Cultural Resources Mitigation Report for the Sheep Creek Quarry Archaeological District: Sites 24ME163, 24ME1109, and 24ME1111, Phase 1 Development Construction, Black Butte Copper Mine Project, Meagher County, Montana

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Prepared for:

Sandfire Resources America, Inc.
Todd Johnson
17 E Main Street
White Sulphur Springs, MT 59645

Prepared by:

Kleinfelder/Garcia and Associates
Jessica Neal, M.A. RPA
William (Bill) Bloomer, M.A. RPA
1716 West Main St., Suite 8F
Bozeman, MT 59715

Cover Photo: Excavation Units at site 24ME1109 with Black Butte in background.

Acknowledgements

We would like to acknowledge and thank Sandfire Resources America, Inc. for their commitment to the preservation and mitigation of cultural resources that fall within the Black Butte Copper Mine Project Area. Sandfire to date has voluntarily committed to protecting and mitigating effects to the cultural resources of Meagher County, outside of any laws, rules, and regulations that would require them to do so. Archaeological research conducted within the project area has contributed significantly to the archaeological record of the Northwestern Plains.

Abstract

Sandfire Resources America, Inc. (Sandfire) is constructing the Black Butte Copper Mine Project (Project) located on private property in Meagher County, Montana. The Project will construct, operate, and reclaim an underground copper mine over a 19-year period. In August 2020, the Montana Department of Environmental Quality (MDEQ) issued a mining permit to Sandfire that allowed for the first phase (Phase 1) of development construction activities to proceed related to initial surface infrastructure. The facilities associated with the first phase of the Project construction are documented in the April 2020 Project Record of Decision document and include: roads, pads, material stockpiles, a borrow area, and the brine-contact water pond.

Cultural resources studies conducted within the Project area identified 22 cultural resources, five of which have been recommended eligible for inclusion in the National Register of Historic Places (NRHP). The construction of the first phase of surface infrastructure for the mine will impact three of the NRHP eligible resources: The Sheep Creek Quarry Archaeological District (24ME1111) and two lithic scatters located within the District, 24ME163 and 24ME1109. Two additional lithic scatters, 24ME166 and 24ME1110 will be impacted by Phase 1 construction, however, they have been recommended ineligible for inclusion in the NRHP. Prior to the start of construction in the summer of 2020, field work and data recovery efforts by GANDA/Kleinfelder were undertaken to mitigate adverse effects to the NRHP eligible sites and District.

The Project area is located on private land and the majority of the Project area has no federal regulatory nexus (no federal permit, funding, lands, or other oversight). However, the Project will impact Waters of the U.S., therefore a U.S. Army Corps of Engineers (Corps) permit (totaling 0.85 acre of wetland) was issued for the discharge of fill materials into Waters of the U.S. The Corps determined that the undertaking would not adversely affect the criteria that make 24ME1111 eligible for the NRHP. SHPO concurred that the undertaking would have no adverse effect on Historic Properties including 24ME1111. Apart from the Corps' permit area, Section 106 of the National Historic Preservation Act (NHPA) does not apply to the Project. The Montana Antiquities Act, which applies to activities conducted on state-owned land, also does not apply to this Project, as it is completely located on private land.

Data recovery at archaeological site 24ME163 included the excavation of six excavation units in the southern section of the site, where Phase 1 Project construction would impact portions of the resource. Two hearth features were identified during excavation in addition to 3,311 pieces of debitage, twelve bifaces (including one possible projectile point fragment), six flake tools, and four cores. Radiocarbon dating of the charcoal recovered from the hearths and obsidian hydration dates of four obsidian flakes from 24ME163

revealed that the site had multiple periods of occupation from the Middle Plains Archaic Period (5,000-3,000 BP) through the Late Prehistoric Period (1,500-300 BP).

Excavation at archaeological site 24ME1109 included the placement of 48 units in the southern two-thirds of the site, where the mine mill pad will be constructed. Controlled archaeological monitoring and placement of an additional seven excavation units occurred in the northern third of the site where an access road was constructed. Five hearth features were identified during excavation as well as 3,543 pieces of debitage, one projectile point fragment, twenty-six bifaces, one uniface, seven flake tools, and one core. Radiocarbon dating of the charcoal recovered from the hearths and obsidian hydration dates from 24ME1109 revealed that the site had multiple periods of occupation from the Middle Plains Archaic Period through the Late Prehistoric Period.

To mitigate for impacts to the Sheep Creek Quarry Archaeological District, a cooperative endeavor with the Archaeometry Laboratory at the University of Missouri Research Reactor (MURR) resulted in chemical characterization of toolstone from the district utilizing both Laser-Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) and Neutron Activation Analysis (NAA). Results indicated that the chert sample provided is distinct from most of the chert samples within MURR's chert database for the Plains region. Both the NAA and LA-ICP-MS analyses were suggestive of spatial patterning within the current dataset, with the NAA dataset more clearly demonstrating some level of possible differentiation between sources within the district itself.

The data collected from the 2020 excavations, along with data from previous studies conducted within the Project area, were used to address research questions concerning chronology, lithic technology, procurement strategies, and the chemical fingerprint of the District's chert. Analysis of the lithic material indicates a variety of activities occurred during multiple, short term, occupations at the quarry over the past 5,000 years ranging from the Middle Plains Archaic Period through the Late Prehistoric Period.

Acronyms and Abbreviations

°F	degrees Fahrenheit
µ	micron
AD	Ad Domini
AMS	accelerator mass spectrometry
amsl	above mean sea level
BC	Before Christ
BIA	Bureau of Indian Affairs
BP	before present
cal BP	calibrated years before present
cm	centimeter(s)
cm bs	centimeter(s) below surface
Corps	U.S. Army Corps of Engineers
District	Sheep Creek Quarry Archaeological District
e.g.	exempli gratia
EHT	Effective Hydration Temperature
EU	Excavation Unit
et al.	et alia
FAR	fire affected rock
ft	foot/feet
GANDA	Garcia and Associates
GPS	global positioning system
in.	inch(es)
km	kilometer(s)
LA-ICP-MS	Laser Ablation Inductively Coupled Plasma Mass Spectrometry
m	meter(s)
MA	magnetic anomaly
MDEQ	Montana Department of Environmental Quality
mph	miles per hour
MURR	University of Missouri Research Reactor
NAA	Neutron Activation Analysis
NHPA	National Historic Preservation Act
n.d.	no date
NRHP	National Register of Historic Places
NWR	Northwest Research
Project	Black Butte Copper Mine Project
Sandfire	Sandfire Resources America, Inc.
SHPO	Montana State Historic Preservation Officer
Tintina	Tintina Montana, Inc.
U.S.	United States
UTM	Universal Transverse Mercator

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1 Introduction

In 1985, the Johnny Lee Copper Deposit was discovered on private property in the Little Belt Mountains of Meagher County, Montana. The Johnny Lee copper concentration was named for a homesteader who lived above the deposit in the early 1900s. The mineral deposit includes two sheet-like zones rich in extremely high-grade copper-iron-sulfide and represents the second highest grade copper deposit currently under permit in the world (Sandfire 2018). In 2008, Tintina Resources, Inc. was formed, and the property became known as the Black Butte Copper Mine Project (Project). In 2015, Tintina Resources, Inc. changed its USA company name to Tintina Montana, Inc. (Tintina). In 2018, a Canadian Company was formed called Sandfire Resources America, Inc. (Sandfire) that wholly owns Tintina.

In August 2020, the Montana Department of Environmental Quality (MDEQ) issued a mining permit for the first phase of the Project to Sandfire. Phase 1 of the Project will construct surface infrastructure including roads, material stockpiles, a borrow area, pads and the brine-contact water pond. Later phases of the Project will include construction of underground tunnels and shafts, mining and processing copper-rich ore during operations, and mine closure and reclamation activities to return the site to pre-mining beneficial uses .

1.1 Project Description

The Project is located approximately 15 miles north of White Sulphur Springs in Meagher County, Montana (See **Figure 1**). The mine permit boundary at the Project area consists of 1,888 acres of privately owned ranch land under lease, with existing core storage buildings and ranching road network throughout.

The Project will construct, operate, and reclaim a new underground copper mine over the next 19 years. Project surface disturbances to private land will total approximately 310.9 acres (MDEQ 2020a and 2020b).

The Project’s major components include a portal and underground mine workings and utilities, as well as a processing plant that includes a crusher, grinding mills, a flotation circuit, tailings thickener, a paste tailings plant, a water treatment plant, concentrate storage facility, parking, and two laydown areas (MDEQ 2020a). Other surface facilities would include a process water pond, contact water pond, non-contact water reservoir, treated water storage pond, wet well and pipeline, buried drainpipes, roads, a waste rock stockpile, an ore stockpile, two overburden (soil) stockpiles, two reclamation material (bedrock) stockpiles, a temporary construction stockpile, power line, ditches, and fencing.

The Record of Decision document (MDEQ 2020b) specifies Phase 1, Phase 2, and other mine development activities that are associated with the construction of certain facilities.

1.2 Cultural Resources

The Project area has been the subject of several previous studies to identify cultural resources prior to the construction of the mine (Tetra Tech 2011, 2013a, 2013b, 2015, 2018, 2020). A total of 22 archaeological sites have been documented within the Project area.

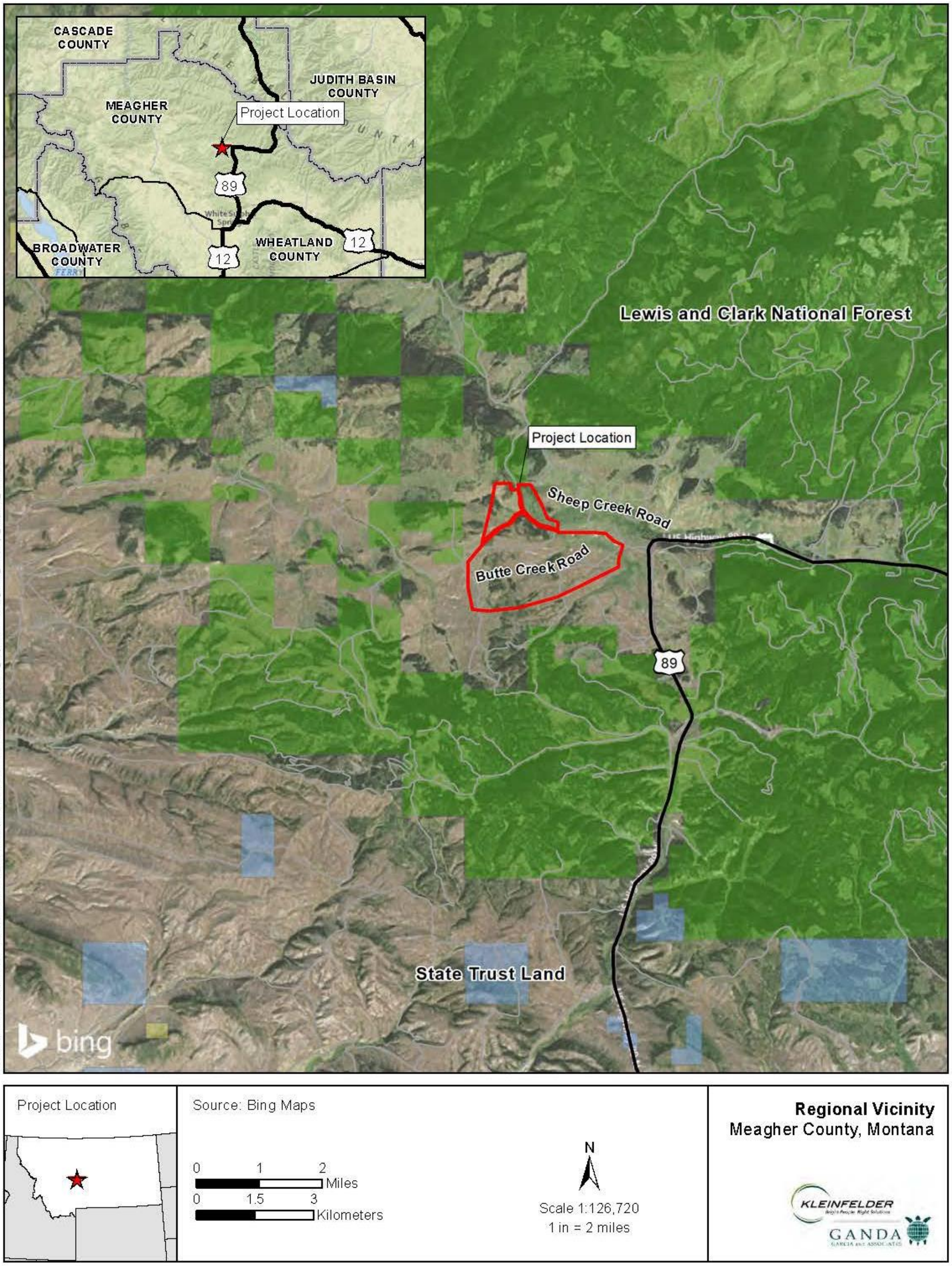


Figure 1: Regional Vicinity Map

Five of the 22 sites have been recommended eligible for inclusion in the National Register of Historic Places (NRHP), three of which could not be feasibly avoided and will be impacted by the first phase of mine construction activities (See **Figure 2).** These include the following archaeological sites.

Site 24ME163

Archaeological site 24ME163 is a prehistoric lithic scatter identified originally in 2011. Eligibility test excavations conducted in 2019 found a wide range of lithic materials within intact subsurface deposits and a buried hearth feature. This information indicates this site has data potential that may provide valuable scientific evidence related to chronology and cultural history, subsistence and settlement strategies, and trade (Tetra Tech 2015, 2020), and is therefore eligible for NRHP listing. The site is located within the footprint of one of the mine's proposed access roads, a sediment trap, and a culvert location. The southern portion of the site cannot be avoided and is subject to direct impact that would result in an adverse effect to this historic property.

The site is one of thirteen contributing lithic scatters that comprise the Sheep Creek Quarry Archaeological District (24ME1111; District). The District has been previously recommended eligible for inclusion in the NRHP, and site 24ME163 is considered a contributor to this District. However, it has not been formally listed on the NRHP.

Site 24ME1109

Archaeological site 24ME1109 is a prehistoric lithic scatter identified during a pedestrian survey in 2015. Pedestrian survey and subsequent test excavation at the site in 2019 found a wide range of lithic materials with intact subsurface deposits and the site has been determined eligible for inclusion in the NRHP (Tetra Tech 2015, 2020). The footprint of the mine's proposed mill pad and an access road are located within the boundaries of the site and impacts to the site cannot be avoided.

The site is one of thirteen contributing lithic scatters that comprise the District (24ME1111). The District has been recommended eligible for inclusion in the NRHP, and site 24ME1109 is a contributing member of the District.

Site 24ME1111

Resource 24ME1111 represents the Sheep Creek Quarry Archaeological District which covers approximately 1,048 acres and is comprised of 13 sites consisting of lithic scatters, including 24ME163 and 24ME1109, and a thin veneer of isolated flakes observed on the surface between scatter areas. The District is located within the mine's footprint and will be directly affected by construction of the proposed adit, mill pad, temporary waste rock storage, portal pad, vent raises, cemented tailings facility, contact water pond, process water pond, and access roads. The District has been recommended eligible for inclusion in the NRHP.

While the majority of the District will be unaffected by mine construction and operations, portions of the District cannot be avoided and will be adversely affected and construction will affect sites 24ME163, 24ME166, 24ME1109, and 24ME110. As discussed above, 24ME163 and 24ME1109 have been individually recommended eligible for inclusion in the NRHP. Sites 24ME166 and 24ME1110 have been subjected to subsurface testing and were found to lack a subsurface deposit that can contribute information important to our understanding of prehistory and have been recommended ineligible for inclusion in the NRHP.

1.3 Regulatory Framework

The Project area is located on private land and the majority of the Project area has no federal regulatory nexus (no federal permit, funding, lands, or other oversight). However, the Project will impact Waters of the U.S., therefore a U.S. Army Corps of Engineers (Corps) permit was issued for the discharge of fill materials into Waters of the U.S. As a result of previous cultural resource studies, two cultural resources were identified within the Corps' permit areas: 24ME1108 and 24ME1111. The Corps consulted with the Montana State Historic Preservation Office (SHPO) on May 18, 2016 for impacts to ten areas within the Project area (including 0.85 acres of wetlands) which included a 50 to 120-foot upland buffer. The preliminary mine access road location was redesigned to avoid impacts to 24ME1108 and the Corps determined that the undertaking would not adversely affect the criteria that make 24ME1111 eligible for the NRHP. SHPO concurred that the undertaking would have no adverse effect on Historic Properties including 24ME1111 (DOD/COE-017-2017051903).

Apart from the Corps' 0.85-acre impact area, Section 106 of the National Historic Preservation Act (NHPA) does not apply to the Project. The Montana Antiquities Act, which applies to activities conducted on state-owned land, also does not apply to this Project, as it is completely located on private land (MDEQ 2020a). Nonetheless, Sandfire has voluntarily conducted due diligence in assessing the presence of historic properties within the Project area and applying appropriate measures to resolve and/or mitigate adverse effects to those resources identified. This has included coordination in the past with MDEQ and SHPO as such, the mitigation plan has been previously vetted and approved by both.

As the Project is entirely on private property, State and Federal standard protocols and policies regarding artifact retention and curation do not apply. As requested, the collection will be returned to the landowner after all fieldwork, laboratory processing, analysis, and reporting is complete. The final disposition of artifacts will be with the landowner.

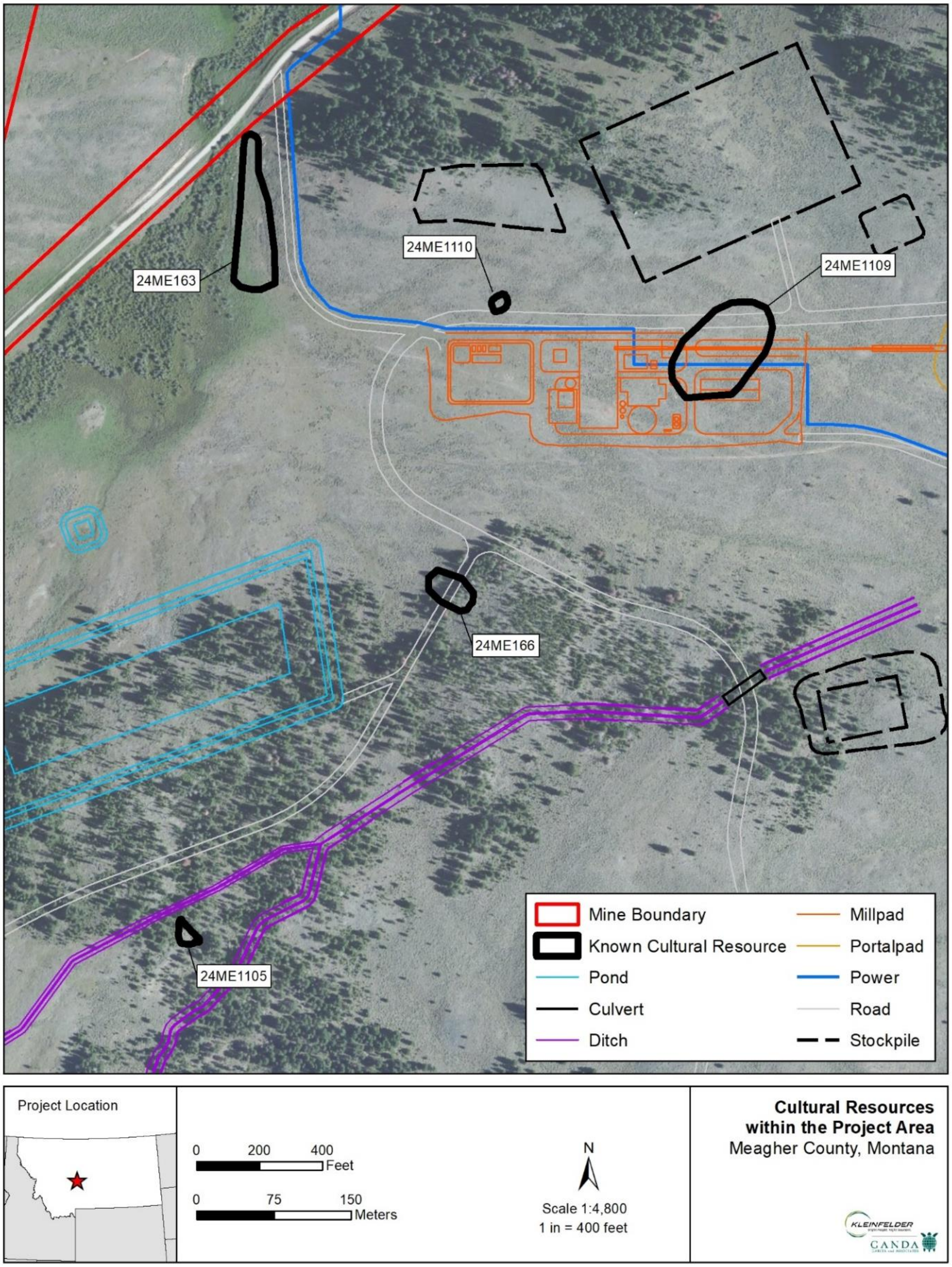


Figure 2: Mine Surface Infrastructure

2 Setting

The Project area is situated in the Little Belt Mountains, in the northern Rocky Mountains in Meagher County, Montana. The Project area is at an elevation between 5,600-6,100 feet (ft) above mean sea level (amsl). Sheep Creek flows through the Project area and terminates at the Smith River, located approximately 11 miles west of the Project location. The Project area is comprised of undeveloped private ranch land with some buildings and road networks throughout. It is located west of U.S. Highway 89. The Sheep Creek and Butte Creek County Roads are used to access the Project area.

