Most of these methods involve comparing the observed rim thickness to radiocarbon measurements or other independently dateable material found in situ with the obsidian item (Baxter 2008; Minor 1985; O'Neill 2004; Pettigrew and Hodges 1995; Wilson 1994). AINW's obsidian age estimate analysis uses a mix of hydration rim values measured on artifacts categorized to temporally sensitive projectile point morphological types (point styles) and rim values associated with radiocarbon dates in order to estimate geochemical source specific hydration rates.

The anhydrous chemistry of obsidian influences the hydration rate; therefore, the AINW age estimation model calculates separate hydration rates for each specific geochemical obsidian source. Restricting the rate calculation to individual obsidian sources also controls for variability in the intrinsic water content observed between obsidian sources. Variability in intrinsic water content within individual obsidian sources is not controlled for by the rate calculation. Proxy values for intrasource intrinsic water content variability are used to determine confidence intervals in individual artifact age estimates.

Because there is wide variability in the temporal spans of each hydration rim/dated time period paring, AINW uses a weighted linear least-squares best-fit regression analysis to create source specific hydration rates. This method assigns a weight factor to each data point paring based on the length of time covered by the association. This weight factor is inversely related to the square of the association's time span. Point styles associated with short time spans and radiocarbon date time spans receive considerably more weight in the regression analysis than point styles known to occur over longer periods of time., but all pairings have some effect in the final hydration rate.

Weighting Factors Equation (Rogers and Duke 2014)

$$w = 1/d^2$$

d = Timespan of projectile point morphological type or radiocarbon date

Time spans for radiocarbon dates were created by calibrating radiocarbon sample results using the Oxford Radiocarbon Accelerator Unit, OxCal software program. Projectile point style timespans were constructed for 23 chronological sensitive projectile points from recent archaeological literature on Great Basin (Aikens et al. 2011; Oetting 1994; Smith et al. 2013) and Plateau (Lohse 1985; Pettigrew and Hodges 1995) projectile point chronologies (Table 1). Arrow-sized points that do not fit into a specific morphological style were considered to have an age span similar to the Rosegate Series. Dart-sized corner-notched points not categorized further were considered to have an age span similar to Elko Series points, and generic dart-sized stemmed points were considered to have a span similar to Great Basin (Western) Stemmed.

TABLE 1

PROJECTILE POINT TYPOLOGICAL AGE ESTIMATES AND WEIGHTING FACTOR

Morphological Types	Beginning Age (years BP)	Ending Age (years BP)	Average Age (years BP)	Timespan (d)	Weight Factor (w)*
Great Basin					
Clovis	13,200	12,800	13,000	400	0.5625
Cottonwood Triangular	1000	200	600	800	0.1406
Desert Side-notched	500	200	350	300	1.0000
Elko Series	4500	1000	2750	3500	0.0073
Gatecliff Series	5000	2700	3850	2300	0.0170
Great Basin (Western) Stemmed	14,500	8200	11,350	6300	0.0023
Humboldt Series	6000	1300	3650	4700	0.0041
Northern Side-notched	7500	4000	5750	3500	0.0073
Rosegate Series	2000	200	1100	1800	0.0278
Willow Leaf/Cascade	10,000	1000	5500	9000	0.0011
Plateau					
Cold Springs Side-notched	7800	3700	5750	4100	0.0054
John Day Series	4500	1400	2950	3100	0.0094
Lanceolate Concave Base	12,400	8300	10,350	4100	0.0054
Madras Series	3000	2000	2500	1000	0.0900
Mahkin Shouldered	9000	3700	6350	5300	0.0032
Miller Island Diamond Stem	2300	100	1200	2200	0.0186
Plateau Corner-notched	2300	100	1200	2200	0.0186
Plateau Side-notched	700	100	400	600	0.2500
Quilomene Bar Basal-notched	3200	900	2050	2300	0.0170
Rabbit Island Stemmed	4500	1400	2950	3100	0.0094

Shaniko Series	5700	900	3300	4800	0.0039
Sherman Pin Stemmed	1400	100	750	1300	0.0533
Willow Leaf/Cascade	9000	3700	6350	5300	0.0032
Willowdale Square Barbed	2300	200	1250	2100	0.0204

*Weight factors have been normalized so the point style with the shortest time span has a factor of one. Normalizing the weight variable does not affect the least-squares best fit slope formula (Rogers and Duke 2014).

Obsidian hydration/ known date range pairs used in the hydration rate equations come from a variety of archaeological investigations conducted throughout Oregon (Bajdek et al. 2016; Baxter 2008; Cadena 2012; Fagan 1996; Fagen et al. 1995; Fagan et al. 2016; Moratto et al. 1994; Ozbun and Steuber 2001). Because of the additive nature of the regression analysis, hydration rates are constantly being refined as additional data points are added to the calculation. To control for temperature, all artifacts used in these formulas have had their hydration rim measurements transformed to a proxy EHT of 12° C using the Rim Correction Factor (RCF) Calculation described in the Estimated Age Calculation section of this document. On artifacts where multiple surfaces were analyzed and hydration rim measurements varied widely between the different surfaces, the rim measurement used in the rate calculation was taken from the surface best representing projectile point manufacture. Hydration rim measurements are not included in rate calculations if they appeared to come from an area of the artifact with a post-depositional break.

Source-Specific Hydration Rate Equation (k)

$$k = \frac{1}{\left(\frac{\sum w_i x_i y_i}{\sum w_i x_i^2}\right)^2}$$

w_i = Morphological type weight factor for each data point
x_i = Rim value at reference EHT for each data point
y_i = Square root of morphological type average age for each data point

Standard Deviation Equation of the Source-Specific Hydration Rate (σ_k)

$$\sigma_k = 2 * \frac{\sigma_s}{S} * k$$

Equations for calculating variables needed by the Hydration Rate Standard Deviation Equation

$$\sigma_s = \sqrt{\left(\frac{\sum w_i \delta_i^2}{(n-1) * \sum w_i x_i^2}\right)} \qquad \delta_i = \hat{y}_i - y_i \qquad \hat{y}_i = S x_i \qquad S = \frac{\sum w_i x_i y_i}{\sum w_i x_i^2}$$

n = Number of artifacts used to compute mean slope

The standard deviation calculated by these formulas produces the range in error in the least-squares best fit equation (Figure 2). It does not account for the other sources of error that affect the artifact age including rim measurement error, variation in intrinsic water content, and error in the EHT calculation. If a hydration rate is not presented with a standard deviation it is because there is currently only one data point available for that obsidian source.

Hydration rates calculated using these equations should always be presented by stating the source and the reference EHT value (ex. Newberry Volcano, 5.69 ± 0.57 microns^2/1000 years at EHT=12° C). Calculated rates vary dramatically between the different sources. Currently the slowest rate calculated by AINW with at least five data points is for the Gregory Creek obsidian source at 1.94 microns^2/1000 years at EHT=12° C, while the fastest calculated rate is from the Massacre Lake/ Guano Valley obsidian source with a rate of 16.20 microns^2/1000 years at EHT=12° C.