2.1 Environmental Setting

Geologically, the Project area is underlain by Precambrian Belt series. These formations had their beginning about one and a half billion years ago when thick deposits of sandy and muddy sediments began to accumulate in sedimentary basins in western Montana (Alt and Hyndman 2000). The deposits ultimately lithified into hard sedimentary formations of sandstone, mudstone, and limestone. Accumulation continued for 600 million years but finally ceased about 800 million years ago. However, this Precambrian basement rock, the continental crust itself, is exposed on the surface a few miles north of Neihart and approximately 15 miles northeast of the Project area (Tetra Tech 2020).

Sandfire geologist Jerry Zieg describes the geology of the proposed mine area and particularly the lithic resource that attracted prehistoric peoples, below (Tetra Tech 2020).

> The Black Butte project area is hosted by a geology that produces voluminous amounts of ‘cherty’ material, generally called ‘jasperoid’ by geologists, or in this area ‘silicified gossan’ (remnants of intensely weathered iron-sulfide mineralization). The genesis of this material involves the surficial weathering of the aerially extensive bedded pyrite zones in the hostrock of the Newland shale. The portion of the Newland outcrop belt that contains the greatest abundance of jasperoid extends from about two miles east of US Highway 89 to west of the Smith River – a distance of approximately 20 miles. This exposure belt averages approximately five miles in width. Bedded pyrite zones are scattered across 3,000 feet of Newland stratigraphy. When these zones oxidize near surface, liberation of the sulfur ions from the weathering of pyrite create sulfuric acid, which carries silica as well as many other ions. This acid is then buffered by the high concentrations of dolomite (a carbonate-rich rock) in the Newland shale, and as the acid is consumed, silica then precipitates as very fine-grained massive material along with a good deal of the iron-oxide liberated during oxidation of pyrite. Huge volumes of this iron-rich silicified material have developed across this 100 square mile area and as a result form a ubiquitous component of the surficial geology – weathered fragments of this material are common in the alluvial material and especially in the soils on and near the exposed weathered portions of the extensive pyrite zones.

> A good example of this surrounds the Black Butte Iron mine, on Iron Butte, where the owners mine this material – there the silica contents are highly variable, but bands of very silicified material are common (Tetra Tech 2020).

Common flora types occurring in the Project area include Douglas-fir, lodgepole pine, Englemann spruce, ponderosa pine, aspen, willow, wheatgrasses, fescues, and some bluegrasses (Payne 1973; Tetra Tech 2015).

Fauna in the region consists of both small, moderate, and large size mammals including bobcat, badger, lynx, short and long-tail weasel, mink, marten, red fox, coyote, raccoon, striped skunk, muskrat, white-tailed jackrabbit, deer, elk, bighorn sheep, pronghorn, moose, mountain lion, and black bear (Tetra Tech 2015; Fisher et al. 2000). Amphibians, reptiles, and birds include western toad, spotted frog, western rattlesnake, western garter snake, hawks, falcons, and golden and bald eagles.

2.2 Cultural Setting in the Northwestern Plains

The following information is extrapolated from the Draft Mitigation of a Portion of Site 24ME163 and National Register Eligibility Testing at Four Lithic Scatters (24ME166, 24ME1105, 24ME1109, and 24ME1110) (Tetra Tech 2020).

The Project area is located within the prehistoric cultural subarea known as the Northwestern Plains, a region that extends from central Alberta to southern Wyoming and from western North Dakota to western Montana (Frison 1991). The prehistoric inhabitants of the Northwestern Plains existed for 12,000 years as semi-nomadic hunters and gatherers. The archaeological record indicates minor changes in tool technologies and subsistence strategies with increasing specialization in bison procurement during the last 3,000 years.

Table 1. Prehistoric Chronology for the Northwestern Plains

Temporal Period	Calibrated Date (cal BP)	Projectile Point Types
Paleoindian Period	12,000-7,500	Clovis, Folsom, Agate Basin, Hell Gap, Cody Knife
Early Plains Archaic Period	7,500-5,000	Bitterroot, Oxbow
Middle Plains Archaic Period	5,000-3,000	Duncan, Hanna, McKean
Late Plains Archaic Period	3,000-1,500	Yonkee, Pelican Lake
Late Prehistoric Period	1,500-300	Besant, Avonlea, Plains Side Notched
Equestrian Nomadic	300- 200	Late Prehistoric Period Points and the presence of Euro-American trade goods

The prehistory of the Northwestern Plains has been classified into four traditions or periods based on similarities of artifact assemblages and overall adaptive strategies. The time periods are known as Paleoindian, Plains Archaic, Late Prehistoric, and Equestrian Nomadic. Apart from the Equestrian Nomadic, these time periods span a couple to several thousand years and consequently researchers have further sub-divided time periods into cultural complexes (See Table 1).

2.2.1 Paleoindian Tradition (12,000 to 7,500 BP [years before present])

The Paleoindian Tradition occurred during the Pre-Boral and Boreal climatic episodes, a time when the climate was cool, moist, and conducive to forest expansion (Bryson et al. 1970). Paleoindian populations practiced generalized foraging strategies and inhabited environmentally diverse sites found in major river valleys and foothills. Paleoindian sites are rarely found on the more homogenous upland prairie. The Paleoindian Tradition is traditionally classified into Clovis, Goshen, Folsom, Hell Gap-Agate Basin, and Cody complexes. However, recent work has identified pre-Clovis occupations along the Pacific Coast in North and South America. At Paisley Caves in south-central Oregon, human coprolites produced dates older than 14,000 years. To date, evidence of this early occupation has not been identified in Montana. However, at the nearby Anzick Site in Park County, a collection of stone and bone tools discovered in 1968 included eight completely fluted points, a hallmark of Clovis culture. In addition to the tools, the skull of an infant boy was also uncovered that returned a radiocarbon date of 12,894 years ago (Hirst 2019). Anzick represents the oldest known burial in North America, and recent DNA analysis of the human remains indicates the infant was closely related to Native American groups in Central and South America rather than groups in Canada and the Arctic (Hirst 2019). This suggests North America was subject to multiple waves of colonization.

A second Paleoindian culture, recognized as Goshen, is not known in the region but has been found in southeastern Montana at the Mill Iron Site. This locality yielded 31 Goshen projectile points which are similar to Clovis but lack the distinctive flute and exhibit parallel flaking. Additionally, bison bone from Mill Iron returned a range of radiocarbon dates from 11,300 to 10,800 years ago (MacDonald 2012). Goshen peoples appear to have favored hunting *Bison antiquus*, the one megafauna species to survive mass extinction. Folsom, another Paleoindian complex that produced fluted points, is a well-established culture that extends from northern Texas to southern Manitoba and from Wisconsin to Idaho (MacDonald 2012). Folsom has also been identified in the Project region at two sites south of Helena; these sites include the Indian Creek Site located along a Missouri River tributary, and the MacHaffie Site found in the Elkhorn Mountains. Samples from these sites produced radiocarbon dates of 10,805 years, and 10,390 and 10,090 years, respectively (MacDonald 2012). Folsom populations are known as specialized big-game hunters who favored bison on the open plains. However, in foothill and mountain terrain, Folsom’s subsistence strategy diversified, and marmots, jackrabbits, and bighorn sheep are found in site assemblages.

The remaining Paleoindian complexes began about 10,200 years ago when Folsom projectile points fell out of use and Agate Basin and Hell Gap stemmed lanceolate points appear. These projectile points are similar to Folsom but lack the distinctive flute. Agate Basin and Hell Gap sites are generally found in Wyoming where faunal assemblages suggest these cultures hunted bison more intensively than the previous Folsom Complex.

The Cody Complex completes the Paleoindian Tradition and spans between 9,500 and 8,000 years ago. Cody sites have also produced evidence of a bison hunting culture that utilized stemmed lanceolate projectile points; these points are believed to be a cultural descendent of Agate Basin and Hell Gap points (MacDonald 2012). The nearest known site with a Cody component is the previously mentioned MacHaffie Site, south of Helena. At MacHaffie, the Cody component overlies an older Folsom component, and produced evidence of stone tool manufacture using locally available materials.

2.2.2 Plains Archaic Tradition (7,500 to 1,500 BP)

The Plains Archaic Tradition is divided into three periods: Early (7,500–5,000 BP), Middle (5,000–3,000 BP), and Late (3,000 BP–1,500 BP). The Early Plains Archaic began during a relatively dry climatic episode known as the Altithermal, and a reduced number of well-excavated sites dating to this period are known. This paucity of sites may be the result of the abandonment of the open plains in favor of uplands and river valleys due to extreme weather conditions (Mulloy 1958). Alternatively, Reeves (1973) suggests excessive erosion led to sediment buildup in the river valleys, which either buried or eroded away Early Plains Archaic sites.

Projectile points associated with the early period are generally rather large, side-notched types that were more plainly made compared to preceding Paleoindian points. In Montana and Wyoming, archaeologists have recovered Early Plains Archaic points still hafted to their atlatl foreshafts. Atlatls are considered an improvement in weapon technology as hunters could fling a dart farther and with greater accuracy than a spear. An atlatl consists of a point, or dart, hafted to a foreshaft that is secured in a notch at the end of a weighted throwing board. In addition to the adoption of the atlatl, other Altithermal and Early Plains Archaic hallmarks include the extinction of *Bison antiquus* and *Bison occidentalis*, leaving the modern, smaller species *Bison*.

In the Project vicinity, the closest Early Plains Archaic component occurs at the Indian Creek Site, south of Helena. However, the most significant Early Plains Archaic site in Montana is Myers-Hindman, located on the banks of the Yellowstone River near Livingston. Archaeological evidence at Myers-Hindman confirms a dietary change for Early Archaic populations as bison remains decreased and other animal remains like pronghorn, deer, elk, sheep, and dog increased substantially. Additionally, a large grinding stone used for food processing was recovered at Myers-Hindman.

The Middle Plains Archaic is marked by a change in subsistence and settlement strategies as sites were increasingly found across the open prairie, and faunal and floral remains suggest an increased reliance on bison and the utilization of plant resources. The increase in bison remains is likely tied to a change in climatic conditions as the Altithermal gradually waned and cooler temperatures and increased precipitation returned to the open plains. As a result of these changes, grasslands increased, and in turn, bison herds grew larger. Human populations are also believed to have increased as the number of Middle Archaic sites is about 25 to 50 percent higher than Early Archaic sites in Montana and Wyoming (MacDonald 2012).

Classic Middle Plains Archaic projectile points include Oxbow, McKean, and Duncan-Hanna. MacDonald (2012) writes Oxbow points are distinguished by indented or concave bases, and frequent side notches while McKean points are lanceolate with concave bases, and common side-notches.

The final part of the Plains Archaic is characterized by additional changes in subsistence strategies as new cooperative hunting techniques were developed to more successfully exploit bison herds. In Montana, the introduction of the dog travois, a simple device dragged behind a dog to carry gear, allowed hunter-gatherers to increase their travels in search of wide-ranging bison herds (MacDonald 2012). Additionally, the use of bison jumps and corrals, which appear sporadically in preceding periods, increases dramatically during the Plains Archaic as hundreds of these sites have been identified across Montana, east of the Rocky Mountains. To underscore the significance of these sites, MacDonald (2012, p. 98) calls Montana “the center of the bison jumping universe.” One of the most important buffalo jumps in the state, known as Wahkpa Chu’gn, is found in Havre, about 135 miles northeast of the Project area. Wahkpa Chu’gn was repeatedly used by Besant groups from 2,050 to 1,450 years ago, and excavations have yielded hundreds of Besant projectile points and bison bones representing hundreds of individual animals.

Another innovation that facilitated the high mobility of bison hunting, and occupation of the open Plains, is the use of tipis as habitation features. These portable hide structures were anchored to the ground with stones, and when amps were struck and tipis dismantled, stone circles remained to mark the former locations of these conical structures. Thousands of stone circles have been identified in Montana that date to the Late Plains Archaic and subsequent Late Prehistoric periods. Researchers believe this increase in site numbers, compared to the quantity of Early and Middle Plains Archaic sites, reflects an overall population increase. Another factor suggesting population increase is the recovery of greater artifact assemblages from Late Plains Archaic sites.

With increasing specialization in bison procurement, Late Archaic groups in the region became actively involved in trade networks as they possessed highly desired bison meat and hides.

2.2.3 Late Prehistoric (1,500 to 300 BP)

The Late Prehistoric is a time of increasing specialization of plains living and utilization of plains resources; most importantly, bison. The bison hunting culture that emerged during the Late Plains Archaic flourished during the Late Prehistoric as kill sites became bigger and the number of individual bison represented increased. Additionally, Late Prehistoric groups became more efficient at processing bison carcasses, and hunters appear active year-round, not just on a seasonal basis.

Additional Late Prehistoric changes occurred in settlement/subsistence practices, stone tool/weapon technology, and population sizes. About 900 years ago, some populations in the Great Plains began to settle down and live in permanent villages (MacDonald 2012). Prior to this, groups had lived as highly mobile hunters-gatherers. In the Dakotas, Missouri River villagers lived in earth lodges and practiced agriculture, growing corn, beans, and squash to trade with bison hunters in Montana. Evidence of village sites is rare in Montana, and for the most part, it appears native populations continued to live in tipis as mobile hunter-gatherers. However, archaeological assemblages from Pictograph Cave and Ghost Cave, near Billings, provides evidence of Missouri River village influence as recovered artifacts include a human face effigy, a turtle pendant, a knife hafted to a handle, and basketry (MacDonald 2012).

The major change in stone tool/weapon technology concerns the replacement of the atlatl with the bow and arrow around 1,500 years ago. Advantages of this technological shift includes a reduction in projectile point size and the decreasing need for large pieces of high-quality stone (MacDonald 2012). Additionally, hunters could fire an arrow from a hidden position, and standing out in the open to throw an atlatl dart, was no longer necessary.

Human populations appear to have experienced growth during this time as the number of Late Prehistoric stone rings and bison kill sites is significantly higher than the number of Late Plains Archaic sites. Archaeologists speculate that population increases probably led to territoriality and diet diversification as all varieties of plants and animals were exploited within tribal territories. The notion of territoriality originates from village sites where fortification structures grew over time and recovered human remains yield evidence of embedded projectile points, an occurrence not identified in earlier times (Scheiber 2006).

2.2.4 Equestrian Nomadic Tradition (300 to 200 BP)

The Equestrian Nomadic Tradition is a transitional time between the prehistoric and historic periods. This time is distinguished by European influences and the subsequent changes that occurred in native subsistence strategies, demographics, social organization, and settlement patterns (Gregg 1985).

Europeans first stepped foot on the southern Plains in 1528 when a Spanish expedition led by Alvar Nunez Cabeza de Vaca crossed Texas and part of northern New Mexico

(Swagerty 2001). Contact between Europeans and Northern Plains tribes did not occur until well over 100 years later when French explorers Pierre Esprit Radisson and Medard Chouart encountered the Santee Sioux near Lake Superior in 1659. French explorers continued to work their way west and by 1700, they were past the mouth of the Missouri River.

One of the most significant impacts to the lifeways of Plains tribes was the arrival of the horse. The first documented appearance of European horses occurred during the 1540s when Spanish expeditions under Hernando de Soto and Francisco Vasquez de Coronado explored the plains of Texas and Kansas (Swagerty 2001). There is no evidence to suggest Native Americans acquired horses during this time. Rather, the transition appears to have occurred during the Pueblo Revolt, 1680 to 1692, when Pueblo tribes confiscated several thousand horses from the Spanish.

Horses spread across the Plains from the Southwest, and around 1725, Northern Plains tribes finally acquired this important animal. Secondary trade centers developed in southwest Wyoming, in the Mandan-Hidatsa and Arikara villages on the Missouri River, and at Sioux gatherings on the James River (Swagerty 2001). By the late 1700s, a horse-trading network was well established that included tribes from the southern, central, and northern Plains, the Plateau, and the Pacific Northwest. With the arrival of the horse, native populations became more sedentary. Women, children, and the elderly could stay behind as hunters mounted on horseback greatly increased their range (Secoy 1953).

In addition to the horse, Europeans introduced the fur trade to the Northern Plains during the first half of the 18th century. The fur trade provided European trade goods in exchange for furs, and for some tribes, their economy shifted from subsistence-based to trade-based. Native perception of land ownership also changed with participation in the fur trade as the exclusive right to hunt particular territories became very important (Deaver 1983).

Although slight changes later occurred, the territories of Montana tribes were established by the end of the Equestrian Nomadic Tradition. The Black Butte Project area lies within the traditional territory of the Blackfeet and their Gros Ventre allies (Bureau of Indian Affairs [BIA] 2016). Bordering Blackfeet/Gros Ventre lands, Salish and Kootenai territories lie to the west, Crow to the southeast, and Assiniboine to the east (see **Figure 3**).

Equestrian Nomadic sites are usually denoted by the presence of Euro-American trade goods like metal points and tools, trade beads, and horse bones. However, sites from this time are not commonly found, and with an absence of Euro-American goods and a continuation of basic native subsistence activities, it is thought most Equestrian Nomadic sites are likely identified as prehistoric.

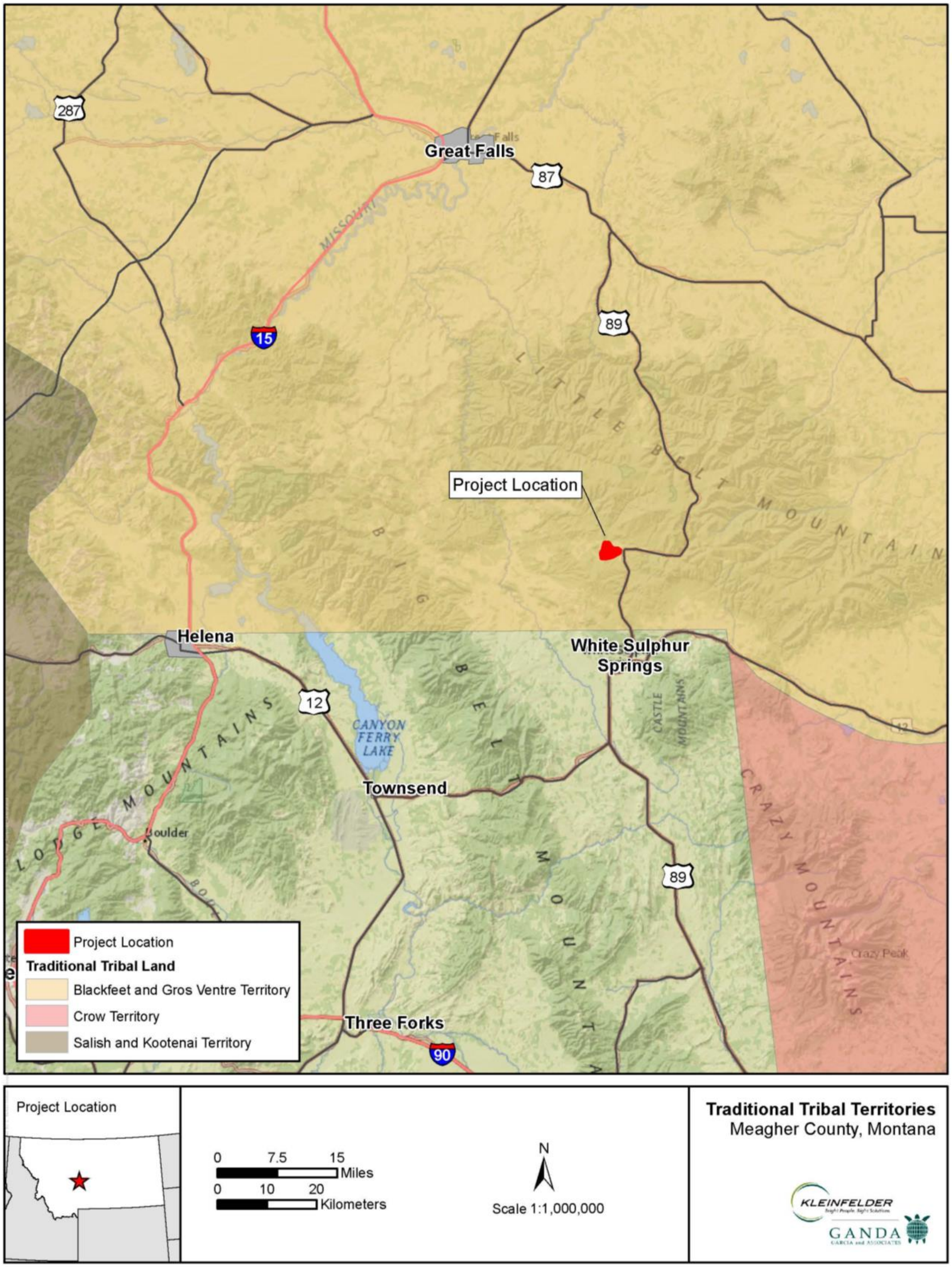


Figure 3: Traditional Tribal Territories

2.3 Prehistoric Quarries of the Northwestern Plains

The procurement of raw materials for stone tool manufacture was an essential task for hunter-gatherers of the Northwestern Plains and is well represented in the archaeological record. The state of Montana has over 749 mapped bedrock and surficial quarries, 248 of which are chert quarries (Schwab 2018). Southwestern Montana has a particularly complex and diverse geologically rich setting, with deposits of raw material, including chert, suitable for stone tool manufacture, and contains approximately three times as many quarries per 1,000 sites compared with the rest of Montana (Roll et al. 2005).