ESTIMATED AGE CALCULATION

Rim Correction Factor Calculation

The RCF is a number used to transform rim thickness values measured for the artifact under analysis into the equivalent thickness value at a reference location that experienced a different EHT.

Rim Correction Factor Equation (Rogers 2007, 2010a)

$$RCF = e^{[-0.06(\mathrm{EHT} - EHT_{ref})]}$$

$$R_{ref} = RCF * r$$

EHT = Effective hydration temperature of measured artifact
EHT_{ref} = Effective hydration temperature of reference location
r = Hydration rim thickness measurement
R_{ref} = Equivalent hydration rim thickness value at reference location

The RCF value is dependent on the EHT value of the location of the artifact and the EHT of the reference location. The reference location can be an actual location on the landscape or a proxy location set to a specific EHT. Standardizing all hydration rim thicknesses to a specific EHT is necessary for directly comparing hydration rim thickness values.

Age Estimate Calculation

The estimated age equation requires a source-specific hydration rate calculated to a reference EHT and the hydration rim value of the artifact transformed to the same reference EHT as the source specific hydration rate.

Age Estimate Equation (t)

$$t = \frac{(R_{ref})^2}{k_{ref}}$$

k_{ref} = Source specific hydration rate of reference location

Standard Deviation of Mean Estimated Age Calculation

Estimated dates are calculated using techniques designed to minimize error. However, these ages should be viewed cautiously, since each step in the process introduces compounding errors. The primary sources of error come from optical measurement of the hydration rim, climate modeling that produces the EHT, the variability in intrinsic water content of each artifact, and the hydration rate calculation (Liritzis and Laskaris 2011; Rogers 2010b; Rogers and Duke 2014).

To show the variability in these estimated ages, a standard deviation is produced and given along with the estimated age. This error range estimate uses the four primary sources of uncertainty to produce a standard deviation (Rogers 2010b, Rogers and Duke 2014). Proxy values for the error in climate modeling and the variability in an artifact's intrinsic water content are used for this equation, since the actual values are unknown. AINW's obsidian age estimate analysis uses a proxy value of 1° C for climate error because climate modeling is unlikely to be more accurate than this value (Liritzis and Laskaris 2011; Rogers 2010b). A proxy value of 15% intrinsic water variability is used, as this value has been used in previous studies (Rogers and Duke 2014). However, it is important to note that there may be considerably more variability in this source of uncertainty (Rogers 2008). Other proposed values for intrinsic water variability range from 10% to 50% (Rogers 2010b).

Age Estimate Standard Deviation Equation (Rogers and Duke 2014)

$$\sigma_t = 2 * t * \sqrt{\left[\left(\frac{\sigma_r}{r}\right)^2 + (0.06\sigma_{EHT})^2 + \left(\frac{CV_{ks}}{2}\right)^2 + {CV_{ke}}^2\right]}$$

t = Age estimate
r = Hydration rim measurement
σ_r = Standard deviation of hydration rim measurement
σ_{EHT} = Rate of uncertainty in climate modeling
CV_{ks} = Rate of uncertainty due to intrinsic water
CV_{ke} = Coefficient of variation of the hydration rate ascribed to the source

Estimated ages are published in years BP by adjusting the age calculated by the age estimate equation by the number of years between when the rim was measured and 1950. This step is performed to ensure consistency between reported age estimates and for easy comparison to other standard chronological dating methods such as radiocarbon dating. Estimated age and the standard deviation in estimated age are rounded to the nearest 25-year interval and the published age range is a width of four standard deviations centered on the estimated age. Assuming normal distribution in the causes for error used in the standard deviation calculation, four standard deviations captures a 95% confidence interval for the estimated age, and provides a reasonable bracket for the age range.

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Archaeological Investigations Northwest, Inc.

Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #: 2017-15
Biface #: 1 - 15
Site: 35MA375
Lot:
Spec:

Sample Geographical Coordinates

Lat/Long (WGS84)
Latitude: NA
Longitude: NA

UTM (NAD 83)
Zone: 10
Easting: 500873
Northing: 4965238

Depth Below Surface: 0.16 meter

Sample Characteristics

Obsidian Source: Obsidian Cliffs
Measured Hydration Rim: 4.2 μ
Measured Hydration Rim Standard Deviation (SD): 0.1 μ
Year Hydration Rind Measured: 2017

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta): 11.5° C
Seasonal Variation (Va): 14.7° C
Daily Variation (Vd): 11.5° C
Effective Hydration Temperature (EHT): **12.9° C**
Climate Modeling Error Proxy: 1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source: Obsidian Cliffs
Intrinsic Water Variability Proxy: 15%
Hydration Rate: **3.74 μ^2/1000 yrs @EHT 12.0° C**
Hydration Rate SD: **0.31 μ^2/1000 yrs @EHT 12.0° C**

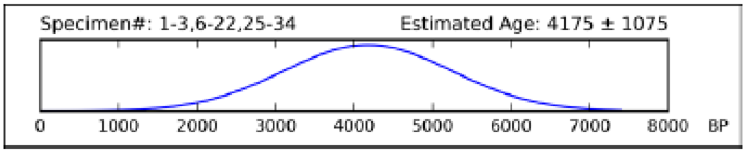
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim: 4.2 μ
Equivolent Hydration Rim at Reference EHT: **3.98 μ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age: **4175**
Mean Estimated Age SD: **1075**
Age Range (2 SD): **6325 - 2025**



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Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #:	2017-15
Biface #:	3, 10
Site:	35MA375
Lot:	
Spec:	

Sample Geographical Coordinates

Lat/Long (WGS84)		UTM (NAD 83)	
		Zone:	10
Latitude:	NA	Easting:	500873
Longitude:	NA	Northing:	4965238

Depth Below Surface: 0.16 meter

Sample Characteristics

Obsidian Source:	Obsidian Cliffs
Measured Hydration Rim:	4.3 μ
Measured Hydration Rim Standard Deviation (SD):	0.1 μ
Year Hydration Rind Measured:	2017

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta):	11.5° C
Seasonal Variation (Va):	14.7° C
Daily Variation (Vd):	11.5° C
Effective Hydration Temperature (EHT):	**12.9° C**
Climate Modeling Error Proxy:	1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source:	Obsidian Cliffs
Intrinsic Water Variability Proxy:	15%
Hydration Rate:	**3.74 μ^2/1000 yrs @EHT 12.0° C**
Hydration Rate SD:	**0.31 μ^2/1000 yrs @EHT 12.0° C**

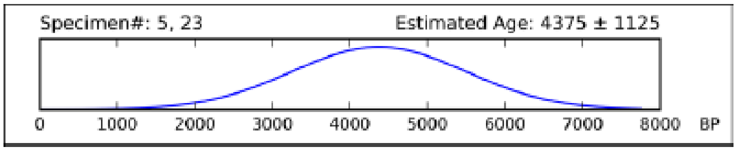
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim:	4.3 μ
Equivolent Hydration Rim at Reference EHT:	**4.07 μ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age:	**4375**
Mean Estimated Age SD:	**1125**
Age Range (2 SD):	**6625 - 2125**



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Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #: 2017-15
Biface #: 11
Site: 35MA375
Lot:
Spec:

Sample Geographical Coordinates

Lat/Long (WGS84)		UTM (NAD 83)	
		Zone:	10
Latitude:	NA	Easting:	500873
Longitude:	NA	Northing:	4965238

Depth Below Surface: 0.16 meter

Sample Characteristics

Obsidian Source: Obsidian Cliffs
Measured Hydration Rim: 6.1 µ
Measured Hydration Rim Standard Deviation (SD): 0.1 µ
Year Hydration Rind Measured: 2017

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta): 11.5° C
Seasonal Variation (Va): 14.7° C
Daily Variation (Vd): 11.5° C
Effective Hydration Temperature (EHT): **12.9° C**
Climate Modeling Error Proxy: 1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source: Obsidian Cliffs
Intrinsic Water Variability Proxy: 15%
Hydration Rate: **3.74 μ^2/1000 yrs @EHT 12.0° C**
Hydration Rate SD: **0.31 μ^2/1000 yrs @EHT 12.0° C**

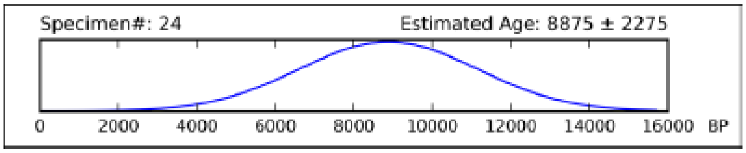
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim: 6.1 µ
Equivolent Hydration Rim at Reference EHT: **5.78 µ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age: **8875**
Mean Estimated Age SD: **2275**
Age Range (2 SD): **13425 - 4325**



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Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #:	2017-08b
Catalog #:	30
Site:	35MA375
Lot:	
Spec:	

Sample Geographical Coordinates

Lat/Long (WGS84)		UTM (NAD 83)	
		Zone:	10
Latitude:	NA	Easting:	500873
Longitude:	NA	Northing:	4965238

Depth Below Surface: 0.45 meter

Sample Characteristics

Obsidian Source:	Inman Creek A
Measured Hydration Rim:	1.6 µ
Measured Hydration Rim Standard Deviation (SD):	0.1 µ
Year Hydration Rind Measured:	2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta):	11.5° C
Seasonal Variation (Va):	14.7° C
Daily Variation (Vd):	11.5° C
Effective Hydration Temperature (EHT):	**12.5° C**
Climate Modeling Error Proxy:	1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source:	Inman Creek A
Intrinsic Water Variability Proxy:	15%
Hydration Rate:	**1.05 μ^2/1000 yrs @EHT 12.0° C**
Hydration Rate SD:	**NA**

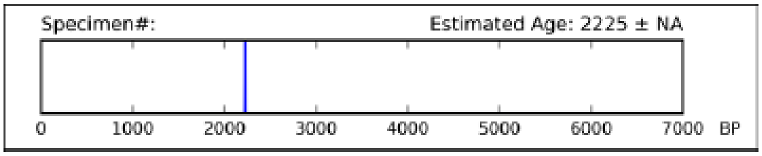
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim:	1.6 µ
Equivolent Hydration Rim at Reference EHT:	**1.55 µ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age:	2225
Mean Estimated Age SD:	**NA**
Age Range (2 SD):	**NA**



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Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #: 2017-08b
Catalog #: 34
Site: 35MA375
Lot:
Spec:

Sample Geographical Coordinates

Lat/Long (WGS84)
Latitude: NA
Longitude: NA

UTM (NAD 83)
Zone: 10
Easting: 500873
Northing: 4965238

Depth Below Surface: 0.15 meter

Sample Characteristics

Obsidian Source: Inman Creek A
Measured Hydration Rim: 1.4 µ
Measured Hydration Rim Standard Deviation (SD): 0.1 µ
Year Hydration Rind Measured: 2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta): 11.5° C
Seasonal Variation (Va): 14.7° C
Daily Variation (Vd): 11.5° C
Effective Hydration Temperature (EHT): **12.9° C**
Climate Modeling Error Proxy: 1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source: Inman Creek A
Intrinsic Water Variability Proxy: 15%
Hydration Rate: **1.05 µ²/1000 yrs @EHT 12.0° C**
Hydration Rate SD: **NA**

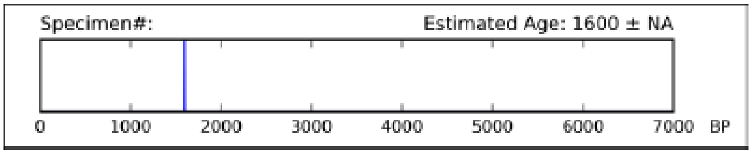
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim: 1.4 µ
Equivolent Hydration Rim at Reference EHT: **1.33 µ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age: **1600**
Mean Estimated Age SD: **NA**
Age Range (2 SD): **NA**



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Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #: 2017-08b
Catalog #: 35
Site: 35MA375
Lot:
Spec:

Sample Geographical Coordinates

Lat/Long (WGS84)
Latitude: NA
Longitude: NA

UTM (NAD 83)
Zone: 10
Easting: 500873
Northing: 4965238

Depth Below Surface: 0.25 meter

Sample Characteristics

Obsidian Source: Inman Creek B
Measured Hydration Rim: 4.4 μ
Measured Hydration Rim Standard Deviation (SD): 0.1 μ
Year Hydration Rind Measured: 2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta): 11.5° C
Seasonal Variation (Va): 14.7° C
Daily Variation (Vd): 11.5° C
Effective Hydration Temperature (EHT): **12.7° C**
Climate Modeling Error Proxy: 1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source: Inman Creek B
Intrinsic Water Variability Proxy: 15%
Hydration Rate: **1.79 μ^2/1000 yrs @EHT 12.0° C**
Hydration Rate SD: **0.34 μ^2/1000 yrs @EHT 12.0° C**

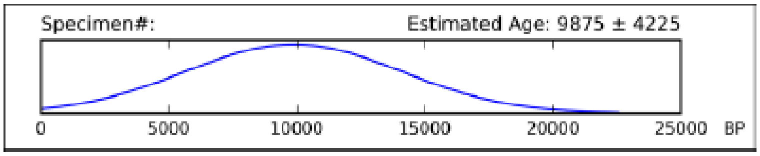
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim: 4.4 μ
Equivolent Hydration Rim at Reference EHT: **4.22 μ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age: **9875**
Mean Estimated Age SD: **4225**
Age Range (2 SD): **18325 - 1425**



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Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #:	2017-08b
Catalog #:	40
Site:	35MA375
Lot:	
Spec:	

Sample Geographical Coordinates

Lat/Long (WGS84)		UTM (NAD 83)	
		Zone:	10
Latitude:	NA	Easting:	500873
Longitude:	NA	Northing:	4965238