With such an abundance of raw stone material in Southwestern Montana, attempts have been made to characterize the unique chemical signatures of source cherts at eight unique quarries (Roll et al. 2005). The eight chert quarries discussed below, has been subject to Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) analysis in an attempt to identify a unique chemical fingerprint of the local chert. Results of the analysis were mixed, but researchers still believe sourcing through chemical analysis is a viable research direction.

2.3.1 Western Montana Chert Quarries

Eyebrow Quarry (24GN501)

Eyebrow Quarry is located approximately 113 mile west of the Sheep Creek Quarry on a prominent landmark known as the eyebrow (**Figure 4**). The site contains numerous quarry pits ranging from 1 to 2 meters (m) in diameter and half a meter deep with the largest pit exceeding 3 m deep and 15-20 m in diameter (Roll et al. 2005). The chert ranges in color from very light to dark brown or black with black inclusions in many larger samples. Chemical analysis of the Eyebrow chert did not identify a unique chemical signature.

Avon Quarry (24PW346)

Avon Quarry is located on the western slope of the Rocky Mountains, approximately 85 miles west of the Sheep Creek Quarry (**Figure 4**). Avon quarry is characterized by at least 76 quarry pits and lithic scatters, occupational debris, and quarry workshop areas over an approximately 28.5 square kilometer (km2) area. The quarry appears to have been occupied in the summer and fall for the purpose of raw tool stone procurement and production (Riley 2004). The quarry chronology is undefined, but a single oxbow point made of Avon chert give a lower limit date range between 5,200 and 3,500 B.P., Middle Plains Archaic (ibid). Avon chert is known for its white-creamy color with a full luster (Roll et al. 2005). The chert has been subject to LA-ICP-MS analysis and has been found to have a distinct chemical signature.

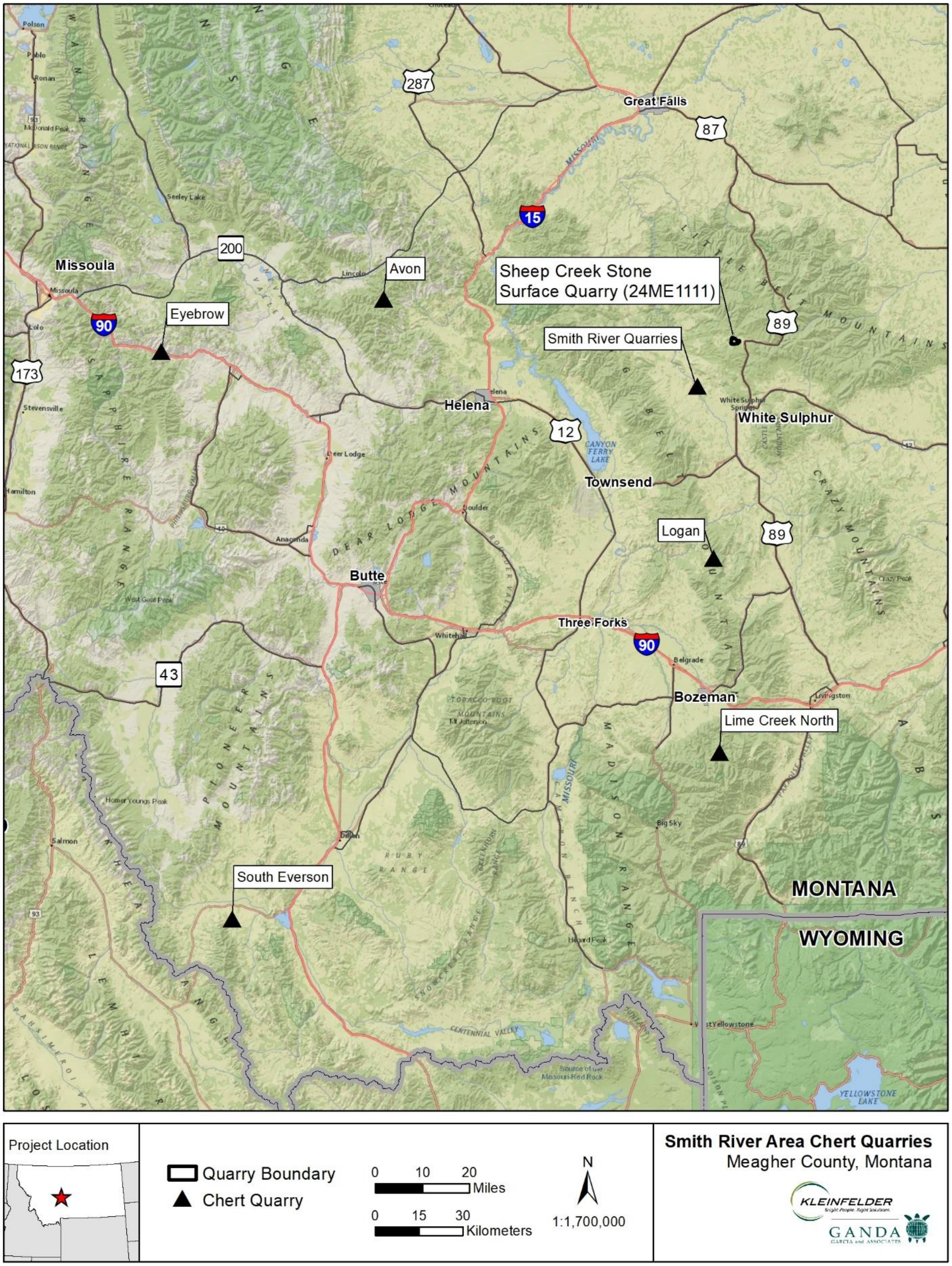


Figure 4: Chert Quarries in Western Montana

South Everson Quarry (24BE559)

South Everson Quarry is located approximately 175 miles southwest of the Sheep Creek Quarry where chert is both a surface and subsurface quarry (**Figure 4**). The South Everson Creek complex contains almost 200 known quarries spread over a variety of landforms and covering approximately 1,000 hectares. There are hundreds of quarry pits, varying in size and depth, along terraces and uplands of the South Fork of Everson Creek and Black Canyon Creek and workshop/habitation sites are consolidated along the streams and springs (Kelly 2000). A hearth from Mammoth Meadow I, a site located within the South Everson Complex, produced charcoal from 3 assemblages with a radiocarbon date range from 490 ± 50 BP to 9390 ± 90 BP, indicating quarry use from the Paleoindian through the Late Prehistoric Period (ibid). Several patterned tools as well as antler tools and rib shafts were identified as digging implements. Chert from this quarry has been subjected to chemical testing which has identified a unique trace element signature of the chert.

Lime Creek Quarry North (24GA1547) and Logan Quarry (24GA400)

Lime Creek North and Logan quarries are located in the drainage of the Gallatin River, located roughly 90 miles and 45 miles south of the Sheep Creek Quarry, respectively (**Figure 4**). Neither site has been the subject of significant archaeological investigation and little is known of the prehistoric use. Both quarries have been the subject of chemical testing; Lime Creek Quarry North produced a distinct chemical signature while Logan Quarry chert studies produced a non-unique chemical signature (Roll et al. 2005).

2.3.2 Smith River Chert Quarries

An area along the Smith River corridor, approximately 20 miles northwest of White Sulphur Springs, and within 15 miles west of the Project area, features several chert quarries that exhibit intensive use by prehistoric peoples (See **Figure 5**). These generally occupy elevations between 4700- 5250 ft amsl and is similar to the chert deposits located with the District. The Smith River corridor deposits are from the Cambrian through Devonian age with the Camp Baker Quarry located a short distance down slope from the Park Shale/Pilgrim Limestone (Cambrian) contact. Tertiary igneous intrusions probably contributed to the formation of local chert deposits regardless of the age of associated bedrock. (Roll 2003; Roll et al. 2005; Hruska 1967).

Doggett Quarry, Camp Baker, and 24ME332 have undergone LA-ICP-MS analysis and a unique chemical signature was not identified for any of the Smith River quarries.

Camp Baker Quarry (24ME467)

The Camp Baker Quarry is located approximately 13 miles west of the Project area near the confluence of Sheep Creek and the Smith River. Camp Baker was initially recorded in 1979 as a lithic scatter and prehistoric quarry (Aaberg 1983; Schwab 1990). In 2001 and 2002, detailed planimetric mapping of the quarry area and test excavations on the edges of two quarry pits identified 52 quarry pits and approximately 14,000 pieces of debitage (Hall and Wendel 2012a and 2021b). Analysis of the debitage from the subsurface testing resulted in the conclusion that work in that portion of the quarry examined consisted primarily of raw material extraction, testing of raw material for quality, removal of undesirable portions from the extracted blocks, and the production of blocky cores and flake blanks for subsequent tool manufacture at other locations (Roll 2003). Essentially no evidence for biface core production, tool manufacture, or tool maintenance was observed (ibid). Chert materials identified at Camp Baker originate from local sources, however, two pieces of obsidian debitage recovered during subsurface testing were subjected to X-ray Fluorescence (XRF) and are from Obsidian Cliff, Wyoming in Yellowstone National Park.

A single, small, and incomplete side-notched projectile point, typical of the Late Prehistoric Period (1,500-300 BP) of the Northwestern Plains, was found at Camp Baker. No intact carbon-bearing features were identified during subsurface testing; small quantities of bone and charcoal were identified in uncertain contexts and thus not suitable for radiocarbon dating (Roll 2003).

Additional reconnaissance survey near Camp Baker identified a continuous band of quarry pits stretching for approximately two miles southwest from Camp Baker. The reconnaissance also discovered a number of very large concentrations of flaking debris and several small tipi-ring sites on south and east facing open slopes overlooking the Smith River indicating significant use of the Camp Baker area for raw material acquisition and processing (Roll 2003).

24ME332

This unnamed chert quarry is located approximately 2 miles southwest of Camp Baker and 15 miles west of the Sheep Creek Quarry. The large quarry contained approximately 35 pits, including some pits more than 15 meters in diameter and several meters deep. Pedestrian reconnaissance surveys between Camp Baker and 24ME332 identified 11 additional concentrations of quarry pits (Roll 2003).

Doggett Quarry (24ME69)

Doggett Quarry is located a quarter mile east of the Smith River, approximately 12.5 miles from the Sheep Creek Quarry and is characterized by bedrock outcroppings of high-grade and variable chert. The quarry consists of three distinct areas that were utilized as a bedrock and surface lithic quarry (Knight 1976; Straight 2014). Although the site has not been extensively investigated, 216 quarry pit features were observed along with nine stone ring features and numerous waste rock berms. Cultural constituents observed on the surface include prepared bifacial cores, basalt biface digging tools, local slate improvised digging tools, and stream-rolled cobble hammers and mauls (Straight 2014).

Songster Butte Quarry

Located along the Smith River corridor approximately 2.7 miles north of Camp Baker and 13 miles west of the Sheep Creek Quarry, Songster Butte Quarry occupies a smaller area than either Doggett or Camp Baker. Surface examination of lithic debris indicated the site contains similar and equally suitable lithic raw material as Camp Baker and Doggett quarries (Roll 2003). Chert from Songster Butte has not been subject to chemical analysis.

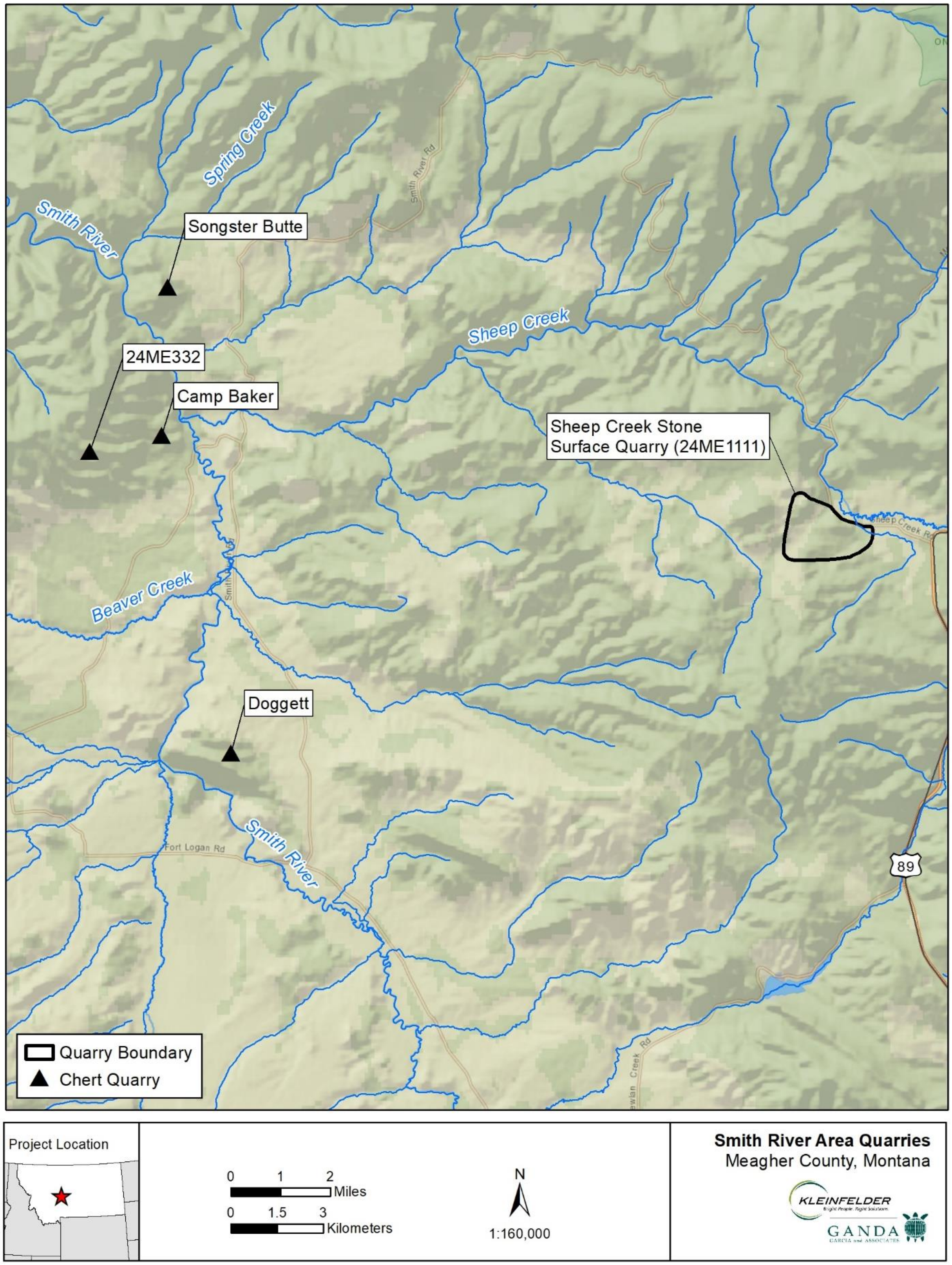


Figure 5: Smith River Area Chert Quarries

3 Previous Research

Previous archaeological surveys examined the Project area to identify cultural resources that may be impacted by the Project (Tetra Tech 2011, 2013a, 2015, 2018, 2020). As a result of these studies, 22 cultural resources were identified within the Project area including 13 prehistoric lithic scatters, a prehistoric district, two historic roads, two log cabins, two irrigation ditches, a mine shaft, and a sheepherder's cairn (See **Table 2** and **Figure 6**). Five of the 22 resources have been recommended eligible for inclusion in the NRHP including three lithic scatters (24ME163, 24ME1105, and 24ME1109), a historic sheepherder's cairn (24ME1104), and the Sheep Creek Quarry Archaeological District (24ME1111).

Table 2. Cultural Sites Identified within the Project Area during Previous Studies

Site Number	Site Type	NRHP Recommendations
Isolate 1	Prospect Pit	Not eligible
Isolate 2	Prospect Pit	Not eligible
24ME0158	Historic Log Structure	Not eligible
24ME0159	Historic Mining	Not eligible
24ME0160*	Lithic Scatter	Unevaluated
24ME0161*	Lithic Scatter	Unevaluated
24ME0162*	Lithic Scatter	Unevaluated
24ME0163 *	Lithic Scatter	Eligible under Criterion D
24ME0164 *	Lithic Scatter	Unevaluated
24ME0165*	Lithic Scatter	Unevaluated
24ME0166 *	Lithic Scatter	Not eligible
24ME0925	Historic Road- Sheep Creek	Not eligible
24ME0936	Historic Road- Butte Creek	Not eligible
24ME0940	Historic Homestead	Not eligible
24ME1104	Historic Sheepherder's Cairn	Eligible under Criterion C
24ME1105 *	Lithic Scatter	Eligible under Criterion D
24ME1106 *	Lithic Scatter	Unevaluated
24ME1107 *	Lithic Scatter	Unevaluated
24ME1108 *	Lithic Scatter	Unevaluated
24ME1109 *	Lithic Scatter	Eligible under Criterion D
24ME1110 *	Lithic Scatter	Not eligible
24ME1111	Sheep Creek Quarry Archaeological District	Eligible under Criterion D
24ME1135	Coon Creek Irrigation Ditch	Not eligible
24ME1136	Sheep Creek Irrigation Ditch	Not eligible

**Contributing member of the Sheep Creek Quarry Archaeological District*

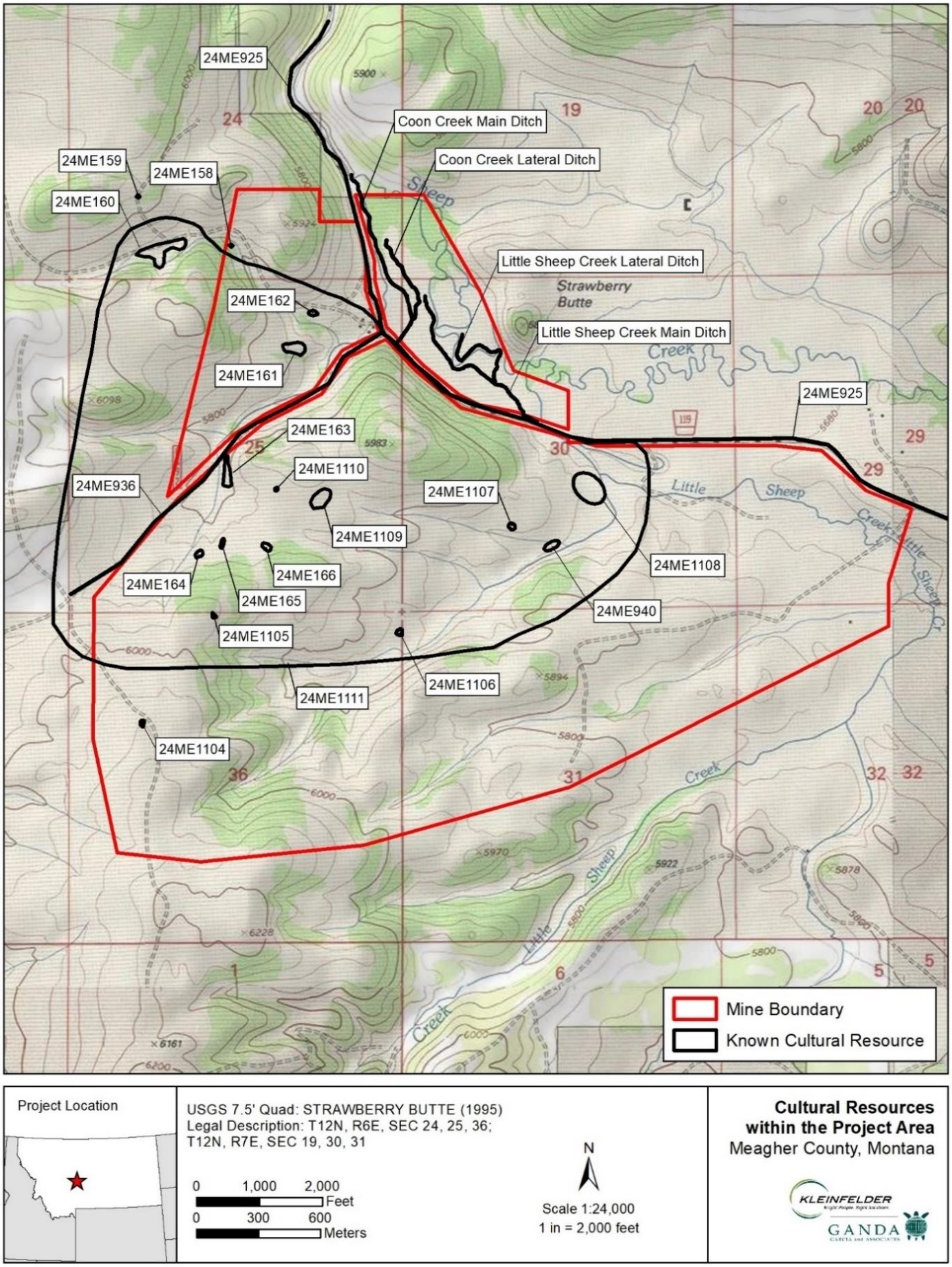


Figure 6: Cultural Resources Identified within the Project Boundary

Of the five eligible resources within the Project footprint, three resources, the District (24ME1111) and two lithic scatters (24ME163 and 24ME1109) cannot be feasibly avoided during the first phase of construction and require data recovery in order to preserve data that would otherwise be lost. Previous studies conducted for each of these resources is detailed below.

3.1 Site 24ME163

Site 24ME163 was initially identified during pedestrian survey in 2011. It was recorded as a sparse lithic scatter consisting of approximately 40 primary chert flakes, one obsidian flake, and one grey quartzite flake visible along the existing two-track road or in rodent back dirt piles (Barnett 2011).

Archaeological testing was conducted in 2012 assess the potential for subsurface data in order to determine if the resource was eligible for inclusion on the NRHP (Tetra Tech 2013b). During testing, eight shovel probes were placed within the site boundary, in a north-south line along the disturbed areas of the existing road. The shovel probes were spaced at approximately 20-m intervals and measured 30 centimeters (cm) in diameter and extended to a depth of 30 cm below surface (cm bs). All shovel probes, with the exception of Shovel Probe-1, produced lithic material. The lithics from shovel probes 2-8 consisted of 26 tertiary and two secondary chert flakes, mostly red in color. No stone tools or other cultural materials were identified.

Shovel probes 7 and 8 were the most prolific, with the highest number of flakes. A single 100 x 100-cm excavation unit was excavated next to Shovel Probe 8 to a depth of 50 cm bs. One hundred and thirty-two lithic artifacts were recovered from the excavation unit extending from the surface to 50 cm bs, and the depth of the cultural deposit was not established during site testing. Artifact recovery peaked between 20 and 30 cm bs but cultural materials were still present to a depth of 50 cm bs. One stone tool, a chert uniface, was identified at approximately 48 cm bs.

In 2012, Tetra Tech consulted with James Strait, MDEQ Archaeologist, and the SHPO on the methods used to test Site 24ME163 and received guidance and concurrence with their approach. In 2013, the SHPO concurred that site 24ME163 was eligible for listing on the NRHP under Criterion D and as a contributor to 24ME1111, the Sheep Creek Quarry Archaeological District

A mitigation plan for site 24ME163 was proposed and discussed between Tintina, the SHPO, and the MDEQ in 2018 and an approach was developed (MDEQ 2020a). Tetra Tech communicated with the MDEQ archeologist and SHPO regarding data recovery mitigation strategy for the entire site. The strategy approved by both MDEQ and SHPO identified a total of 10 hand excavation units across the entire site. A culvert was required within the site boundary, as such Tetra Tech consulted with James Strait (MDEQ) in 2019 about an approach to mitigate adverse effects within this location. Through this coordination it was determined the excavation of three of the 10 proposed 1-m x 1-m units would satisfy mitigation of adverse effects in the culvert area (Tetra Tech 2020).

Additional fieldwork occurred in spring 2019 prior to the installation of a culvert within the site boundary. Data recovery was conducted to collect a representative sample of cultural materials from the location that was to be impacted. Three 1 x 1-m units were excavated. Unit 3 partially identified a hearth feature, and an additional fourth unit was excavated to uncover the entire feature (Tetra Tech 2020).

The four excavation units produced stone flaking debris, six unpatterened stone tools, and one hearth feature. The debitage assemblage consisted of primary chert (nine chalcedony flakes were identified) and included 266 flakes and 152 pieces of shatter. Five of the flakes exhibited potlids suggesting heat treatment occurred. The six tools all consisted of chert and included three early-stage biface fragments, one modified flake, and two cores. The hearth feature consisted of a few pieces of charcoal, ash and charcoal stained sediment, and numerous pieces of fire cracked rock. Ash and charcoal stained sediment samples from the hearth feature were submitted for radiocarbon analyses which yielded a radiocarbon date of 3,215+20, which calibrates to 1520-1430 BC, indicating a Middle Plains Archaic occupation (Tetra Tech 2020).

24ME163 is one of 13 contributing lithic scatters that comprise the Sheep Creek Quarry Archaeological District (24ME1111).

3.2 Site 24ME1109

Site 24ME1109 was initially identified during pedestrian survey in 2015. It was recorded as a sparse lithic scatter on a sage-covered terrace, consisting of 10 tertiary chert flakes in a generally linear area measuring 80 x 50 m (Tetra Tech 2015). Naturally occurring chert nodules were noted at the site.

Archaeological testing was completed in 2019 to assess the potential for subsurface data in order to determine if the resource was eligible for inclusion on the NRHP (Tetra Teach 2020). The research goals for testing were to determine if potentially significant cultural remains present at the site, types of lithic procurement strategies at the site, and site chronology.

In 2019, the site was surveyed prior to archaeological testing to establish the site boundary and record surface artifacts (Tetra Tech 2020). As a result of the survey, the site boundary was expanded to measure 115 x 70 m. Subsurface testing was conducted in June 2019. Two test units and eleven shovel probes were placed within the site boundary. Both the test units and shovel probes reached depths ranging from 12 cm to 30 cm below surface where shale bedrock was encountered. One exception was at Shovel Probe-11, at the northeastern edge of the site boundary where shale rock was only minimally present here at 30 cm bs.

Artifacts recovered include chipped stone flaking debris and no tools or other cultural features were identified as a result of the investigation. Both the test units and shovel probes-1, -5, -6, -10, and -11 were positive for cultural resources. Chert was the primary lithic material represented, but flakes of obsidian were also present. Test Unit-1 was placed near Shovel Probe-1 where the obsidian was found, and Test Unit-2 was located near Shovel Probe-6 which yielded 22 flakes/pieces of shatter. Test Unit-1 yielded a total of 13 pieces of flaking debris/shatter, extending from the surface to 20 cm bs. The assemblage consisted of one primary, seven secondary, and five tertiary flakes. In addition to chert debitage, one quartzite piece of shatter and one tertiary chalcedony flake were recovered. Test Unit-2 produced 40 chert flakes/pieces of shatter that included seven primary, 27 secondary, and six tertiary flakes. Artifacts were recovered from the surface to 22 cmbs.

The recovery of flakes exhibiting potlids suggests site occupants were heat treating chert to improve its knapping quality. The excavation of test units-1 and 2 identified 13 and 40 pieces of lithic debitage, respectively. These numbers exceed the 6+ lithic items suggested to trigger further attention in the data recovery stage (Deaver and Peterson 1999).

Following the subsurface testing, a magnetic geophysical survey of the 6,265-square meter site was conducted in September 2019 (Michaletz 2019; Tetra Tech 2020). The purpose of the survey was to identify magnetic anomalies which could indicate prehistoric hearth features. The magnetic geophysical survey identified seven anomalies in the site area: one in the proposed access road area in the northern portion of the site and the remaining anomalies in the proposed mill pad area.

The site is one of thirteen contributing lithic scatters that comprise the Sheep Creek Surface Stone Quarry District (24ME1111).

3.3 Archaeological District 24ME1111- Sheep Creek Quarry Archaeological District

The Sheep Creek Quarry Archaeological District (24ME1111) is an archaeological district which covers approximately 1,048 acres. The District is a stone surface quarry comprised of 13 lithic scatters (24ME160-24ME166 and 24ME1105-24ME1110) and numerous isolated flakes dispersed between these sites. The District was identified as a result of cultural resource surveys conducted by Tetra Tech in 2011, 2012, and 2015.

The quarry is characterized as a surface quarry; no quarry pits or stone ring features have been identified within the District to date and the volume of lithic scatter sites and isolated flakes within such a close proximity indicate the site area of 24ME1111 was likely used as a surface stone quarry (Tetra Tech 2015; Peterson and Barnett 2015). Chert naturally occurs around the area and the composition of the District suggests prehistoric occupants tested chert nodules and conducted some lithic reduction but did not produce highly patterned tools. The available chert is generally a poor-quality material for stone tools.

The majority of the lithic materials are chert flakes; however, chalcedony, porcellanite, and obsidian flakes have been identified. Primary, secondary, and tertiary flakes are all represented including cores, a possible projectile point mid-section, worked flakes, and tested nodules.

Subsurface testing was conducted in 2015 and 2019 at sites 24ME163, 24ME166, 24ME1105, 24ME1109, and 24ME1110 to identify if intact subsurface deposits were present within the District (Tetra Tech 2015, 2020). Sites 24ME163, 24ME1105, and 24ME1109 yielded evidence that could contribute to our understanding of prehistoric lifeways and consequently, are recommended eligible to the NRHP. Sites 24ME166 and 24ME1110 were found to lack a subsurface deposit and have been recommended ineligible for inclusion in the NRHP.

In sum, three of the thirteen lithic scatters located within the district (24ME163, 24ME1105, and 24ME1109) have been recommended individually eligible for inclusion in the NRHP under Criterion D. Two lithic scatters (24ME166 and 24ME1110) have been recommended individually ineligible for inclusion in the NRHP as they lack subsurface deposits. Eight of the lithic scatters have not been individually evaluated for inclusion in the NRHP. The District has been recommended eligible for inclusion in the NRHP under Criterion D and all thirteen lithic scatters located within the District boundaries are contributing members to the district.

SHPO Consultation

As the Project will impact Waters of the U.S., a Corps permit was issued for the discharge of fill materials into Waters of the U.S. The Corps consulted with the SHPO on May 18, 2016 for impacts to ten areas with the Project area (including 0.85 acres of wetlands)) which included a 50 to 120-foot upland buffer. The Corps determined that the undertaking would not adversely affect the criteria that make 24ME1111 eligible for the NRHP. SHPO concurred that the undertaking would have no adverse effect on Historic Properties including 24ME1111.

In addition to the formal consultation with the Corps, there were previous communications between Tetra Tech, James Strait, Archaeologist at the MDEQ, and Jessica Bush, Compliance Officer at SHPO, to help determine the most effective means to recover a representative sample of data in order to contribute to the archaeological dataset. These previous communications identified the Project effects recovery at the District (24ME1111) would be through chert chemical analyses in an effort to identify a chemical fingerprint of the Sheep Creek cherts (Johnson 2020).

4 Research Design

The Sheep Creek District (24ME1111), 24ME163, and 24ME1109 have been recommended eligible for the NRHP under Criterion D for their potential information important in prehistory. Due to the design of the Project, avoidance of the sites and the District is not feasible. As such, the GANDA/Kleinfelder research design was developed to guide data recovery in order to retrieve a representative sample of data from these resources that are subject to direct effects as a result of this project, in order to recover a subset of the cultural materials within each site that may help address information important to the prehistory of the region. Research efforts such as this are informed by the general canon of commonly accepted regional archaeological questions.

4.1 Chronology

The basic directive of archaeological research is to describe cultural change over time. Therefore, most archaeological questions have a chronological component. For example, understanding population movements requires knowledge of the relative time frames of occupation of sites throughout a region. Likewise, in order to understand cultural adaptations to environmental changes, it is necessary to place regional sites in time and interpret that chronology against environmental histories. Key chronometric research domains would be (1) the reliability and refinement of regional dating, (2) the character and timeframe of occupation within the region, and (3) scientific data related to chronology and culture history, subsistence and settlement strategies, and trade.

Chronology is of basic importance to any archaeological research endeavor because it provides a context for addressing many other research issues. Thus, the precision and accuracy of dates are critical because they form the baseline for the other research topics. For example, chronological data could potentially contribute to our understanding of the nature and timing of population movements in the area and to establish relationships among sites in the local or broader region. Chronological determinations may also assist in refining regional or local culture historical sequences.

The Smith River area, including the Project area, was likely occupied from the Paleoindian period to Late Prehistoric times (Roll 2003). Previous research within the District has successfully produced carbon bearing features. Archaeological testing at site 24ME1105, located within the District, produced a radiocarbon date of 795+15 (AD 1210-1270), indicating a Late Prehistoric occupation and testing at 24ME163 produced a radiocarbon date of 3,215+20, which calibrates to 1520-1430 BC, indicating a Middle Plains Archaic occupation (Tetra Tech 2020).

One of the primary goals of data recovery is to generate information related to the occupational history of a site that could potentially be lost through unavoidable impacts to the site. It is hypothesized that by collecting additional data from 24ME163 and

24ME1109, and through further analysis, a better understanding of the prehistoric site will be ascertained (i.e., identifying if the site is a result of multiple or single use occupation). Information from features originating at different soil horizons (rather than the same level, as might be expected from a single occupation site) would shed light on such questions. Therefore, such data through further excavations may reveal that the location was visited multiple times in the past, demonstrating a temporally mixed site.

Absolute Dating

Absolute dating techniques are preferable to relative dating of diagnostic artifacts because absolute dating is an independent assessment of the age of the site. Radiocarbon dating is an extremely accurate and reliable method for establishing the age of organic materials (e.g., charcoal, wood, burned floral remains, bone, shell, or organic-rich soil). Multiple radiocarbon dates that cluster together (i.e., have a high degree of overlap in their standard deviations) represent organic matter that was deposited in a relatively short span of time. If, however, dates are acquired that have little to no overlap, it is more likely that the material was deposited at different times, which may reflect multiple occupations and/or the use of different areas or portions of the site through time.

Relative Dating

In additional to the identification material appropriate for establishing absolute dates for a site, a relative chronology may be established by linking temporally diagnostic artifact types (e.g., projectile points, basketry, shell or glass beads) present at the site to the regional culture history. This latter relative dating method would, however, be much less precise. Ideally, relative dating results from a site support absolute dating results, so that ages obtained through radiocarbon, obsidian hydration, or thermoluminescence techniques can be used in conjunction with diagnostic time-marker artifacts to assess the overall age of a site.

Obsidian hydration data have the potential to date artifacts, archaeological strata, and sites. However, before hydration data can be used to achieve chronological objectives, it is necessary to acknowledge the variables that can affect the patterning of hydration data (i.e., sampling strategies, environmental variables, technological variables, and the application of hydration rate formulae, projectile point chronology, and post-depositional processes). Obsidian hydration and projectile point types are routinely interpreted as chronological indicators.

Research Questions:

- When was site 24ME163 occupied? Are there multiple occupation periods?
- When was site 24ME1109 occupied? Are there multiple occupation periods?

Data Requirements:

- Projectile points, pottery, and other temporal indicators

- Obsidian for hydration studies to complement and compare with chronological interpretations of the projectile point types and other temporal indicators
- Intact subsurface hearths or house remains with charcoal for radiocarbon dating
- Single-component cultural deposits
- Stratified cultural deposits

4.2 Lithic Procurement and Lithic Technology

Procurement Strategy

The procurement of raw materials for stone tool manufacture was an essential task for hunter-gatherers of the Northwestern Plains. Procurement strategy may be defined by lithic material types and tool types and can occur in a variety of ways. The collection of raw stone material is often discussed in terms of embedded or disembedded/direct procurement (Binford 1979). Embedded procurement occurred in conjunction with general day to day activities while disembedded procurement occurred as a dedicated task to acquire valuable materials.

Peterson postulates that those who visited the Sheep Creek Quarry practiced embedded procurement based on presence of expedient tools manufactured of local chert and complete absence of formal tools found during 2019 test excavations (Tetra Tech 2020). The recovery of additional lithic materials can provide additional data for the procurement strategies and lithic technologies practiced.

Lithic Technology

Expedient and patterned tools reflect lithic technology. Expedient tools are manufactured, shaped, and retouched for immediate use and require little production effort (Andrefsky 2005). After this need has been met, these tools are often abandoned near use locations. In contrast, formalized or patterned tools require an investment of time and energy, and as such, these tools tend to be retained. These tools are designed to be used repeatedly and are generally abandoned after they have been broken or exhausted. Broken patterned tools are frequently encountered at production sites, such as quarries (Andrefsky 2005). These two types of lithic technologies are known as expedient and curative, and it is likely all prehistoric groups used both technologies. However, the extent to which each strategy was predominantly employed may be apparent at individual sites. Additionally, an expedient lithic technology may be suggested by a high ratio of flakes to tools while a curative lithic technology may be represented by a lower ratio of flakes to tools.

Data from the previous work from subsurface testing within the quarry identified 18 tools from sites 24ME163 and 24ME1105 (a lithic scatter site recommended eligible for the NRHP within the District avoided during Phase 1 project impacts) and the assemblages include eight cores, three modified flakes, and four early-stage bifaces. No stone tools have been recovered from 24ME1109. The tools from 24ME163 and 24ME1105 are defined as expedient due to the high ratio of flakes to tools with the recovery of 1,132 pieces of flaking debris and 18 tools, indicating prehistoric groups primarily practiced an expedient lithic technology within these two locations (Tetra Tech 2020). However, the expedient strategy was not an absolute practice, as demonstrated by the presence of non-local lithic materials, including obsidian, quartzite, and chalcedony, indicating curated raw materials and tools were imported to the Project area and retouched during site occupation (ibid).

Research Questions:

- What types of procurement strategies were practiced within the District?
- What type of lithic technologies were employed at Site 24ME163 and Site 24ME1109 and do they differ from each other?

Data Requirements:

- Intact subsurface deposits with lithic debitage at sites 24ME1109 and 24ME163
- Expedient and patterned tools at both 24ME163 and 24ME1109

4.3 Chemical Make-up of the Sheep Creek Chert

Lithic materials can be difficult materials to source. Some materials can be reliably attributed to their source by visual examination, but visual methods are not always reliable and are often arbitrary and based on color. Research at a single quarry pit at Camp Baker, located in the same region as the Project area, exhibited a huge amount of variation in color, translucence, luster, texture, and structure, demonstrating the unreliability of basing chert sourcing on the lithics' appearance (Roll et al. 2005). Sheep Creek, which runs through the Project area, lies 11 miles east of the Smith River, in an area well known for its chert quarries including the Camp Baker Quarry and the Dogget Quarry (Tetra Tech 2015). Previous archaeological research in the region has attempted to distinguish chemical "fingerprints" of Montana chert samples for the purpose of chemically sourcing chert artifacts through the use of chemical testing (Roll et al. 2005).

Chemistry-based methods including XRF and Neutron Activation Analysis (NAA) have gained traction in their ability to source lithic materials. Measuring the elements present in chert can be used to identify chemical fingerprints in the chert and can thus trace unique sources (Roll et al. 2005). Research using the application of laser ablation-inductively coupled plasma mass spectrometry (LA-ICP-MS) has shown promise in chemically sourcing chert artifacts. Previous analyses of southwest Montana chert were conducted by the Archaeometry Laboratory within the University of Missouri Research Reactor (MURR) department. Although the LA-ICP-MS results were mixed, researchers still believe sourcing through chemical analysis is a viable research direction.