Depth Below Surface: 0.55 meter

Sample Characteristics

Obsidian Source:	Obsidian Cliffs
Measured Hydration Rim:	4.4 μ
Measured Hydration Rim Standard Deviation (SD):	0.1 μ
Year Hydration Rind Measured:	2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta):	11.5° C
Seasonal Variation (Va):	14.7° C
Daily Variation (Vd):	11.5° C
Effective Hydration Temperature (EHT):	**12.4° C**
Climate Modeling Error Proxy:	1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source:	Obsidian Cliffs
Intrinsic Water Variability Proxy:	15%
Hydration Rate:	**3.74 μ^2/1000 yrs @EHT 12.0° C**
Hydration Rate SD:	**0.31 μ^2/1000 yrs @EHT 12.0° C**

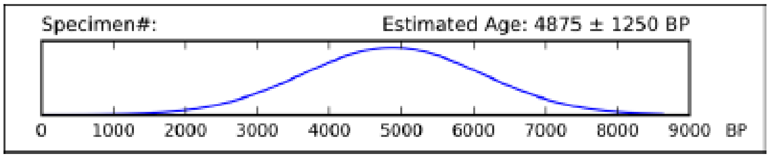
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim:	4.4 μ
Equivolent Hydration Rim at Reference EHT:	**4.3 μ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age:	**4875**
Mean Estimated Age SD:	**1250**
Age Range (2 SD):	**7375 - 2375**



Archaeological Investigations Northwest, Inc.

Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #: 2017-08b
Catalog #: 42
Site: 35MA375
Lot:
Spec:

Sample Geographical Coordinates

Lat/Long (WGS84)		UTM (NAD 83)	
		Zone:	10
Latitude:	NA	Easting:	500873
Longitude:	NA	Northing:	4965238

Depth Below Surface: 0.15 meter

Sample Characteristics

Obsidian Source: Inman Creek A
Measured Hydration Rim: 1.3 μ
Measured Hydration Rim Standard Deviation (SD): 0.1 μ
Year Hydration Rind Measured: 2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta): 11.5° C
Seasonal Variation (Va): 14.7° C
Daily Variation (Vd): 11.5° C
Effective Hydration Temperature (EHT): **12.9° C**
Climate Modeling Error Proxy: 1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source: Inman Creek A
Intrinsic Water Variability Proxy: 15%
Hydration Rate: **1.05 μ^2/1000 yrs @EHT 12.0° C**
Hydration Rate SD: **NA**

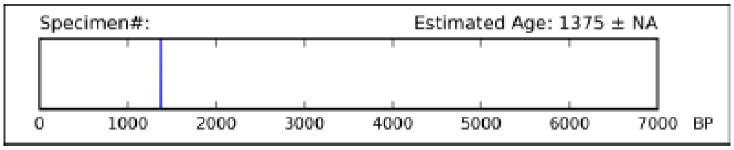
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim: 1.3 μ
Equivolent Hydration Rim at Reference EHT: **1.23 μ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age: **1375**
Mean Estimated Age SD: **NA**
Age Range (2 SD): **NA**



Archaeological Investigations Northwest, Inc.

Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #:	2017-08b
Catalog #:	43
Site:	35MA375
Lot:	
Spec:	

Sample Geographical Coordinates

Lat/Long (WGS84)		UTM (NAD 83)	
		Zone:	10
Latitude:	NA	Easting:	500873
Longitude:	NA	Northing:	4965238

Depth Below Surface: 0.25 meter

Sample Characteristics

Obsidian Source:	Inman Creek B
Measured Hydration Rim:	1.5 µ
Measured Hydration Rim Standard Deviation (SD):	0.1 µ
Year Hydration Rind Measured:	2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta):	11.5° C
Seasonal Variation (Va):	14.7° C
Daily Variation (Vd):	11.5° C
Effective Hydration Temperature (EHT):	**12.7° C**
Climate Modeling Error Proxy:	1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source:	Inman Creek B
Intrinsic Water Variability Proxy:	15%
Hydration Rate:	**1.79 µ²/1000 yrs @EHT 12.0° C**
Hydration Rate SD:	**0.34 µ²/1000 yrs @EHT 12.0° C**

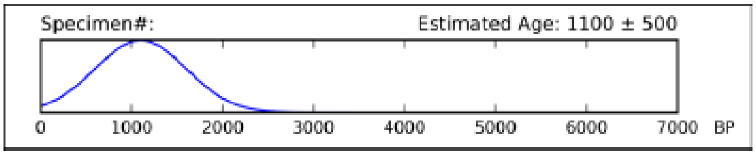
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim:	1.5 µ
Equivolent Hydration Rim at Reference EHT:	**1.44 µ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age:	**1100**
Mean Estimated Age SD:	**500**
Age Range (2 SD):	**2100 - 100**



Archaeological Investigations Northwest, Inc.

Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #: 2017-08b
Catalog #: 49-S2
Site: 35MA375
Lot:
Spec:

Sample Geographical Coordinates

Lat/Long (WGS84)		UTM (NAD 83)	
		Zone:	10
Latitude:	NA	Easting:	500873
Longitude:	NA	Northing:	4965238

Depth Below Surface: 0.35 meter

Sample Characteristics

Obsidian Source: Inman Creek A
Measured Hydration Rim: 1.1 µ
Measured Hydration Rim Standard Deviation (SD): 0.1 µ
Year Hydration Rind Measured: 2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta): 11.5° C
Seasonal Variation (Va): 14.7° C
Daily Variation (Vd): 11.5° C
Effective Hydration Temperature (EHT): **12.6° C**
Climate Modeling Error Proxy: 1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source: Inman Creek A
Intrinsic Water Variability Proxy: 15%
Hydration Rate: **1.05 μ^2/1000 yrs @EHT 12.0° C**
Hydration Rate SD: **NA**

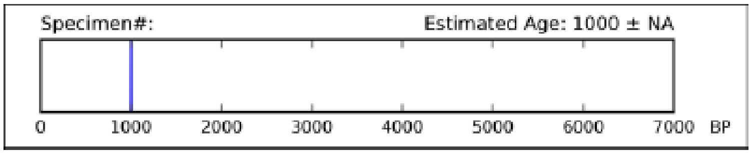
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim: 1.1 µ
Equivolent Hydration Rim at Reference EHT: **1.06 µ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age: **1000**
Mean Estimated Age SD: **NA**
Age Range (2 SD): **NA**



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Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #: 2017-08b
Catalog #: 54
Site: 35MA375
Lot:
Spec:

Sample Geographical Coordinates

Lat/Long (WGS84)
Latitude: NA
Longitude: NA

UTM (NAD 83)
Zone: 10
Easting: 500873
Northing: 4965238

Depth Below Surface: 0.65 meter

Sample Characteristics

Obsidian Source: Inman Creek B
Measured Hydration Rim: 3.0 µ
Measured Hydration Rim Standard Deviation (SD): 0.1 µ
Year Hydration Rind Measured: 2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta): 11.5° C
Seasonal Variation (Va): 14.7° C
Daily Variation (Vd): 11.5° C
Effective Hydration Temperature (EHT): **12.4° C**
Climate Modeling Error Proxy: 1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source: Inman Creek B
Intrinsic Water Variability Proxy: 15%
Hydration Rate: **1.79 μ^2/1000 yrs @EHT 12.0° C**
Hydration Rate SD: **0.34 μ^2/1000 yrs @EHT 12.0° C**

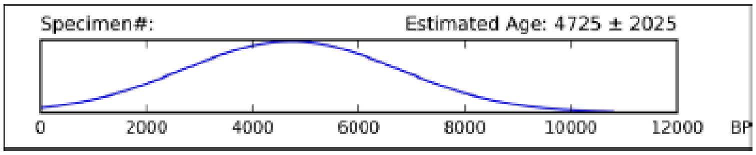
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim: 3.0 µ
Equivolent Hydration Rim at Reference EHT: **2.93 µ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age: **4725**
Mean Estimated Age SD: **2025**
Age Range (2 SD): **8775 - 675**



Archaeological Investigations Northwest, Inc.

Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #: 2017-08b
Catalog #: 55
Site: 35MA375
Lot:
Spec:

Sample Geographical Coordinates

Lat/Long (WGS84)		UTM (NAD 83)	
		Zone:	10
Latitude:	NA	Easting:	500873
Longitude:	NA	Northing:	4965238

Depth Below Surface: 0.15 meter

Sample Characteristics

Obsidian Source: Inman Creek B
Measured Hydration Rim: 1.7 µ
Measured Hydration Rim Standard Deviation (SD): 0.1 µ
Year Hydration Rind Measured: 2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta): 11.5° C
Seasonal Variation (Va): 14.7° C
Daily Variation (Vd): 11.5° C
Effective Hydration Temperature (EHT): **12.9° C**
Climate Modeling Error Proxy: 1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source: Inman Creek B
Intrinsic Water Variability Proxy: 15%
Hydration Rate: **1.79 μ^2/1000 yrs @EHT 12.0° C**
Hydration Rate SD: **0.34 μ^2/1000 yrs @EHT 12.0° C**

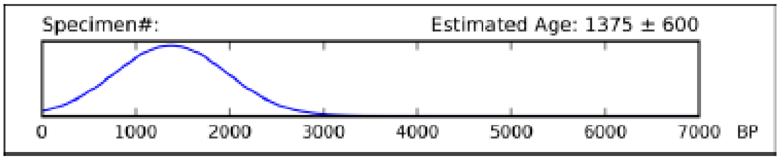
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim: 1.7 µ
Equivolent Hydration Rim at Reference EHT: **1.61 µ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age: **1375**
Mean Estimated Age SD: **600**
Age Range (2 SD): **2575 - 175**



Archaeological Investigations Northwest, Inc.

Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #: 2017-08b
Catalog #: 58
Site: 35MA375
Lot:
Spec:

Sample Geographical Coordinates

Lat/Long (WGS84)		UTM (NAD 83)	
		Zone:	10
Latitude:	NA	Easting:	500873
Longitude:	NA	Northing:	4965238

Depth Below Surface: 0.25 meter

Sample Characteristics

Obsidian Source: Inman Creek B
Measured Hydration Rim: 2.0 μ
Measured Hydration Rim Standard Deviation (SD): 0.1 μ
Year Hydration Rind Measured: 2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta): 11.5° C
Seasonal Variation (Va): 14.7° C
Daily Variation (Vd): 11.5° C
Effective Hydration Temperature (EHT): **12.7° C**
Climate Modeling Error Proxy: 1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source: Inman Creek B
Intrinsic Water Variability Proxy: 15%
Hydration Rate: **1.79 μ^2/1000 yrs @EHT 12.0° C**
Hydration Rate SD: **0.34 μ^2/1000 yrs @EHT 12.0° C**

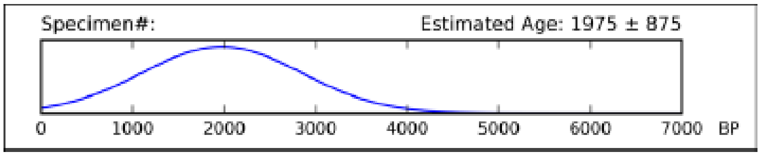
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim: 2.0 μ
Equivolent Hydration Rim at Reference EHT: **1.92 μ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age: **1975**
Mean Estimated Age SD: **875**
Age Range (2 SD): **3725 - 225**



Archaeological Investigations Northwest, Inc.

Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #: 2017-08b
Catalog #: 59
Site: 35MA375
Lot:
Spec:

Sample Geographical Coordinates

Lat/Long (WGS84)
Latitude: NA
Longitude: NA

UTM (NAD 83)
Zone: 10
Easting: 500873
Northing: 4965238

Depth Below Surface: 0.35 meter

Sample Characteristics

Obsidian Source: Obsidian Cliffs
Measured Hydration Rim: 3.0 µ
Measured Hydration Rim Standard Deviation (SD): 0.1 µ
Year Hydration Rind Measured: 2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta): 11.5° C
Seasonal Variation (Va): 14.7° C
Daily Variation (Vd): 11.5° C
Effective Hydration Temperature (EHT): **12.6° C**
Climate Modeling Error Proxy: 1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

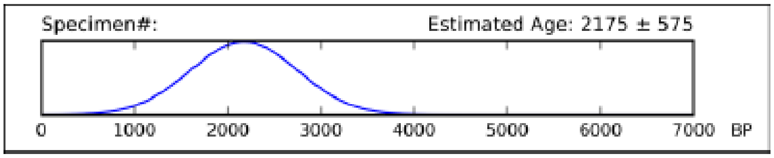
Obsidian Source: Obsidian Cliffs
Intrinsic Water Variability Proxy: 15%
Hydration Rate: **3.74 μ^2/1000 yrs @EHT 12.0° C**
Hydration Rate SD: **0.31 μ^2/1000 yrs @EHT 12.0° C**

ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim: 3.0 µ
Equivolent Hydration Rim at Reference EHT: **2.89 µ @EHT 12.0**

Estimated Age of Artifact (BP)
Mean Estimated Age: **2175**
Mean Estimated Age SD: **575**
Age Range (2 SD): **3325 - 1025**



Archaeological Investigations Northwest, Inc.

Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #: 2017-08b
Catalog #: 61
Site: 35MA375
Lot:
Spec:

Sample Geographical Coordinates

Lat/Long (WGS84)
Latitude: NA
Longitude: NA

UTM (NAD 83)
Zone: 10
Easting: 500873
Northing: 4965238

Depth Below Surface: 0.05 meter

Sample Characteristics

Obsidian Source: Inman Creek B
Measured Hydration Rim: 1.9 µ
Measured Hydration Rim Standard Deviation (SD): 0.1 µ
Year Hydration Rind Measured: 2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta): 11.5° C
Seasonal Variation (Va): 14.7° C
Daily Variation (Vd): 11.5° C
Effective Hydration Temperature (EHT): **13.3° C**
Climate Modeling Error Proxy: 1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source: Inman Creek B
Intrinsic Water Variability Proxy: 15%
Hydration Rate: **1.79 μ^2/1000 yrs @EHT 12.0° C**
Hydration Rate SD: **0.34 μ^2/1000 yrs @EHT 12.0° C**

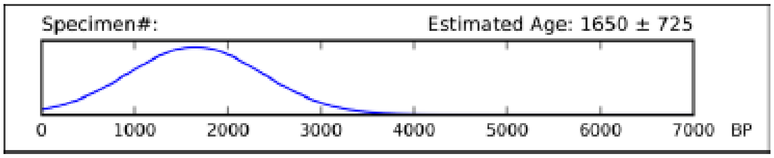
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim: 1.9 µ
Equivolent Hydration Rim at Reference EHT: **1.76 µ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age: **1650**
Mean Estimated Age SD: **725**
Age Range (2 SD): **3100 - 200**



Archaeological Investigations Northwest, Inc.

Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #: 2017-08b
Catalog #: 63
Site: 35MA375
Lot:
Spec:

Sample Geographical Coordinates

Lat/Long (WGS84)
Latitude: NA
Longitude: NA

UTM (NAD 83)
Zone: 10
Easting: 500873
Northing: 4965238

Depth Below Surface: 0.15 meter

Sample Characteristics

Obsidian Source: Obsidian Cliffs
Measured Hydration Rim: 2.6 µ
Measured Hydration Rim Standard Deviation (SD): 0.1 µ
Year Hydration Rind Measured: 2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta): 11.5° C
Seasonal Variation (Va): 14.7° C
Daily Variation (Vd): 11.5° C
Effective Hydration Temperature (EHT): **12.9° C**
Climate Modeling Error Proxy: 1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source: Obsidian Cliffs
Intrinsic Water Variability Proxy: 15%
Hydration Rate: **3.74 μ^2/1000 yrs @EHT 12.0° C**
Hydration Rate SD: **0.31 μ^2/1000 yrs @EHT 12.0° C**

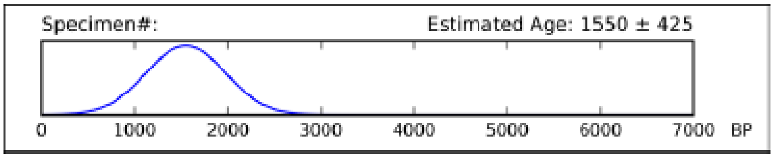
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim: 2.6 µ
Equivolent Hydration Rim at Reference EHT: **2.46 µ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age: **1550**
Mean Estimated Age SD: **425**
Age Range (2 SD): **2400 - 700**



Archaeological Investigations Northwest, Inc.

Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #: 2017-08b
Catalog #: 65
Site: 35MA375
Lot:
Spec:

Sample Geographical Coordinates

Lat/Long (WGS84)
Latitude: NA
Longitude: NA

UTM (NAD 83)
Zone: 10
Easting: 500873
Northing: 4965238

Depth Below Surface: 0.15 meter

Sample Characteristics

Obsidian Source: Inman Creek A
Measured Hydration Rim: 1.3 µ
Measured Hydration Rim Standard Deviation (SD): 0.1 µ
Year Hydration Rind Measured: 2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta): 11.5° C
Seasonal Variation (Va): 14.7° C
Daily Variation (Vd): 11.5° C
Effective Hydration Temperature (EHT): **12.9° C**
Climate Modeling Error Proxy: 1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source: Inman Creek A
Intrinsic Water Variability Proxy: 15%
Hydration Rate: **1.05 µ²/1000 yrs @EHT 12.0° C**
Hydration Rate SD: **NA**

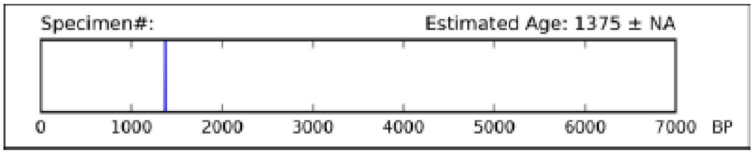
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim: 1.3 µ
Equivolent Hydration Rim at Reference EHT: **1.23 µ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age: **1375**
Mean Estimated Age SD: **NA**
Age Range (2 SD): **NA**



Archaeological Investigations Northwest, Inc.

Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #: 2017-08b
Catalog #: 68
Site: 35MA375
Lot:
Spec:

Sample Geographical Coordinates

Lat/Long (WGS84)
Latitude: NA
Longitude: NA

UTM (NAD 83)
Zone: 10
Easting: 500873
Northing: 4965238

Depth Below Surface: 0.35 meter

Sample Characteristics

Obsidian Source: Inman Creek B
Measured Hydration Rim: 2.0 µ
Measured Hydration Rim Standard Deviation (SD): 0.1 µ
Year Hydration Rind Measured: 2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta): 11.5° C
Seasonal Variation (Va): 14.7° C
Daily Variation (Vd): 11.5° C
Effective Hydration Temperature (EHT): **12.6° C**
Climate Modeling Error Proxy: 1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source: Inman Creek B
Intrinsic Water Variability Proxy: 15%
Hydration Rate: **1.79 μ^2/1000 yrs @EHT 12.0° C**
Hydration Rate SD: **0.34 μ^2/1000 yrs @EHT 12.0° C**

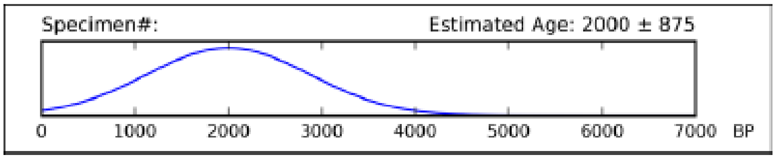
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim: 2.0 µ
Equivolent Hydration Rim at Reference EHT: **1.93 µ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age: **2000**
Mean Estimated Age SD: **875**
Age Range (2 SD): **3750 - 250**



Archaeological Investigations Northwest, Inc.

Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #:	2017-08b
Catalog #:	70
Site:	35MA375
Lot:	
Spec:	

Sample Geographical Coordinates

Lat/Long (WGS84)		UTM (NAD 83)	
		Zone:	10
Latitude:	NA	Easting:	500873
Longitude:	NA	Northing:	4965238

Depth Below Surface: 0.45 meter

Sample Characteristics

Obsidian Source:	Inman Creek A
Measured Hydration Rim:	1.1 μ
Measured Hydration Rim Standard Deviation (SD):	0.1 μ
Year Hydration Rind Measured:	2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta):	11.5° C
Seasonal Variation (Va):	14.7° C
Daily Variation (Vd):	11.5° C
Effective Hydration Temperature (EHT):	**12.5° C**
Climate Modeling Error Proxy:	1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source:	Inman Creek A
Intrinsic Water Variability Proxy:	15%
Hydration Rate:	**1.05 μ^2/1000 yrs @EHT 12.0° C**
Hydration Rate SD:	**NA**

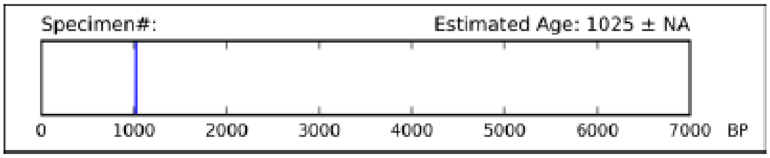
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim:	1.1 μ
Equivolent Hydration Rim at Reference EHT:	**1.07 μ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age:	**1025**
Mean Estimated Age SD:	**NA**
Age Range (2 SD):	**NA**



Archaeological Investigations Northwest, Inc.

Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #:	2017-08b
Catalog #:	71
Site:	35MA375
Lot:	
Spec:	

Sample Geographical Coordinates

Lat/Long (WGS84)		UTM (NAD 83)	
		Zone:	10
Latitude:	NA	Easting:	500873
Longitude:	NA	Northing:	4965238

Depth Below Surface: 0.55 meter

Sample Characteristics

Obsidian Source:	Inman Creek A
Measured Hydration Rim:	1.2 µ
Measured Hydration Rim Standard Deviation (SD):	0.1 µ
Year Hydration Rind Measured:	2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta):	11.5° C
Seasonal Variation (Va):	14.7° C
Daily Variation (Vd):	11.5° C
Effective Hydration Temperature (EHT):	**12.4° C**
Climate Modeling Error Proxy:	1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source:	Inman Creek A
Intrinsic Water Variability Proxy:	15%
Hydration Rate:	**1.05 μ^2/1000 yrs @EHT 12.0° C**
Hydration Rate SD:	**NA**

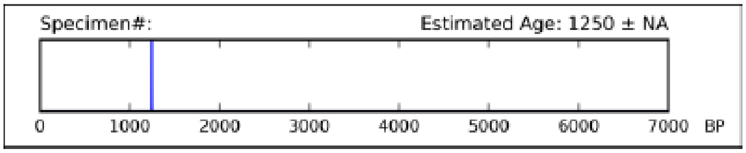
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim:	1.2 µ
Equivolent Hydration Rim at Reference EHT:	**1.17 µ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age:	**1250**
Mean Estimated Age SD:	**NA**
Age Range (2 SD):	**NA**



Archaeological Investigations Northwest, Inc.

Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #:	2017-08b
Catalog #:	75
Site:	35MA375
Lot:	
Spec:	

Sample Geographical Coordinates

Lat/Long (WGS84)		UTM (NAD 83)	
		Zone:	10
Latitude:	NA	Easting:	500873
Longitude:	NA	Northing:	4965238

Depth Below Surface: 0.15 meter

Sample Characteristics

Obsidian Source:	Inman Creek B
Measured Hydration Rim:	1.4 µ
Measured Hydration Rim Standard Deviation (SD):	0.1 µ
Year Hydration Rind Measured:	2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta):	11.5° C
Seasonal Variation (Va):	14.7° C
Daily Variation (Vd):	11.5° C
Effective Hydration Temperature (EHT):	**12.9° C**
Climate Modeling Error Proxy:	1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source:	Inman Creek B
Intrinsic Water Variability Proxy:	15%
Hydration Rate:	**1.79 µ²/1000 yrs @EHT 12.0° C**
Hydration Rate SD:	**0.34 µ²/1000 yrs @EHT 12.0° C**

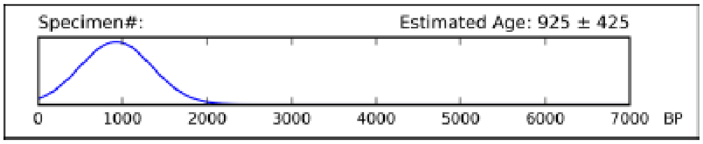
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim:	1.4 µ
Equivolent Hydration Rim at Reference EHT:	**1.33 µ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age:	**925**
Mean Estimated Age SD:	**425**
Age Range (2 SD):	**1775 - 75**



Archaeological Investigations Northwest, Inc.

Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #: 2017-08b
Catalog #: 76
Site: 35MA375
Lot:
Spec:

Sample Geographical Coordinates

Lat/Long (WGS84)
Latitude: NA
Longitude: NA

UTM (NAD 83)
Zone: 10
Easting: 500873
Northing: 4965238

Depth Below Surface: 0.15 meter

Sample Characteristics

Obsidian Source: Inman Creek B
Measured Hydration Rim: 3.1 µ
Measured Hydration Rim Standard Deviation (SD): 0.1 µ
Year Hydration Rind Measured: 2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta): 11.5° C
Seasonal Variation (Va): 14.7° C
Daily Variation (Vd): 11.5° C
Effective Hydration Temperature (EHT): **12.9° C**
Climate Modeling Error Proxy: 1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source: Inman Creek B
Intrinsic Water Variability Proxy: 15%
Hydration Rate: **1.79 μ^2/1000 yrs @EHT 12.0° C**
Hydration Rate SD: **0.34 μ^2/1000 yrs @EHT 12.0° C**

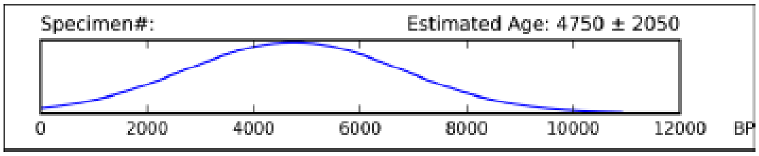
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim: 3.1 µ
Equivolent Hydration Rim at Reference EHT: **2.94 µ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age: **4750**
Mean Estimated Age SD: **2050**
Age Range (2 SD): **8850 - 650**



Archaeological Investigations Northwest, Inc.

Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #: 2017-08b
Catalog #: 78-S1
Site: 35MA375
Lot:
Spec:

Sample Geographical Coordinates

Lat/Long (WGS84)
Latitude: NA
Longitude: NA

UTM (NAD 83)
Zone: 10
Easting: 500873
Northing: 4965238

Depth Below Surface: 0.25 meter

Sample Characteristics

Obsidian Source: Inman Creek B
Measured Hydration Rim: 1.7 µ
Measured Hydration Rim Standard Deviation (SD): 0.1 µ
Year Hydration Rind Measured: 2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta): 11.5° C
Seasonal Variation (Va): 14.7° C
Daily Variation (Vd): 11.5° C
Effective Hydration Temperature (EHT): **12.7° C**
Climate Modeling Error Proxy: 1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source: Inman Creek B
Intrinsic Water Variability Proxy: 15%
Hydration Rate: **1.79 μ^2/1000 yrs @EHT 12.0° C**
Hydration Rate SD: **0.34 μ^2/1000 yrs @EHT 12.0° C**

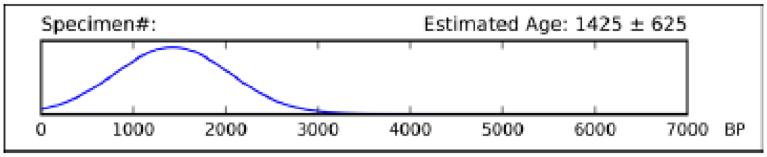
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim: 1.7 µ
Equivolent Hydration Rim at Reference EHT: **1.63 µ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age: **1425**
Mean Estimated Age SD: **625**
Age Range (2 SD): **2675 - 175**



Archaeological Investigations Northwest, Inc.

Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #: 2017-08b
Catalog #: 79
Site: 35MA375
Lot:
Spec:

Sample Geographical Coordinates

Lat/Long (WGS84)		UTM (NAD 83)	
		Zone:	10
Latitude:	NA	Easting:	500873
Longitude:	NA	Northing:	4965238

Depth Below Surface: 0.35 meter

Sample Characteristics

Obsidian Source: Inman Creek A
Measured Hydration Rim: 1.9 µ
Measured Hydration Rim Standard Deviation (SD): 0.1 µ
Year Hydration Rind Measured: 2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta): 11.5° C
Seasonal Variation (Va): 14.7° C
Daily Variation (Vd): 11.5° C
Effective Hydration Temperature (EHT): **12.6° C**
Climate Modeling Error Proxy: 1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source: Inman Creek A
Intrinsic Water Variability Proxy: 15%
Hydration Rate: **1.05 µ²/1000 yrs @EHT 12.0° C**
Hydration Rate SD: **NA**

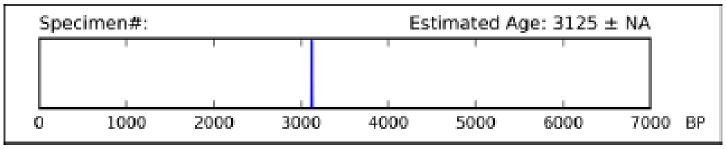
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim: 1.9 µ
Equivolent Hydration Rim at Reference EHT: **1.83 µ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age: **3125**
Mean Estimated Age SD: **NA**
Age Range (2 SD): **NA**



Archaeological Investigations Northwest, Inc.

Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #:	2017-08b
Catalog #:	82
Site:	35MA375
Lot:	
Spec:	

Sample Geographical Coordinates

Lat/Long (WGS84)		UTM (NAD 83)	
		Zone:	10
Latitude:	NA	Easting:	500873
Longitude:	NA	Northing:	4965238

Depth Below Surface: 0.45 meter

Sample Characteristics

Obsidian Source:	Inman Creek B
Measured Hydration Rim:	1.4 µ
Measured Hydration Rim Standard Deviation (SD):	0.1 µ
Year Hydration Rind Measured:	2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta):	11.5° C
Seasonal Variation (Va):	14.7° C
Daily Variation (Vd):	11.5° C
Effective Hydration Temperature (EHT):	**12.5° C**
Climate Modeling Error Proxy:	1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source:	Inman Creek B
Intrinsic Water Variability Proxy:	15%
Hydration Rate:	**1.79 μ^2/1000 yrs @EHT 12.0° C**
Hydration Rate SD:	**0.34 μ^2/1000 yrs @EHT 12.0° C**

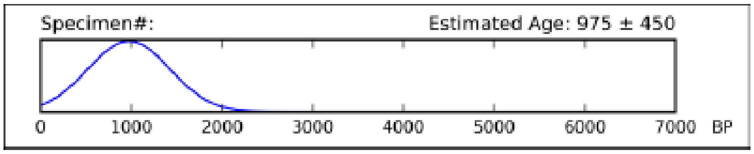
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim:	1.4 µ
Equivolent Hydration Rim at Reference EHT:	**1.36 µ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age:	**975**
Mean Estimated Age SD:	**450**
Age Range (2 SD):	**1875 - 75**



Archaeological Investigations Northwest, Inc.

Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #: 2017-08b
Catalog #: 84
Site: 35MA375
Lot:
Spec:

Sample Geographical Coordinates

Lat/Long (WGS84)		UTM (NAD 83)	
		Zone:	10
Latitude:	NA	Easting:	500873
Longitude:	NA	Northing:	4965238

Depth Below Surface: 0.45 meter

Sample Characteristics

Obsidian Source: Inman Creek B
Measured Hydration Rim: 2.4 μ
Measured Hydration Rim Standard Deviation (SD): 0.1 μ
Year Hydration Rind Measured: 2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta): 11.5° C
Seasonal Variation (Va): 14.7° C
Daily Variation (Vd): 11.5° C
Effective Hydration Temperature (EHT): **12.5° C**
Climate Modeling Error Proxy: 1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source: Inman Creek B
Intrinsic Water Variability Proxy: 15%
Hydration Rate: **1.79 μ^2/1000 yrs @EHT 12.0° C**
Hydration Rate SD: **0.34 μ^2/1000 yrs @EHT 12.0° C**

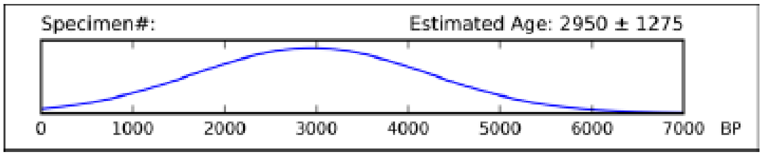
ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim: 2.4 μ
Equivolent Hydration Rim at Reference EHT: **2.33 μ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age: **2950**
Mean Estimated Age SD: **1275**
Age Range (2 SD): **5500 - 400**



Archaeological Investigations Northwest, Inc.

Oregon Obsidian Hydration Age Analysis Results

Sample Identification

Hydration Lab Report #:	2017-08b
Catalog #:	85
Site:	35MA375
Lot:	
Spec:	

Sample Geographical Coordinates

Lat/Long (WGS84)		UTM (NAD 83)	
		Zone:	10
Latitude:	NA	Easting:	500873
Longitude:	NA	Northing:	4965238

Depth Below Surface: 0.45 meter

Sample Characteristics

Obsidian Source:	Inman Creek A
Measured Hydration Rim:	1.1 µ
Measured Hydration Rim Standard Deviation (SD):	0.1 µ
Year Hydration Rind Measured:	2018

EFFECTIVE HYDRATION TEMPERATURE

(See Effective Hydration Temperature Equation, page 2)

Average Temperature (Ta):	11.5° C
Seasonal Variation (Va):	14.7° C
Daily Variation (Vd):	11.5° C
Effective Hydration Temperature (EHT):	**12.5° C**
Climate Modeling Error Proxy:	1.0° C

HYDRATION RATE OF OBSIDIAN SOURCE

(See Specific Hydration Rate Equations, page 5)

Obsidian Source:	Inman Creek A
Intrinsic Water Variability Proxy:	15%
Hydration Rate:	**1.05 µ²/1000 yrs @EHT 12.0° C**
Hydration Rate SD:	**NA**

ESTIMATED AGE

(See Rim Correction Factor and Age Estimate Equations, pages 6 and 7)

Measured Hydration Rim:	1.1 µ
Equivolent Hydration Rim at Reference EHT:	**1.07 µ @EHT 12.0**

Estimated Age of Artifact (BP)

Mean Estimated Age:	**1025**
Mean Estimated Age SD:	**NA**
Age Range (2 SD):	**NA**