As the district consists primarily of a stone quarrying site, the research design has been developed to guide recovery of data that would potentially be lost through implementation of this Project. Data sought are those which would contribute new and/or unique information to prehistory beyond the current body of literature.

Research Question:

- What is the chemical make-up of the chert within the Sheep Creek Quarry Archaeological District and does a unique chemical signature exist?

Data Requirements:

- Approximately 30 chert samples weighing at least 10 grams each collected from across the District.

5 Methods

The methods applied for data recovery will be consistent with excavation techniques used by other cultural resource professionals in the Northwestern Plains.

5.1 Field Methods

All excavation units were vertically controlled levels within a horizontally controlled, site-wide Cartesian grid. Units were dug and screened in 10-cm levels through ¼-inch (in.) mesh screen; in keeping with the field methods previously used at the site and industry standards, ¼-in. mesh screen was used.

Collected artifacts were bagged and labeled with the provenience, date, project, and site name clearly labeled, and initials of excavation crew. In addition, excavation units and bag numbers were assigned consecutively and tracked in a master log sheet with data cross-referenced between logs (ex. Unit 1, Site Name, Feature/Artifact Number, Bag Numbers) and field forms.

All field activity was documented with standardized sketches of soil profiles; along with, photographs of soil profiles, excavation units, and site-wide overviews; and archaeological forms that document all excavation activity. All artifacts were properly stabilized in the field, placed in bags, and labeled to include all provenience data. Following the fieldwork, all artifacts and field records were transported to one of Kleinfelder/Garcia and Associates' (GANDA's) laboratory facilities for analysis.

Photographs were taken with a Sony Cybershot 20.1-megapixel digital camera. Opening and closing plan view photos were taken of units. A sub-meter accuracy Trimble Global Positioning System (GPS) unit was used to record Universal Transverse Mercator (UTM) points in NAD83 on surface artifacts and at the southwest corner of units.

5.2 Laboratory Methods

The following laboratory procedures were used to sort and analyze cultural materials recovered during excavation. All materials recovered during fieldwork were processed in sequential order (by unit or feature and level from top to bottom) and by complexity of category. All tools received an individual catalog designation, whereas debitage was assigned a group number. Smaller items or materials were packaged in storage bags or appropriate material and accompanied by separate provenience labels. Large items were individually labeled and wrapped as necessary to prevent damage.

Following the testing, artifacts were placed in water and gently washed with a toothbrush. They were allowed to dry and were then placed in clean industrial polyethylene bags with labels containing the site number, unit, depth, and date of excavation. Kleinfelder/GANDA lithic analyst Bill Bloomer then created an artifact catalog (**Appendices A and B**) and completed the lithic catalog of materials with individual number, weight, and description.

5.2.1 Flaked Stone Analysis

Technological analyses were conducted for flaked stone tools, cores, and debitage, incorporating a suite of morphological characteristics and technological attributes to study assemblage composition, toolstone procurement and tool manufacture, use, and maintenance patterns. Technological core and debitage analyses detail the kinds of flaked stone tool making and maintenance activities conducted across the site. General methods of flaked stone analysis applied to all tools and cores are described first. Tool and core type definitions follow, with specific analytical methods for each artifact type. Flake types are also defined with a discussion of technological debitage analysis. Provenience, technological data, and metric dimensions for 24ME163 and 24ME1109 flaked stone artifacts are tabulated in **Appendix A** and **Appendix B**.

Analytical Methods

Analytical data includes toolstone type, condition, metric dimensions, blank type, breakage type, extant flaking technique, and use wear with specific comments for each artifact. Additional recorded typological descriptions and morphological attributes are discussed below for each tool type.

Toolstone type is recorded as basalt (BAS), chert (CHT), chalcedony (CHL), obsidian (OBS), and quartzite (QTZ). Condition classifies the artifact as a whole specimen, or as one of several fragment types. Condition was recorded as whole (WHL), nearly complete (NC), proximal (PRX), medial (MED), distal (DST), undifferentiated end (END), lateral margin (LAT), undifferentiated margin (MRG), or undifferentiated fragment (FRG). The recorded metric dimensions include length, width, thickness in millimeters, and weight in grams.

Blank type describes the form of the unworked piece of toolstone at the beginning of artifact manufacture and is important for understanding toolstone procurement and the initial steps in tool manufacture. Blank types might include cobble, pebble, block, flake, or any of the technologically diagnostic flake types defined below in the discussion of debitage analysis. Indeterminate blanks are worked beyond the point where original blank morphology is visible.

Breakage types often indicate whether an artifact was broken during manufacture or maintenance reduction, use, or as a result of post-depositional processes. Unfortunately, general bending fractures are the most common break type. They can result from reduction, use, or post-depositional trampling, and so are not diagnostic. Transverse bending fractures, perverse fractures, outrepassé removals, material flaws, and some thermal breaks indicate manufacture failure. Bending fractures are typically flat and perpendicular, caused by tension or compression from impact shock or trampling that bends the artifact beyond its limits. If concentric rings are visible on the break, they emanate from the center of one face. Transverse bending fractures are the same as general bending fractures, except that the concentric rings emanate from one lateral edge indicating that intentional percussion initiated the fracture. Perverse fractures are spiral or twisting breaks, initiated as a flake removal at the artifact's edge. An outrepassé is an "overshot" flake removal that went too far across the artifact's face, removing the opposite margin. Material flaws are vugs, irregularities or natural fracture planes within the unworked toolstone, which become apparent during reduction. Thermal breaks, such as internal crenulations and curvilinear fractures, result from failed heat treatment during the manufacture process. Thermal breaks, such as pot lids and surface crazing, result from post-depositional exposure to direct flame.

Use is sometimes indicated by bending fractures with finial terminations, which extend the fracture scar beyond the bending plane, lipped onto one face of the artifact. This lipped extension is often caused by a forceful impact at the tip of an artifact such as when a projectile point hits a hard object. Burination scars along a lateral edge, or facial, also reflect use impact. General percussion fractures might also reflect use, or failed reduction.

Extant flaking technique concerns the method of flake removal, indicated by the types of negative flake scars apparent on the discarded artifact. Flaking techniques, including percussion, pressure, a combination of percussion and pressure, and bipolar, are recorded to identify reduction patterns that might vary by site area and through time. Sometimes, especially during biface finishing, pressure flaking can obliterate the evidence of previous percussion reduction. Small flake removals typically result from use of an artifact's edge for scraping or cutting. Other use wear along a tool edge is macroscopically evident as small step fractures, crushing, rounding, and polish.

<u>Projectile Points</u>

Projectile points are typically bifacial tools with a pointed tip and basal hafting elements, such as notches or a stem, used to attach the point to an arrow or dart shaft. Most points are extensively shaped and well formed, using pressure reduction techniques during final shaping. Point type classifications and chronological interpretations are based on recognized Northwestern Plains typology (Tetra Tech 2020: Figure 3). Metric attributes were recorded as defined by Thomas (1970, 1981). Bifacial tool fragments that might be projectile point or knife parts, such as distal tips and medial sections, are classified as biface fragments.

<u>Bifaces</u>

Bifaces are flaked stone tools that are relatively ovate in shape, but pointed at one or both ends, with lenticular cross-sections at their greatest width. Bifaces differ from projectile points in that they have no distinct hafting elements, such as notches or a stem, for attachment to arrow or dart shafts. Finished bifacial tools are typically well-shaped using percussion and/or pressure reduction techniques, which leave flake scars across both faces of the biface.

During manufacture, bifaces go through several technological stages of reduction from initial shaping to the final form. Therefore, bifaces in this collection have been classified by manufacture stage to study tool production. Biface stage classifications follow a five-stage adaptation (Bloomer et al. 1997: Appendix H) of Callahan's (1979) more comprehensive stage classification system. In brief, stage categories are based on percussion and pressure flake scar patterning, which reflects the extent of reduction through the continuum of biface manufacture. Completeness of shape is also a variable, in that the shape becomes refined through manufacture from an irregular flake blank to a symmetrical and straight-edged final form. At any point along the reduction continuum, a biface might have been used as a tool, with subsequent reduction directed towards continued manufacture or maintenance.

Stage 1 bifaces are essentially flake blanks showing only minimal reduction, which served to remove large irregularities. Stage 2 bifaces have undergone initial shaping and edge preparation to make a bifacial edge for further reduction and thinning. Initial biface thinning and shape regularization occurs during stage 3. Stage 4 bifaces show secondary thinning and are typically well-shaped. Final shaping occurs during stage 5, usually with pressure reduction. Small fragments of extensively well-shaped bifacial tools are often classified as stage 5. Small thin bifaces with remnant flake blank morphology and only pressure reduction that have not been reduced through the percussion to pressure reduction continuum are classified as pressure-only bifaces.

Unifaces

Unifaces are intentionally flaked and sometimes extensively shaped so that original flake blank morphology is obscured. Unifaces typically have well-shaped steeply angled unifacial use edges, but secondary bifacial use edges might also be present. The number of modified edges is recorded, as well as attributes for the primary and secondary use edges. The recorded attributes include type of modification, whether the intentional modification was percussion or pressure, position of the modification, the surface modified, edge shape, edge angle, and use wear. Comments are recorded for additional use edges.

Flake Tools

Flake tools are reduction flakes which have been intentionally modified by percussion or pressure to manufacture a use edge, as well as flakes with less invasive edge modifications that were produced directly by use. The number of modified edges is recorded, as well as attributes for the primary and secondary use edges. The recorded attributes include the type of modification, whether the modification was intentional percussion or pressure, position of the modification, the surface modified, edge shape, edge angle, and use wear. Comments are recorded for additional use edges. Flake tool length measures the flake blank from platform to termination, which may be less than the width.

Cores

Cores are masses of toolstone from which usable flakes were removed by percussion. Core type was recorded as multi-directional, bifacial, unidirectional, or bipolar. Each type describes the flake scar patterning that reflects the technique used for producing flakes. Bipolar cores are struck while resting on an anvil, removing thin straight flakes from opposite directions at the same time.

Debitage

Debitage is the waste flakes produced by percussion and pressure reduction techniques during flaked stone tool manufacture and maintenance. A technological analysis of the debitage was conducted to characterize the predominant flaked stone reduction patterns. The assumption behind technological analysis is that distinct reduction activities produce distinct debitage assemblages. The reduction technology evident for any given debitage assemblage is characterized by the variable proportions of the diagnostic flake types. Core reduction and the initial reduction of flake blanks produce high percentages of cortical flakes and interior flakes, with only a low frequency of edge preparation flakes and no biface thinning flakes or pressure flakes. Biface reduction, through the entire continuum of early (stages 1 to 3) to late stages (3 and 4) and pressure flaking (stage 5), results in a relatively even representation of each flake type. An assemblage entirely composed of late-stage biface reduction debris will be dominated by late-stage biface thinning flakes and pressure flakes, evincing only small frequencies of cortical flakes, interior flakes, edge preparation flakes, and early biface thinning flakes. When thin flake blanks are pressure flaked, with little or no initial percussion thinning, early pressure flakes are conspicuous in the assemblage. In this case, pressure flakes, including early and late pressure flakes, will comprise a large part of the debitage assemblage.

In addition, the extent of reduction through the core and biface reduction continuums indicates the kinds of tools that were made. Core reduction generally produced flakes for flake tools. Core reduction flakes also became flake blanks for bifacial tool manufacture. Biface reduction of a flake blank is the process of making bifacial edges and shaping bifacial forms. The biface often goes through a continuum of reduction to produce a well-shaped relatively symmetrical and lenticular finished form. The further along the biface reduction continuum, the better shaped is the bifacial tool.

Twelve flake type categories are considered technologically diagnostic in this analysis. That is, the relative proportions of these flake types indicate the manufacture techniques and the kinds of tools being made. The diagnostic flake types include cortical, complex interior, simple interior, linear, simple interior/complex platform, edge preparation, early biface thinning, late biface thinning, early pressure, late pressure, notching pressure, and bipolar. Five other flake type categories are considered non-diagnostic: platform preparation/pressure, simple fragment, complex fragment, cortical fragment, and shatter.

Technological analysis separated debitage into four size grades: 2 in., 1 in., ½ in., and ¼ in. Size grades represent the screen mesh size that will hold the debitage. Size grades yield data on relative raw material size, core size, and the relative size of flake blanks and bifaces reduced at various stages through the reduction continuum.

Flake Types

CORT - Cortical - a flake with cortex, generally covering over 25% of its dorsal surface. Other flake types with small amounts of cortex, such as biface thinning flakes, are not classified as cortical flakes.

CINT - Complex Interior - a non-cortical flake with three or more negative flake scars on its dorsal surface, not counting platform preparation scars. Negative flake scar patterning on the dorsal surface is not typically linear along the axis of the flake but shows a complexity of scars emanating from various and opposing directions. Platforms are simple or complex with multiple facets.

SINT - Simple Interior - a non-cortical flake with three or fewer negative flake scars on its dorsal surface, not counting platform preparation scars. Negative flake scar patterning on the dorsal surface is typically linear along the axis of the flake. Simple, single-facet platforms are typical.

LIN - Linear - Long, blade-like interior flake.

SINT/CP - Simple Interior/Complex Platform - same as for a simple interior flake, but the platform is complex with multiple facets.

EP - Edge Preparation - a group of several distinct flake types, which result from shaping an unworked edge of a flake blank. These flakes include edge preparation flakes, which are wider than they are long, with pronounced bulbs of percussion and dorsal areas with few or no negative flake scars; bulb removal flakes, which retain a remnant of the flake blank's ventral bulb of percussion; and alternate flakes, which are wider than long, and wedge-shaped, resulting from the reduction of a thick square edge.

EBT - Early Biface Thinning - an often slightly curved flake with a simple or complex bifacial platform and a few dorsal flake scars which emanate generally from the flake's platform.

LBT - Late Biface Thinning - a curved or flat flake with a bifacial platform and multiple dorsal flake scars, which may reveal a complex pattern of previous flake removals. Typical late-stage thinning flakes retain partial dorsal scars showing previous flake removals from the opposite edge of the biface.

EPR - Early Pressure - the first pressure flakes removed from a flake blank or percussion flaked biface show few to no dorsal flake scars, depending on the morphology of the worked surface. Platforms may be perpendicular or oblique to the longitudinal axis of the flake. Shapes vary from wide and short to long and narrow.

LPR - Late Pressure - late pressure flakes have a complex dorsal surface, and platforms are typically oblique to the longitudinal axis of the flake. Shapes are most often long and narrow, and either straight or doglegged.

NPR - Notching Pressure - notching flakes result from notching a projectile point. Notching flakes are fan shaped, short, and round, with the platform set into a depression.

BP - Bipolar - bipolar flakes are a result of percussion from opposite directions at the same time, typically from placing the toolstone mass on an anvil and then down striking with a hard hammerstone from above. Flake attributes include crushing at opposite ends, with distinct cones of percussion and straight ventral and dorsal surfaces.

PP - Platform Preparation/Pressure - platform preparation flakes typically result from the light percussion of a bifacial edge to prepare a flake detachment platform. Pressure flakes are often indistinguishable from light percussion platform preparation flakes, and so this category subsumes less distinctive flakes, which may have resulted from pressure reduction.

SF - Simple Fragments – fragments with simple dorsal flake scar morphology.

CF - Complex Fragments – typically fragments of complex interior flakes, biface thinning flakes, pressure flakes, and platform preparation/pressure flakes.

CTF - Cortical Fragments - fragments of flakes with cortex.

SH - Shatter - angular fragments of toolstone without typical flake attributes. Shatter includes fragments and potlids from unintentional thermal alteration.

5.2.2 X-ray Fluorescence Analysis

All obsidian debitage recovered from both 24ME163 and 24ME1109 was selected as samples for XRF spectrometer analysis to investigate the sources of toolstone which indicate the interaction spheres of population movement and trade. The obsidian tools from each site were included in this analysis. All of the obsidian flakes meeting the size requirements for XRF analysis were selected from surface contexts, as well as from variable depths within several spatially representative excavation units at each site. In total, 11 obsidian samples were submitted to Northwest Research Obsidian Studies Laboratory in Corvallis, Oregon.

Alex Nyers (2021) describes the analytical techniques in his XRF report (**Appendix D**), and an excerpt is below:

> “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”.

5.2.3 Obsidian Hydration Analysis

All obsidian flakes recovered, 11 in total, from both sites were selected for obsidian hydration. Following XRF analysis, the obsidian samples were submitted for microscopic obsidian hydration analysis to provide temporally relative data for chronological interpretations. Obsidian samples were analyzed at Willamette Analytics in Corvallis, Oregon.

Jennifer Thatcher (2021) describes the analytical techniques in her obsidian hydration report (**Appendix E**) and an excerpt is below:

> 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 0.100 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.

Hydration Interpretation based on the Tahoe Sierra Hydration Curve

Obsidian hydration data from sites 24ME163 and 24ME1109 are interpreted chronologically with reference to a hydration curve (**Figure 7**) developed for the Tahoe Sierra Nevada mountain region in California and in conjunction with regional data (Bloomer and Jaffke 2012). The hydration curve represents the general tendency for the rate of obsidian hydration above the 5,500 ft elevation. The 5,500-ft elevation is significant because at this high elevation the hydration rate is noticeably slower than at lower elevations along the western Sierra Nevada foothills. Chilling temperatures, periodic forest fires, and constant bioturbation of archaeological deposits above 5,500 ft likely contribute to a variable hydration rate along the general curve. Because of this variability, the curve is applied irrespective of obsidian source for most of the obsidian sources, excluding obsidian sources known to hydrate at much faster rates or much slower rates.

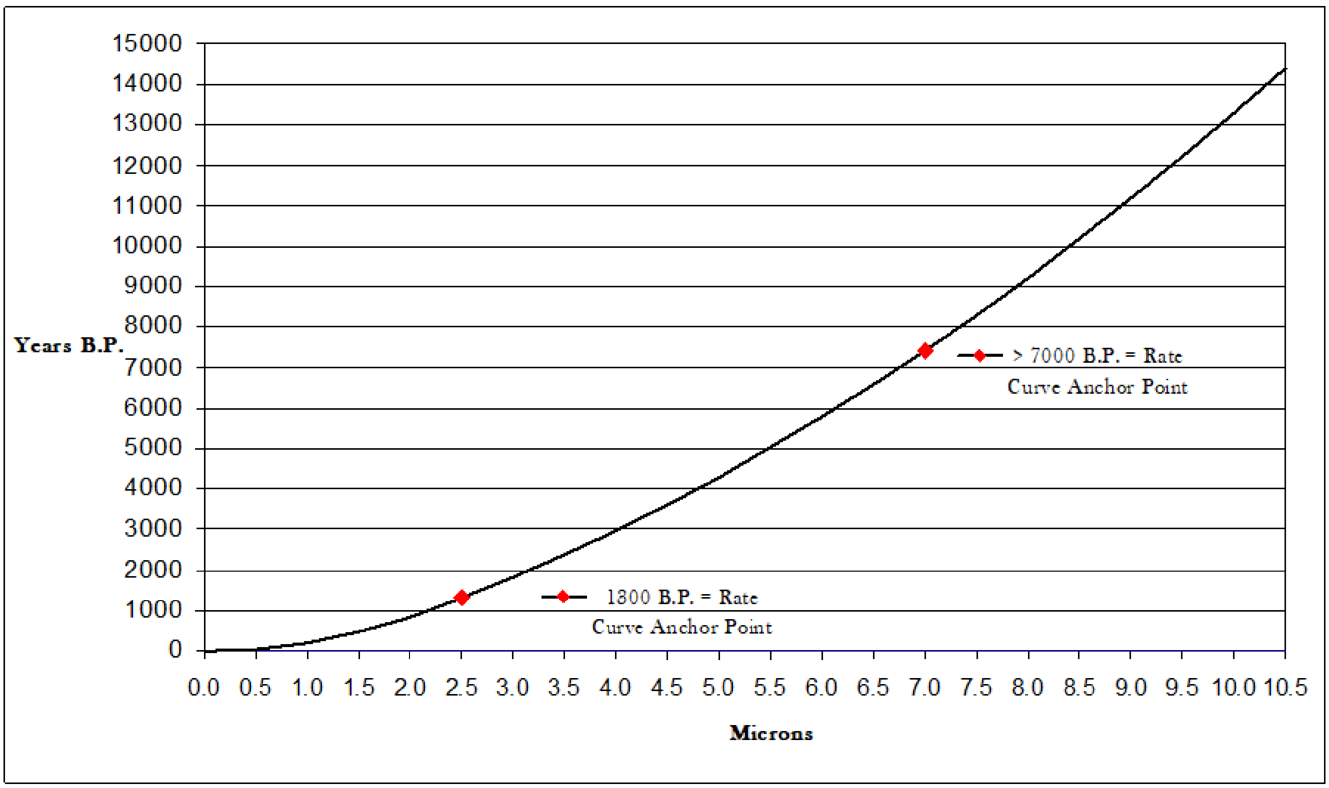


Figure 7: Tahoe Sierra Obsidian Hydration Curve

The curve is based on two anchor points, one at each end of the temporal spectrum. The older end of the curve is anchored by a 7.0µ (micron) hydration mean associated with a single-component Pre-Archaic deposit at site FS 05-19-795 in South Lake Tahoe, California (Martin 1998). Pre-archaic deposits typically predate 7,000 BP, therefore, the

7.0µ value is interpreted as greater than 7,000 BP and plotted at 7,420 BP on the hydration curve. The younger end of the curve is anchored by the 2.5µ value at the 1,300 BP Tahoe Sierra transition from Middle Archaic to Late Archaic, because Late Archaic arrow point hydration data are relatively consistent at less than 2.5µ. The relative accuracy and efficacy of this hypothetical curve is supported by a Tahoe Sierra hydration/XRF database that includes 294 chronologically typable obsidian projectile points and 1,460 hydration rim values.

The application of the Tahoe Sierra hydration curve is appropriate because both 24ME163 and 24ME1109 are located at elevations from 5,800 to 6,000 feet above sea level within a mountain environment with mean high and low temperatures similar to that for the Tahoe Sierra region (see climatological data for White Sulphur Springs, Montana, compared with that for various climatological stations in the vicinity of Lake Tahoe, California [https://wrcc.dri.edu/Climate/west coop summaries.php]). Regional temperature variation is an important factor in influencing obsidian hydration rates, represented as Effective Hydration Temperature (EHT). EHT is defined as a constant temperature which yields the same hydration results as the actual temperature as it varies through time.

The application of the Tahoe Sierra hydration curve is further supported by comparison with a recent analysis of obsidian hydration/XRF data from the Clark Creek Cache, located near Helena in west-central Montana (Rennie and Davis 2016), approximately 90 km (56 miles) west of the Black Butte Copper Project area. The Clark Creek Cache is characterized by the predominance of 39 obsidian flake tools, associated in a small pit with several chert flake tools and a small number of unmodified obsidian and chert flakes. Five of the obsidian flake tools were submitted to Dr. Richard Hughes for geochemical XRF trace element analysis at his Geochemical Research Laboratory in California. Analytical results indicated that all five were identified from the Bear Gulch, Idaho, source located in the Centennial Mountains near the Idaho/Montana border, approximately 280 km (174 miles) south of the Clark Creek Cache and approximately 280 km (174 miles) southwest of the Black Butte Copper Project area,

The same five flake tools were then submitted to Tom Origer at Origer's Obsidian Laboratory in California for hydration analysis and age calculation. Hydration analysis returned five original rim values (Rennie and Davis 2016: Table 7) with a 1.4µ hydration mean. Age calculations relied on a hydration rate formula (years BP = 153.4x2, where x is the hydration rim value) for the Napa Valley obsidian source in north-central California. Adjustments were made for EHT variation between Napa Valley and the Clark Creek Cache location, using climatological data from Helena, as well as adjustments for obsidian source hydration rate variability between Napa Valley obsidian and Bear Gulch obsidian. The result of these adjustments was that the hydration rim value measured for each flake tool was increased by 0.4µ (e.g., from 1.2µ to 1.6µ; Rennie and Davis 2016: Table 7) for application of the Napa Valley formula. Therefore, the reported 1.7µ adjusted hydration mean rim value for the five flake tools was applied to the Napa Valley formula and interpreted at approximately 444 ± 18 BP near the end of the Late Prehistoric Period. In comparison, applying the original 1.4µ unadjusted hydration mean rim value on the Tahoe Sierra Hydration Curve equates to approximately 416 BP, only ten years different than the calculated 444 ± 18 years margin of error. Hence, application of the Tahoe Sierra Hydration Curve is a relatively accurate method for interpreting hydration data from sites 24ME163 and 24ME1109.

5.2.4 Radiocarbon Analysis

Nine hearth features were encountered during excavation, all of which contained varying amounts of charcoal. Charcoal samples were carefully excavated from an in-situ context, packaged in aluminum foil, and placed in a bag and labeled. Each feature contained charcoal deemed suitable for accelerator mass spectrometry (AMS) radiocarbon dating. Two charcoal samples from each feature were sent to Beta Analytic Testing Laboratory in Miami, Florida (expect for one feature for which only one sample was sent), where they were assessed and subjected to pretreatment procedures prior to being dated.

Analytical techniques conducted by Beta Analytic radiocarbon testing laboratory are described in the radiocarbon report (**Appendix F**) and an excerpt is below:

> "Reported results are accredited to ISO/IEC 17025:2017 Testing Accreditation PJLA #59423 standards and all chemistry was performed here in our laboratory and counted in our own accelerators here. Conventional Radiocarbon Ages and sigmas are rounded to the nearest 10 years per the conventions of the 1977 International Radiocarbon Conference. When counting statistics produce sigmas lower than +/- 30 years, a conservative +/- 30 BP is cited for the result unless otherwise requested. The reported d13C values were measured separately in an IRMS (isotope ratio mass spectrometer)".

6 Data Recovery at Site 24ME163

The field methods used at 24ME163 aligned with the research design and approach prepared for this project. The excavation unit placement deviated from the original plan to excavate intact subsurface features.

Site 24ME163 is located along a dirt and gravel access road just south and east of Butte Creek Road. Coon Creek, a tributary to Sheep Creek, makes up the western boundary of the site. Portions of the dirt access road within the site boundary were capped with gravel to avoid impacts to the site during routine vehicular traffic prior to mine construction activities. Vegetation within the site consists of annual grasses, scrubland plants, and riparian vegetation closer to the creek. The site slopes gently to the west and is at an elevation of 5790 ft amsl (**Figure 8**).

Mine construction may require the placement of a culvert, a sediment trap east of the culvert, and improvements to the existing access road within the southern portion of site 24ME163. As described in Chapter 3, as a result of informal consultation between Tetra Tech and James Strait (MDEQ), it was determined the excavation of 10 units would satisfy mitigation of potential adverse effects of the site. Four units were excavated in 2019 at the proposed culvert location. Additional data recovery in 2020 included the placement of six (1x1 m) excavation units, which will bring the total number of data recovery units to 10, including the four units previously excavated in 2019.

Figure 8: Overview of 24ME163, facing northwest.

Prior to excavation, the site was surveyed, and the construction methods and the culvert and sediment trap location were discussed with Sandfire Senior Geologist Todd Johnson. Excavation units were subsequently laid out to capture a sample of the site where ground disturbance could be occurring.

Archaeological fieldwork was conducted over a 6-day period, Tuesday June 23, 2020 - Sunday June 28, 2020. The excavation crew consisted of Kleinfelder/GANDA archaeologists Jessica Neal, M.A., RPA, and Cole Wandler, M.A., RPA, and project manager Pam Spinelli. Weather was generally cool and clear in the morning with thunderstorms developing in the afternoon. The final day of excavation was impacted by a large storm system producing significant rainfall.

Six excavation units were placed in the southern portion of the site slated to be impacted by proposed road improvements and culvert construction activities (**Figures 9 and 10**). The excavation of the six units resulted in the recovery of 3,300 pieces of chert debitage, five chalcedony flakes, four obsidian flakes, two quartzite flakes, twelve bifaces, including one possible projectile point base fragment, six flake tools, one uniface, four cores, two hearth features, and charcoal.

The following discussion details the results of data recovery at 24ME163.

Figure 9: Excavation at 24ME163 with Black Butte in background

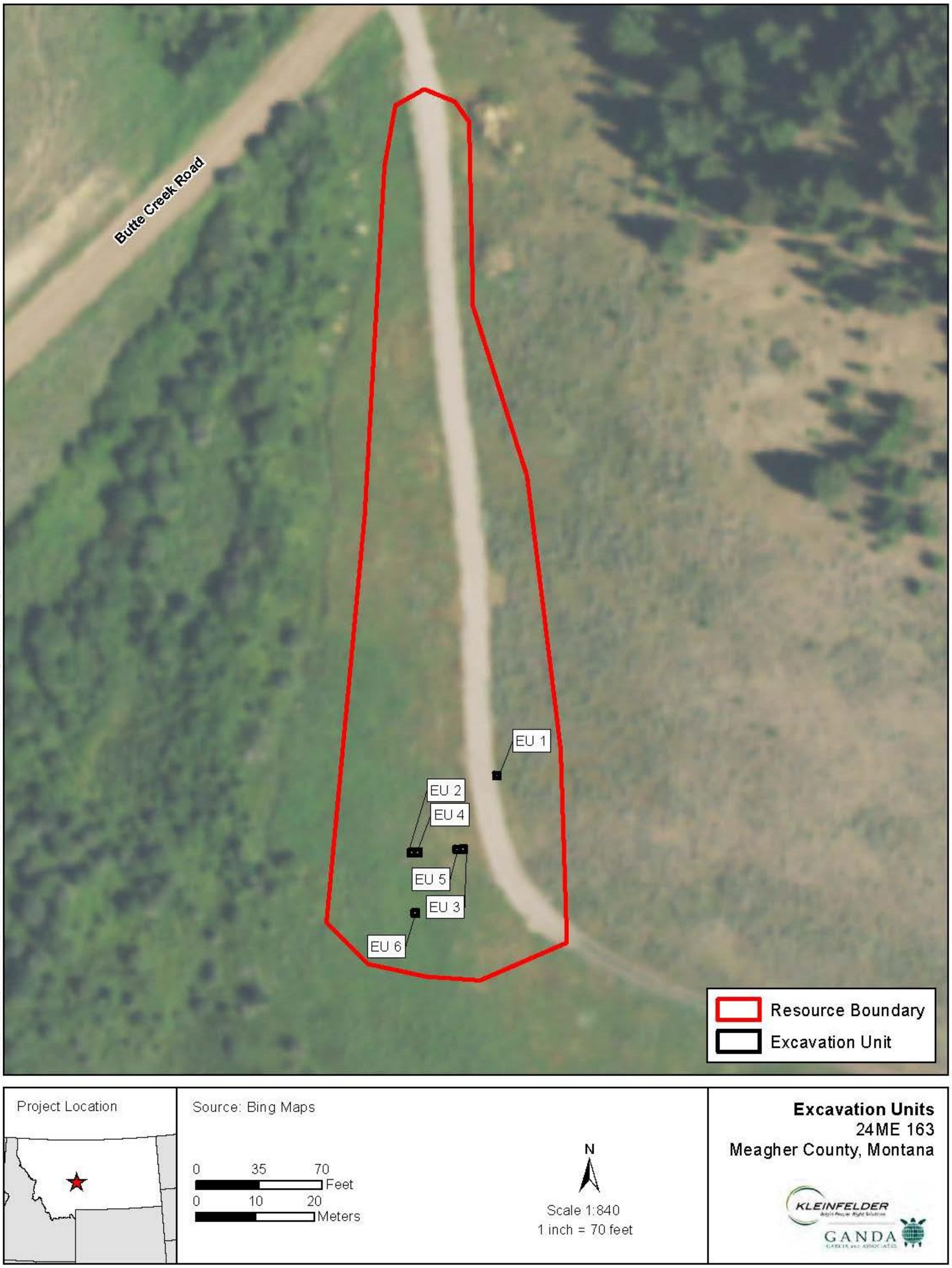


Figure 10: Excavation Units at 24ME163

6.1 Stratigraphy

Two stratigraphic units were identified during data recovery and were consistent with the stratigraphic units encountered during previous subsurface testing and data recovery (Tetra Tech 2020). The top layer consisted of a loosely consolidated, very dark brown silty loam (10 YR 2/2) with medium to fine sod roots that extended approximately 8 cm bs. The lower stratigraphic layer is a silty clay loam extending from approximately 8cm bs. The lower boundary grades into the weathered shale bedrock.

6.2 Excavation Units

Six excavation units (EU) were placed in the southern portion of the site (see **Table 3** for details). One unit was placed just west of the access road, where the site would be impacted by minor access road improvements, and five units were placed west of the access road where the culvert and sediment trap may be constructed. The lower boundaries of the units graded into weather shale bedrock. Sterile levels were not encountered as debitage and shale became increasingly mixed.

Table 3. Excavation Unit Summary at 24ME163

Unit	SW Corner UTM	Max. Depth	Notes	Debitage Total	Tools
EU 1	506272mE 5179842mN	80 cm bs	Hit shale bedrock at 60cm bs	255	None
EU 2	506257mE 2179829mN	60 cm bs	Contained Feature 1	606	1 Flake Tool, 4 Bifaces
EU 3	506266mE 5179830mN	50 cm bs	Contained Feature 1	284	1 Uniface, 2 Flake Tools, 2 Bifaces, 2 Cores
EU 4	506258mE 5179829mN	50 cm bs	Contained Feature 2	660	3 Bifaces, 1 Core
EU 5	506265mE 51797830mN	50 cm bs	Contained Feature 2	577	2 Flake Tools, 1 Biface, 1 Core
EU 6	506258mE 5179818mN	40 cm bs	Did not encounter bedrock, unit prematurely stopped due to weather; 10-40 cm bs wet screened due to wet soil	952	1 Flake Tool, 1 Biface, 1 Possible Projectile Point Fragment

6.3 Features

The following details the features identified during the data recovery program of site 24ME163. Two hearth features were exposed during the excavation (see **Table 4** and **Figure 11**). Both features contained large quantities of fire affected rock (FAR), charcoal, and debitage. Hearths at hunter-gather sites generally served three main functions: lighting, warming, or cooking (Kornfeld et al. 2010). Additionally, hearths were used for the heat treatment of chert, which can improve the workability of the raw material.

Table 4. Hearth Features at 24ME163

Feature	Unit	Details	Depth	Radiocarbon Dates
Feature 1	EU 2/ EU 4	Disturbed Rock Hearth	20-40 cm bs	900 BP and 950 BP
Feature 2	EU 3/ EU 5	Disturbed Rock Hearth	20-50 cm bs	900 BP and 930 BP

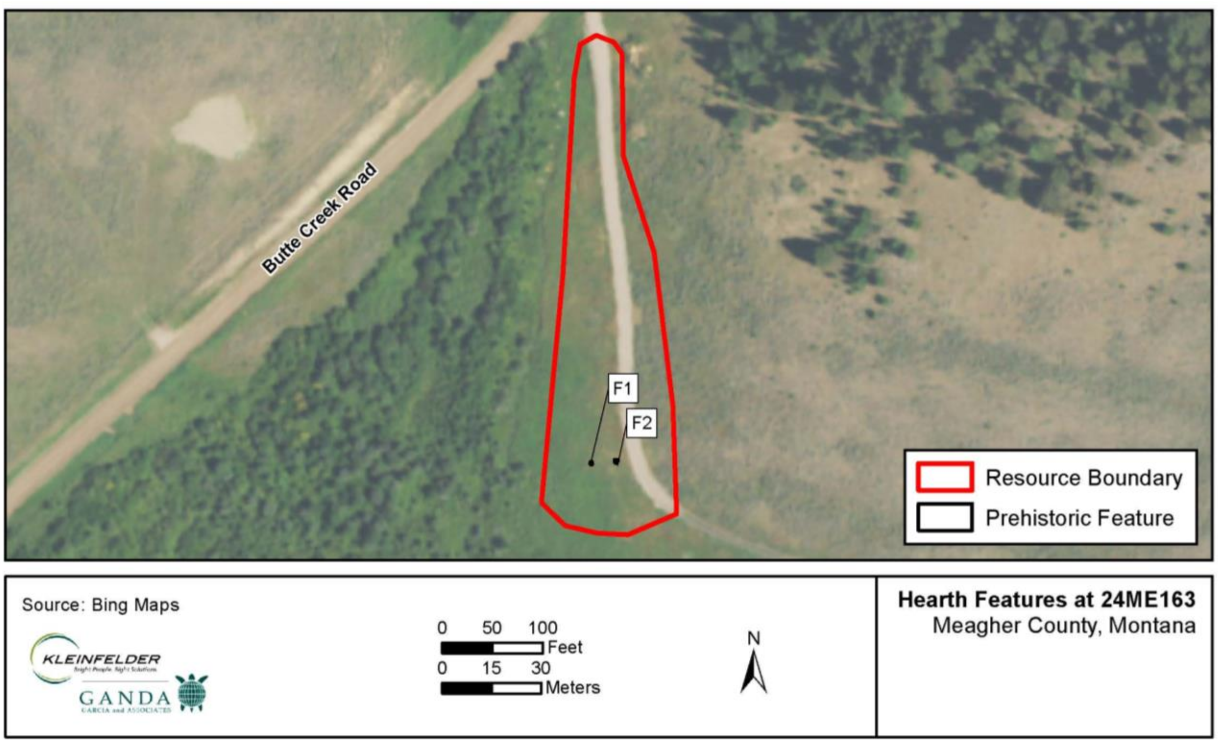


Figure 11: Features in 24ME163

Feature 1 (EU 2 and 4)

Feature 1 was initially exposed in EU 2 and a second unit (EU 4) was placed directly east to expose the majority of the feature (**Figures 12 and 13)**. A large quantity of fractured rocks was located to a depth of approximate 20 cm bs. Charcoal was found in situ adjacent to the FAR. Debitage was found intermixed within the feature.

Two charcoal samples were submitted to Beta Analytics (2020) for radiocarbon analysis. Charcoal Sample 002 was excavated from EU 2, 20-30 cm bs along with FAR. The sample produced a radiocarbon date of 900 +/- 30 BP. Charcoal Sample 006 was excavated from EU 4 at a depth of 30-40 cm bs and was identified in situ along with FAR. The sample produced a radiocarbon date of 950 +/- 30 BP.

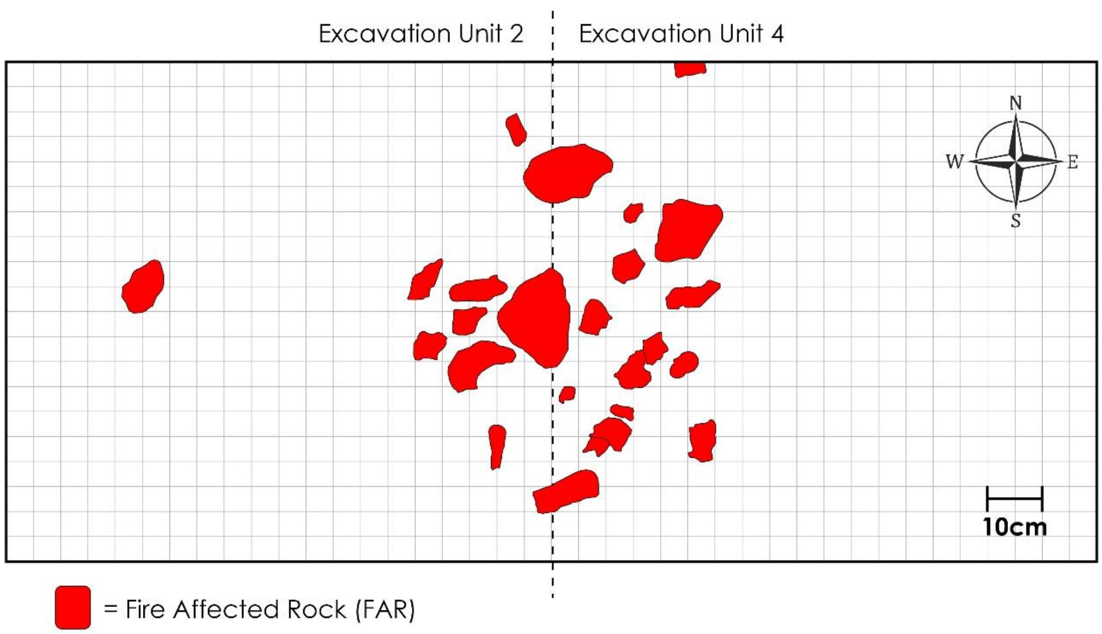


Figure 12: Sketch of Feature 1 (EU 2 and 4)

Figure 13: Feature 1 in EU 4 (bisected)

Feature 2 (EU 3 and 5)

A hearth feature was exposed in EU 3 and 5 and consists of cracked rock, several pieces of charcoal, and charcoal stained sediment (**Figures 14** and **15).** FAR was located to a depth of approximate 40 cm bs. Charcoal was found in situ adjacent to the FAR. Debitage was found intermixed within the feature.

Two charcoal samples were submitted to Beta Analytics for radiocarbon analysis. Charcoal Sample 004 was excavated from EU 3, 20-30 cm bs along with FAR. The sample produced a radiocarbon date of 930 +/- 30 BP. Charcoal Sample 008 was excavated from EU 5 at a depth of 20-30 cm bs and was identified in situ along with FAR. The sample produced a radiocarbon date of 900 +/- 30 BP.

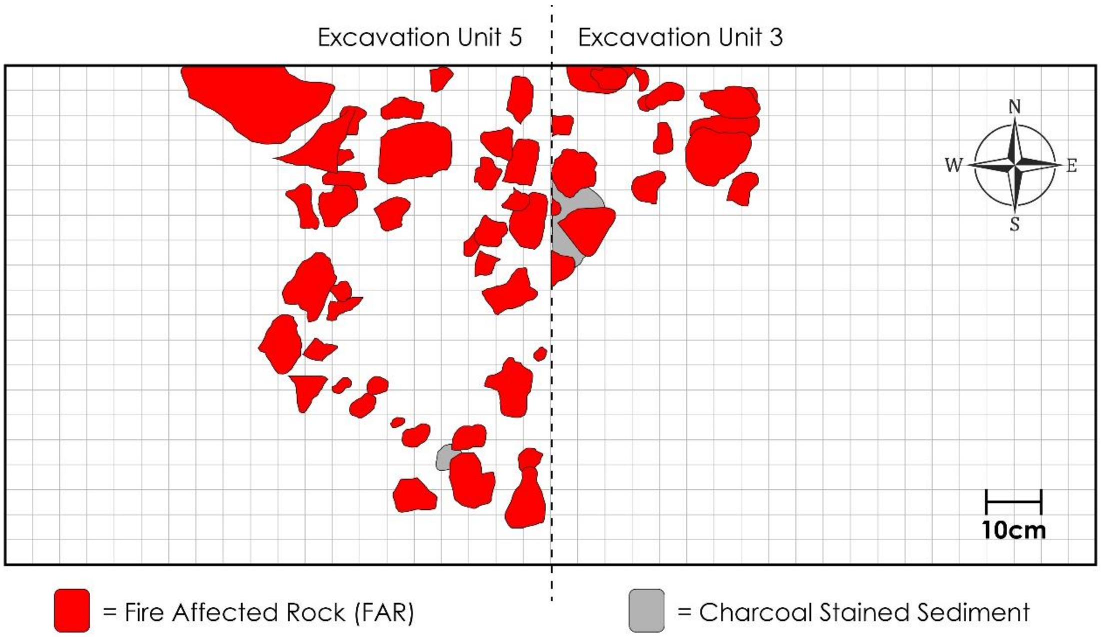


Figure 14: Sketch of Feature 2 (EU 3 and 5)

Figure 15: Feature 2 in Unit 5 (bisected)

6.4 Flaked Stone

The following section details the flaked stone identified during the data recovery of site 24ME163. The flaked stone collection for 24ME163 (**Table 5**) includes 12 bifaces, one uniface, six flake tools, four cores, and 3,311 flakes, flake fragments, and shatter. Local chert is the predominant toolstone, accounting for over 99% of the flaked stone assemblage. In addition, one flake tool and five flakes are chalcedony. Chalcedony is reported to have possibly been imported from sources in the Belt Mountains (Tetra Tech 2020: 24, referencing personal communication from Jerry Zieg, Jan. 2020), located approximately 28 miles (45 kms) southwest of the Project area. Four obsidian flakes and two quartzite flakes were also recovered.

Table 5. 24ME163 Artifact Counts by Toolstone

	Chalcedony	Chert	Obsidian	Quartzite	**Total**
Artifact Type					
Bifaces		12			12
Uniface		1			1
Flake Tools	1	5			6
Cores		4			4
Debitage	5	3300	4	2	3311

Bifaces

The following details the bifaces identified from the data recovery of site 24ME163. A total of 12 bifaces were recovered from the site and consisted of local chert **(Figures 16** and **17**). Ten are obvious manufacture failures. Most are margin and end fragments of indeterminate manufacture stage, and two stage 3 and one stage 4 bifaces (**Appendix A, Table A1**). Fragment size indicates that flake blanks selected for biface manufacture ranged from small (**Figure 17,** cat# 044) to relatively large (**Figure 17,** cat#s 014 and 040). Fortunately, two nearly complete ovate stage 4 bifaces (**Figure 17,** cat#s 011 and 043) are representative of bifacial tool size and shape. The smaller of the two (**Figure 17,** cat# 011) is percussion and pressure flaked with remnant flake blank morphology. Flake scars emanating from the two small margin breaks indicate either attempted maintenance or possibly use. Therefore, this biface might not be a manufacture failure. The larger biface (**Figure 17,** cat# 043) is only percussion flaked. It was a nicely shaped biface until fractured on a material flaw that resulted in a fatal bending break.

In contrast to the larger manufacture failures, one small pressure-flaked indeterminate stage end fragment (**Figure 16**, cat# 064) is probably the basal corner of a projectile point with a slightly concave base. Notches are not evident. Its curved bending fracture might be a use break resulting from impact. If so, this possible projectile point fragment would probably have been discarded from the haft during tool kit maintenance. Regional projectile points with similar basal morphology include the Duncan-Hanna and Pelican Lake types (Tetra Tech 2020: Figure 3), with temporal ranges from late Middle Plains Archaic to early Late Plains Archaic. This age range brackets a radiocarbon date (3,470 – 3,380 cal BP) from a hearth feature exposed during previous excavations at 24ME163 in 2019 (Tetra Tech 2020).

Figure 16: Possible Projectile Point Base Fragment (Cat #64)

Figure 17: 24ME163 Bifaces

Uniface

The following details the uniface identified from the data recovery of site 24ME163. One whole chert uniface (**Figure 18,** cat# 021) was recovered from EU 3 at 0 - 10 cm bs. It was made on a cortical flake blank by pressure flaking three steep unifacial margins. This is a well-made, relatively rectangular robust tool with a convex distal end, which is probably the primary use edge. Stepping and flaking use wear is evident on the distal edge, with crushing and rounding use wear evident along the relatively straight lateral edges. Its yellowish brown and grayish brown color and fine grain texture, showing probably natural luster, is similar to some of the highest quality toolstone in the collection.

Flake Tools

The following details the flaked tools identified from the data recovery of site 24ME163. The six flake tools include five chert and one chalcedony (**Figure 18**). Three cortical flakes, a simple interior flake, and an early biface thinning flake were selected for flake tool manufacture with one indeterminate (**Appendix A: Table A3**). Two (**Figure 18**, cat#s 019 and 024) have relatively long convex use edges with bifacial flaking use wear, indicating they were used for cutting. Catalogue number 024 is whole with a short straight secondary use edge with unifacial flaking use wear, indicating it was also used for scraping. The other four flake tools are unifacial, primarily used for scraping. Two have single use edges that were intentionally shaped by pressure flaking. One (**Figure 18,** cat# 051) is a chalcedony cortical flake with a sinuous steep use edge showing crushing and stepping use wear. This tool is a proximal fragment that was fractured by percussion, indicating it might have been intentionally truncated. The other (**Figure 18,** cat# 025) is whole with a straight, moderately steep robust use edge, but with indeterminate use wear. The two other flake tools include a whole robust tool (**Figure 18,** cat# 046) with steep flaking along a straight use edge, and a small distal fragment (**Figure 18,** cat# 061) with two converging thin convex edges showing flaking use wear on both margins of its pointed end.

Cores

The following details the cores identified from the data recovery of site 24ME163. Three of the four chert cores are relatively large chunky end and margin fragments with multidirectional percussion flake removals (**Figure 19,** cat#s 032, 033, and 056). Two (**Figure 19,** cat#s 032 and 056) have remnant cortical surfaces, indicating they were reduced from cobble blanks. One standout core (**Figure 19,** cat# 035) is a nearly complete tabular cobble with multidirectional percussion flake scars at opposite ends. It was likely broken during reduction and subsequently discarded. Its distinct morphology suggests it might have been intended as a tool manufacture blank. High luster on the flake scars indicates this relatively thin core was heat treated prior to reduction.

Figure 18: Flake Tools and Uniface (Cat # 021) at 24ME163

Figure 19: Cores from 24ME163

Debitage

The following details the debitage identified from the data recovery of site 24ME163. The debitage collection from 24ME163, including technologically diagnostic flakes, flake fragments and pieces of shatter, is comprised of 3,300 chert, five chalcedony, four obsidian, and two quartzite. Sorting diagnostic (predominantly whole) flakes by size grade during laboratory analysis shows that the majority of the debitage is ¼-in. size, falling through ½-in. mesh (**Table 6**). Only chert debitage is represented in the 1-in. and large 2-in. size grades. The quartzite flakes are ½-in. and ¼-in. size non-diagnostic fragments.

Table 6. 24ME163 Diagnostic Flake Size Grade Percentages by Toolstone

	2-Inch Size	1-Inch Size	½-Inch Size	¼-Inch Size
Chalcedony*	---	---	50%	50%
Chert	< 1%	3%	32%	64%
Obsidian**	---	---	---	100%

(rounded percentages may not total 100%)
** only four diagnostic flakes*
*** only three diagnostic flakes*

Summary of Lithic Materials

The technological reduction profile for 1,184 diagnostic chert flakes, representing 39% of the analyzed collection, is characterized by an overwhelming emphasis on percussion core reduction and the initial reduction of flake blanks (90%; **Table 7**). Cortical flakes and cortical flake fragments are conspicuous in the debitage assemblage, indicating cortical cobbles were being selected for core reduction. Two of the four cores in the collection retain cobble cortex. The small amount of percussion biface thinning flakes (9%) is mirrored by the biface manufacture failures in the tool collection, pointing up the fact that a low number of early- and late- stage bifacial tools were manufactured on-site. Although most of the bifaces in the collection are fragments with indeterminate stage classifications, two are stage 3 and two are stage 4 bifaces. The lack of pressure reduction (< 1%) may be the result of screening the excavated deposit through ¼-in. size mesh instead of through smaller ⅛-in. size mesh. At the same time, there is only a low frequency of pressure-flaked bifaces and flake tools in the collection. Hence, pressure reduction was probably infrequent on the site.

Chalcedony, obsidian, and quartzite are only minimally present in the collection. Technologically diagnostic chalcedony flakes are cortical and simple interior flakes representing only core reduction and the initial reduction of flake blanks. The diagnostic obsidian flakes include complex and simple interior flakes representing core/initial flake blank reduction, and one late biface thinning flake that by itself probably represents tool maintenance rather than manufacture.

The two quartzite flakes are simple flake fragments. Quartzite was often used to manufacture large flake tools and core tools (see the uniface from 24ME1109, **Figure 43**, cat# 168). Quartzite was also used as hammerstones during percussion reduction (Roll 2003). Therefore, these quartzite flakes might represent hammerstone breakage during core reduction.

Table 7. 24ME163 Reduction Technology Percentages for Diagnostic Debitage by Toolstone

	Percussion Core Reduction and Initial Flake Blank Reduction	Percussion Biface Thinning	Pressure Reduction
Chalcedony*	100%	---	---
Chert	90%	9%	< 1%
Obsidian**	67%	33%	---

(rounded percentages may not total 100%)
** only four diagnostic flakes*
*** only three diagnostic flakes*

6.5 Obsidian X-ray Fluorescence and Obsidian Hydration Analysis

Four obsidian flakes were submitted from site 24ME163 for obsidian studies (**Table 8**; **Figure 16**). Three were identified from the Obsidian Cliff source in the northwest corner of Wyoming, approximately 217 km (135 miles) south of the Project area (**Figure 20**). One is from Big Southern Butte, approximately 408 km (254 miles) southwest of the Project area in southeast Idaho (**Figure 21**). Hydration rim values for the Obsidian Cliffs sample range from 5.9µ to 4.5µ, which is interpreted using the Tahoe Sierra Hydration Curve at 5,620 BP to 3,620 BP (**Table 9**), with a 5.2µ mean interpreted at 4,588 BP. The Big Southern Butte sample has a 5.8µ rim value interpreted at 5,476 BP. Together the obsidian hydration data indicate the southern end of the site area in the vicinity of EU 3, EU 4, and EU 5 was occupied at various times within a 2,000-year time frame spanning the transition from the Early to Middle Plains Archaic Tradition.

Table 8. 24ME163 Obsidian Studies Sample

Cat #	Unit	Depth (cm bs)	Description	Rim	Source
31	EU 3	30-40	Flake	5.8	Big Southern Butte
42	EU 4	30-40	Flake	5.9	Obsidian Cliff
49a	EU 5	10-20	Flake	4.5	Obsidian Cliff
49b	EU 5	10-20	Flake	5.3	Obsidian Cliff

**Rim values in Microns*

Table 9. Obsidian Studies Data – Source, Hydration Ranges, Means, and Variance

Site	Source	Count	Range	Age Range	Mean	Mean Age	SD	CV
24ME163	Obsidian Cliff	3	5.9-4.5	5,620-3,620	5.2	4,588	0.67	0.13
24ME163	Big Southern Butte	1	N/A	N/A	5.8	5,476	N/A	N/A

Ranges and Means in Microns
*Ages are approximate years before present (BP) based on the Tahoe Sierra Hypothetical Hydration Curve (**Figure 7**)*
SD = Standard Deviation: a measure of the amount of variation of a set of values. A low standard deviation indicates that the values tend to be close to the mean.
CV = Coefficient of Variation: the ratio of the standard deviation to the mean, showing the extent of variability in relation to the mean of the population. A low CV indicates a close association.

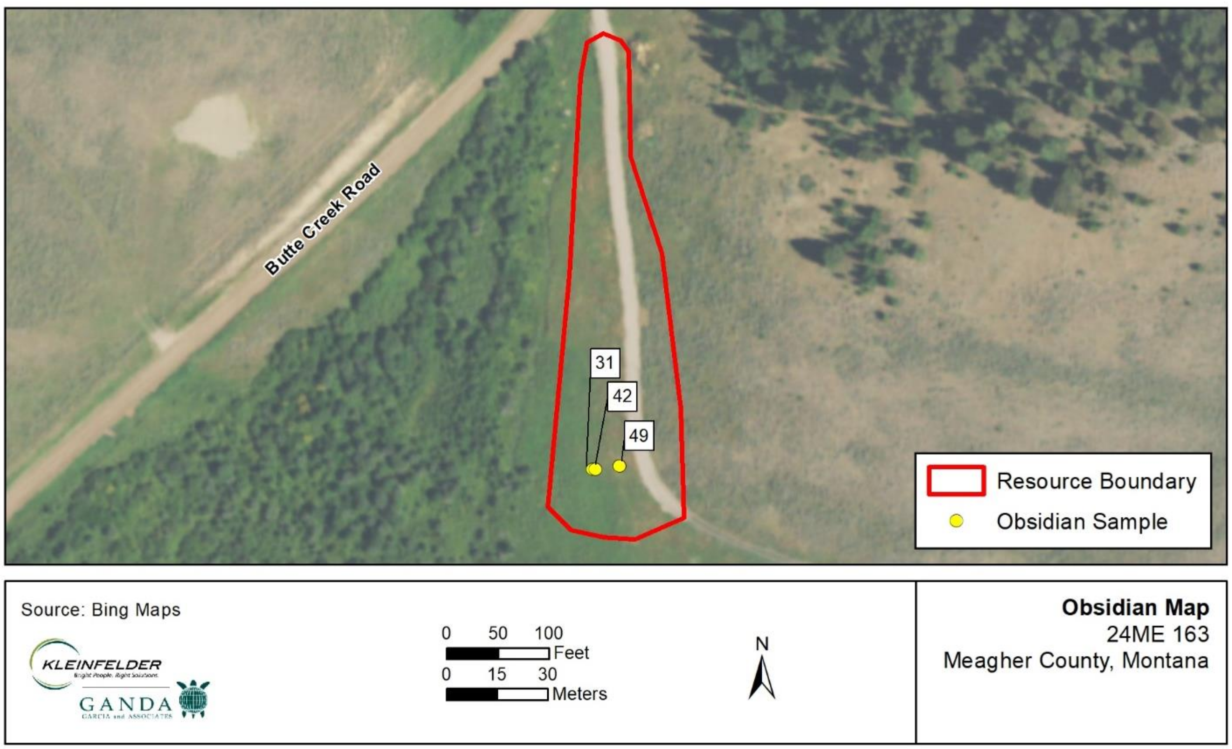


Figure 20: Obsidian Flake Provenance

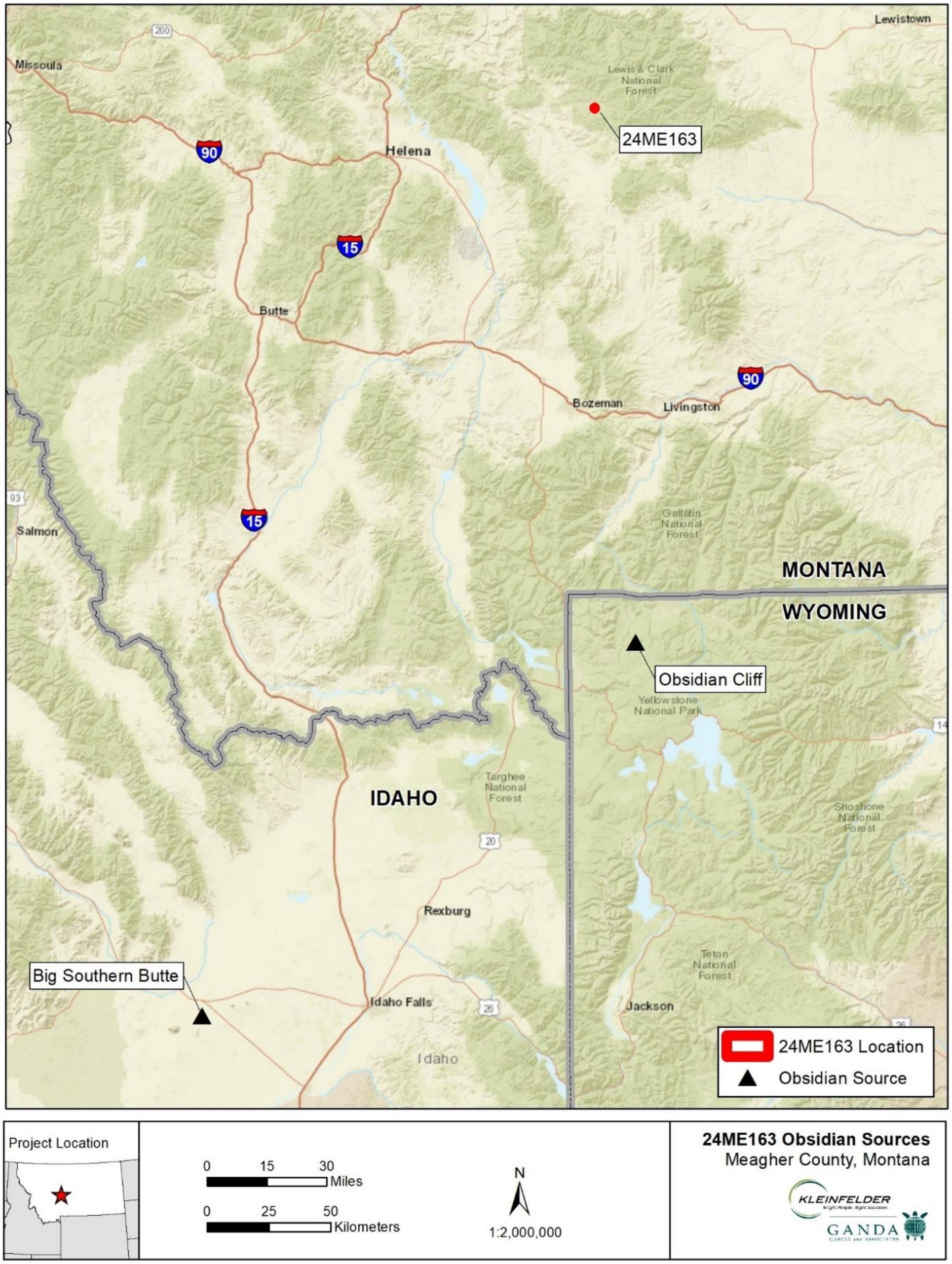


Figure 21: Obsidian Source Results Maps

7 Data Recovery at Site 24ME1109

The field methods used at 24ME1109 aligned with the previous Tetra Tech research design and approach prepared for this project. The excavation unit placement deviated from the original plan to excavate intact subsurface features. Site 24ME1109 is located on a sage covered terrace near two unnamed intermittent drainages (**Figure 22**). The location offers sweeping views of the Sheep Creek Valley. Vegetation consists of annual grasses and upland shrub plants including sagebrush.

The footprint of the mine's proposed mill pad and an access road are located within the site boundary and the majority of the site will be destroyed by construction and ground-moving activities. As such, 48 excavation units (EUs) were determined to be adequate to capture data in the southern two-thirds of the site where the mill pad will be constructed. The 48 (1x1 m) excavation units (EU) within the site boundary were planned along a Cartesian grid across the site, approximately every 10 meters. As discussed above, subsurface testing revealed intact subsurface cultural deposits and magnetic geophysical survey identified six anomalies in southern half of the site area. The unit placement was adjusted to capture all six magnetic anomalies in this portion of the site and to explore subsurface features. Controlled monitoring of ground disturbing construction activity was conducted within the northern portion of the site as it consists of a lower density of artifacts and will be subject to less intensive ground disturbance.

Figure 22: Overview of 24ME1109, facing east.

Prior to excavation and the field investigation, Sandfire had a professional surveyor install “no disturbance” stakes in the field marking the boundary of the site that included a 60-foot added buffer. In addition,construction methods and the location of the proposed access road and mill pad were delineated. Excavation units were subsequently laid out by GANDA/Kleinfelder personnel to capture a sample of the site where ground disturbance would be occurring (**Figure 23**).

Archaeological fieldwork was conducted over two rotations, a 14-day period, July 16 – July 30, 2020, and an 8-day period, August 3 – August 10, 2020. Forty-eight excavation units were placed in the southern portion of the site where the mill pad will be constructed. The excavation crew consisted of Kleinfelder/GANDA archaeologists Jessica Neal, M.A., RPA, Bill Bloomer, M.A., RPA, Andrea Van Schmus, Chase Young, Brianna Boyd, and Kathleen Ambrosino. Controlled monitoring occurred in the northern portion of the site during access road construction from August 24 – August 27, 2020. An additional seven excavation units were placed in the northern portion of the site during monitoring.

Weather was generally warm and sunny with pop-up thunderstorms occurring occasionally. The entire terrace is covered in dense sagebrush which were clipped and removed prior to excavation. Sage roots were present in most excavation units.

The following discussion details the results of data recovery at 24ME1109.

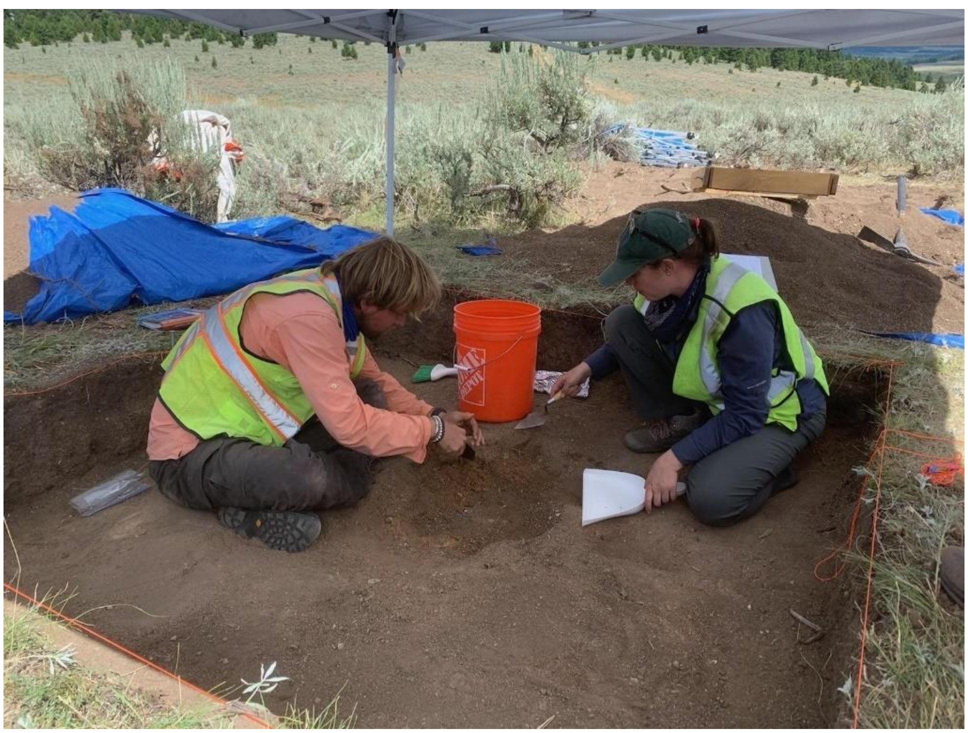


Figure 23: Excavation of Feature 6 at site 24ME1109.

7.1 Stratigraphy

Two stratigraphic units were identified within the site during data recovery of 24ME1109 and were consistent with the stratigraphic units encountered during previous subsurface testing and data recovery (Tetra Tech 2020). The first stratum (Stratum I) consists of a yellowish brown (10YR 3/4) sandy loam with a subangular blocky structure that extends from the surface to approximately 5-7 cm bs. This sod layer contained many fine rootlets. The next layer (Stratum II) is a yellowish brown (10YR 3/4) sandy loam and contained fine roots and shale gravel. The lower boundary grades into the weathered shale bedrock.

7.2 Excavation Units

Forty-eight 1x1 m excavation units were placed in the southern portion of the site that would be impacted by mill pad construction and an additional seven units were placed within the northern portion of the site during controlled construction monitoring for access road construction (summarized in **Table 10**; **Figure 24**). The excavation resulted in the recovery of 3,508 pieces of chert debitage, seven obsidian flakes, nine quartzite flakes, one basalt flake tool, six chert flake tools, 26 bifaces, one projectile point fragment, one quartzite uniface, five hearth features, and charcoal.

The densest concentration of lithics and features, is located in the southeastern portion of the site. Several units were placed outside of the defined site boundary in the location of magnetic anomalies, detailed below. Following further subsurface investigation, the site boundary was expanded to the southeast.

Table 10. Excavation Unit Summary at 24ME1109

Unit	SW Corner UTM	Max. Depth	Notes	Debitage Total	Tools
EU 1	506684mE 5179738mN	40 cm bs	Placed at Magnetic Anomaly; Adjacent to EU 10	17	None
EU 2	506690mE 5179735mN	30 cm bs	Placed at Magnetic Anomaly	8	None
EU 3	506683mE 5179705mN	18 cm bs	Placed at Magnetic Anomaly	8	2 Bifaces
EU 4	506707mE 5179712mN	20 cm bs	Placed at Magnetic Anomaly	41	2 Bifaces
EU 5	506707mE 5179713mN	20 cm bs	Placed at Magnetic Anomaly	94	2 Bifaces
EU 6	506717mE 5179714mN	18 cm bs	Placed at Magnetic Anomaly	44	None
EU 7	506697mE 5179714mN	20 cm bs	None	22	None
EU 8	506688mE 5179714mN	23 cm bs	None	14	None

Unit	SW Corner UTM	Max. Depth	Notes	Debitage Total	Tools
EU 9	506688mE 5179724mN	10 cm bs	None	1	None
EU 10	506684mE 5179737mN	30 cm bs	Placed at Magnetic Anomaly; Adjacent to EU 1	8	None
EU 11	506678mE 5179723mN	20 cm bs	None	3	None
EU 12	506697mE 5179724mN	40 cm bs	None	7	None
EU 13	506708mE 5179724mN	40 cm bs	None	29	None
EU 14	506717mE 5179724mN	30 cm bs	Contains Feature 1; Adjacent to EU 17	25	None
EU 15	506726mE 5179724mN	20 cm bs	None	93	2 Bifaces
EU 16	506731mE 5179717mN	35cm bs	Contains Feature 3; Adjacent to EU 19	159	1 Flake Tool
EU 17	506717mE 5179723mN	30 cm bs	Contains Features 2A and 2B; Adjacent to EU 14 and EU 18	26	1 Biface
EU 18	506716mE 5179723mN	30 cm bs	Contains Features 2A and 2B; Adjacent to EU 17	44	None
EU 19	506731mE 5179716mN	40 cm bs	Contains Features 3 and 4; Adjacent to EU 16, 20, and 22	190	3 Bifaces
EU 20	506731mE 5179715mN	40 cm bs	Contains Feature 4; Adjacent to EU 16, 20, and 22	322	1 Flake Tool
EU 21	506732mE 5179715mN	40 cm bs	Contains Feature 4; Adjacent to EU 16, 20, and 22	348	1 Flake Tool
EU 22	506732mE 5179716mN	40 cm bs	Contains Features 4; Adjacent to EU 16, 20, and 22	157	1 Biface, 1 Flake Tool
EU 23	506747mE 5179734mN	30 cm bs	None	23	None
EU 24	506737mE 5179734mN	60 cm bs	None	143	1 Flake Tool, 1 Projectile Point
EU 25	506727mE 5179734mN	30 cm bs	None	42	None
EU 26	506677mE 5179744mN	20 cm bs	None	12	None
EU 27	506687mE 5179764mN	20 cm bs	None	5	None
EU 28	506707mE 5179764mN	20 cm bs	None	8	None
EU 29	506697mE 5179744mN	20 cm bs	None	46	None
EU 30	506727mE 5179764mN	20 cm bs	None	79	1 Flake Tool

Unit	SW Corner UTM	Max. Depth	Notes	Debitage Total	Tools
EU 31	506717mE 5179744mN	17 cm bs	None	4	None
EU 32	506747mE 5179764mN	20 cm bs	None	15	None
EU 33	506737mE 5179744mN	30 cm bs	Contains Feature 3	12	None
EU 34	506757mE 5179754mN	20 cm bs	None	6	None
EU 35	506724mE 5179709mN	23 cm bs	Placed at Magnetic Anomaly	86	2 Bifaces
EU 36	506732mE 5179714mN	40 cm bs	None	278	6 Bifaces
EU 37	506723mE 5179709mN	20 cm bs	Placed at Magnetic Anomaly	94	None
EU 38	506724mE 5179710mN	20 cm bs	Placed at Magnetic Anomaly	42	None
EU 39	506732mE 5179713mN	40 cm bs	None	212	1 Biface, 1 Core
EU 40	506708mE 5179713mN	20 cm bs	Placed at Magnetic Anomaly	22	None
EU 41	506727mE 5179715mN	30 cm bs	Contains Feature 6	89	1 Biface
EU 42	506737mE 5179715mN	20 cm bs	None	62	None
EU 43	506727mE 5179705mN	30 cm bs	None	43	1 Biface
EU 44	506737mE 5179705mN	30 cm bs	None	88	1 Uniface
EU 45	506727mE 5179716mN	30 cm bs	Contains Feature 6	80	None
EU 46	506726mE 5179716mN	30 cm bs	Contains Feature 6	66	None
EU 47	506726mE 5179715mN	30 cm bs	Contains Feature 6	110	None
EU 48	506708mE 5179705mN	20 cm bs	None	66	None
EU 49	506731mE 5179778mN	10 cm bs*	Excavated During Controlled Monitoring	12	None
EU 50	506731mE 5179779mN	10 cm bs*	Excavated During Controlled Monitoring	21	1 Biface
EU 51	506732mE 5179779mN	10 cm bs*	Excavated During Controlled Monitoring	17	None
EU 52	506732mE 5179778mN	10 cm bs*	Excavated During Controlled Monitoring	9	None
EU 53	506730mE 5179779mN	10 cm bs*	Excavated During Controlled Monitoring	19	None
EU 54	506730mE 5179778mN	10 cm bs*	Excavated During Controlled Monitoring	15	None
EU 55	506759mE 5179777mN	34 cm bs*	Excavated During Controlled Monitoring	18	1 Flake Tool, 1 Biface

**Top 5cm removed with blade*

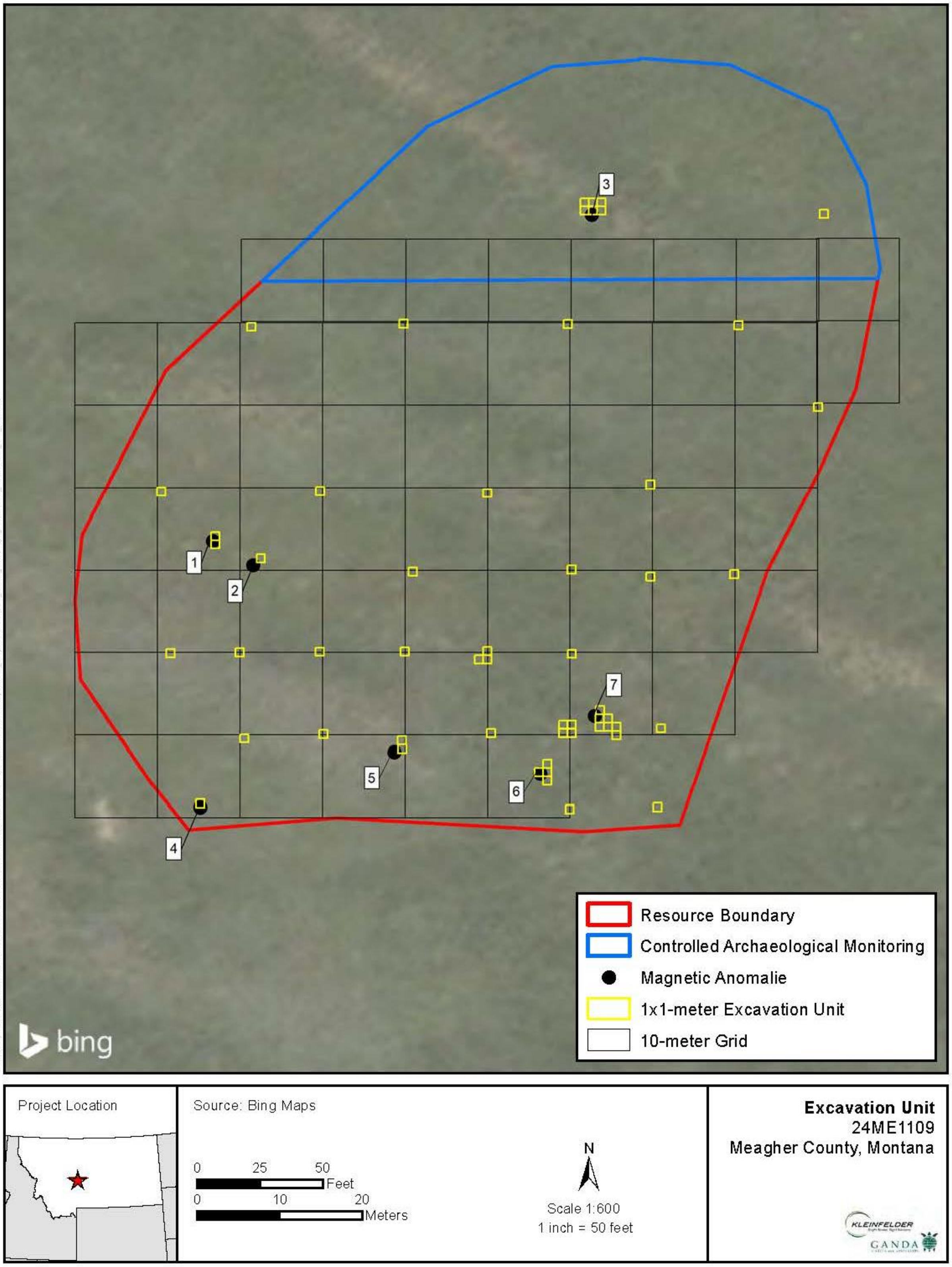


Figure 24: Excavation Units at modified 24ME1109

7.2.1 Magnetic Anomalies

Prior to data recovery efforts, magnetic geophysical survey of the 6,265-square meter site area was conducted in September 2019 (Michaletz 2019; Tetra Tech 2020). The purpose of the survey was to identify magnetic anomalies that may indicate prehistoric hearth features which tend to be central to human activity. When rock is heated in a hearth, magnetic minerals within the rock realign to magnetic north; consequently, the rocks appear as an anomaly in the magnetic field.

Seven magnetic anomalies (MA) were identified during the 2019 survey, six in the southern portion of the site and one in the northern portion (see **Figure 24**). Excavation units were placed at each of the anomalies. Five had negative results (MA 2-6), one contained charcoal but no observable features (MA 1), and one (MA 7) resulted in the finding of two separate hearth features (Features 3 and 4), see below for details.

Although only one of the seven magnetic anomalies, MA 7, resulted in the identification of a buried features, the two Features located at the MA identified valuable data that would not otherwise have been recovered had the geophysical survey not been conducted. MA 7 was located outside the original site boundary and was covered in dense vegetation with very poor ground visibility. This area of the now expanded site boundary represents the highest density subsurface lithic deposits within the site.

MA 1 (EU 1)

Excavation Unit 1 (EU 1) was placed at the location of MA 1; and significant amounts of charcoal were observed in the unit at 30 cm bs across the unit; with charcoal concentration higher in the southern half of the unit; krotovina disturbance was also present. No features were observed in in this unit. A second unit (EU 10) was placed to the south to further explore the location of the anomaly. Charcoal was also present at 30cm bs, but no features were observed. The charcoal identified within MA 1 (EU 1) was not selected for radiocarbon dating as it was from a disturbed context, located in and around a rodent krotovina. It is possible a hearth feature could have been located near the two units resulting in the charcoal deposit, but no defined features were captured within EU 1 or EU 10.

MA 7 (EU 16)

Excavation Unit (EU) 16 was placed at MA 7, located just outside of the previously determined site boundary for 24ME1109. In level 2 at 20-30 cm bs, charcoal, oxidized red burnt earth, and several small pieces of fractured rock were encountered in the southeastern corner of the unit. Large quantities of chert debitage were noted in the unit. A second unit was opened immediately south to further explore the feature (Feature 3). During excavation of the second unit (EU 19) a second feature, Feature 4, was observed in the southern half third of EU19 consisting of a large fire cracked chert rock and a large granitic rock, charcoal, and dark stained soil. See Features 3 and 4 below for additional details.

7.2.2 Controlled Monitoring

Controlled archaeological monitoring was done within the northern portion of site, consisting of approximately 1,274 square meter, between August 24-27, 2020. The topsoil was removed mechanically with a tractor blade, in 5-10 cm levels (**Figure 25**). An archaeologist observed the soils after each pass and communicated closely with the equipment operater when to stop in order to investigate. The controlled destruction of this portion of the site was implemented based on the previous survey and testing results, indicating a very low-likelihood for buried cultural materials within this soil matrix.

After an initial scrape, work was stopped in the area of the magnetic anomaly MA 3. The top level of soil in the area surrounding the anomaly was scraped by machine, resulting in approximately 5 cm of topsoil being removed prior to excavation. Six excavation units (EU 49-EU 54) were placed in the area of the anomaly, each encountered weathered shale bedrock around 8 cm bs. The units were excavated to a depth of 10 cm bs; no hearths or features were identified. One additional unit was placed at the northeastern portion of the site in an area not subject to impact, in order to obtain a controlled/ representative sample for comparison in this area of the site.

Figure 25: Controlled monitoring within 24ME1109.

7.3 Features

The following section details the features identified during the data recovery program of site 24ME1109. Six features were identified during excavation at site 24ME1109, all of which were generally located in the southeastern portion of the site (see **Figure 26**). Each of the features contained a hearth and produced in situ charcoal suitable for carbon dating. Two of the features were initially excavated separately, however, Feature 1 and Feature 2A/2B were subsequently determined to be one large, disturbed hearth, resulting in a total of five features (**Table 11**).

Table 11. Hearth Features Summary at 24ME1109

Feature (F) No.	Unit	Details	Approx. Depth	Dates BP	Corresponding Dates
F 1	14, 17	Hearth	15-26 cm bs	2,220 +/- 30 2,280 +/- 30	375 - 203 BC 403 - 352 BC
F 2A	17, 18	Hearth	12-21 cm bs	2,220 +/- 30 2,190 +/- 30	375 - 203 BC 361 - 177 BC
F 2B	17, 18	Hearth	14-29 cm bs	2,200 +/- 30 2,290 +/- 30	366 - 186 BC 405 - 353 BC
F 3	16, 19	Disturbed Rock Hearth	20-30 cm bs	1,320 +/- 30 2,490 +/- 30 *	652 – 722 AD 781 - 510 BC*
F 4	19, 20, 21, 22	Rock Hearth	28-50 cm bs	2,510 +/- 30 3,540 +/- 30	696 - 540 BC 1954 - 1767 BC
F 5	33	Disturbed Rock Hearth	20-31 cm bs	4,900 +/- 30	3715 - 3638 BC
F 6	41, 46, 47, 48	Hearth	31-40 cm bs	2,420 +/- 30 3,210 +/- 30	556 - 402 BC 1532 - 1418 BC

**This sample initially associated with Feature 3, but likely from Feature 4*

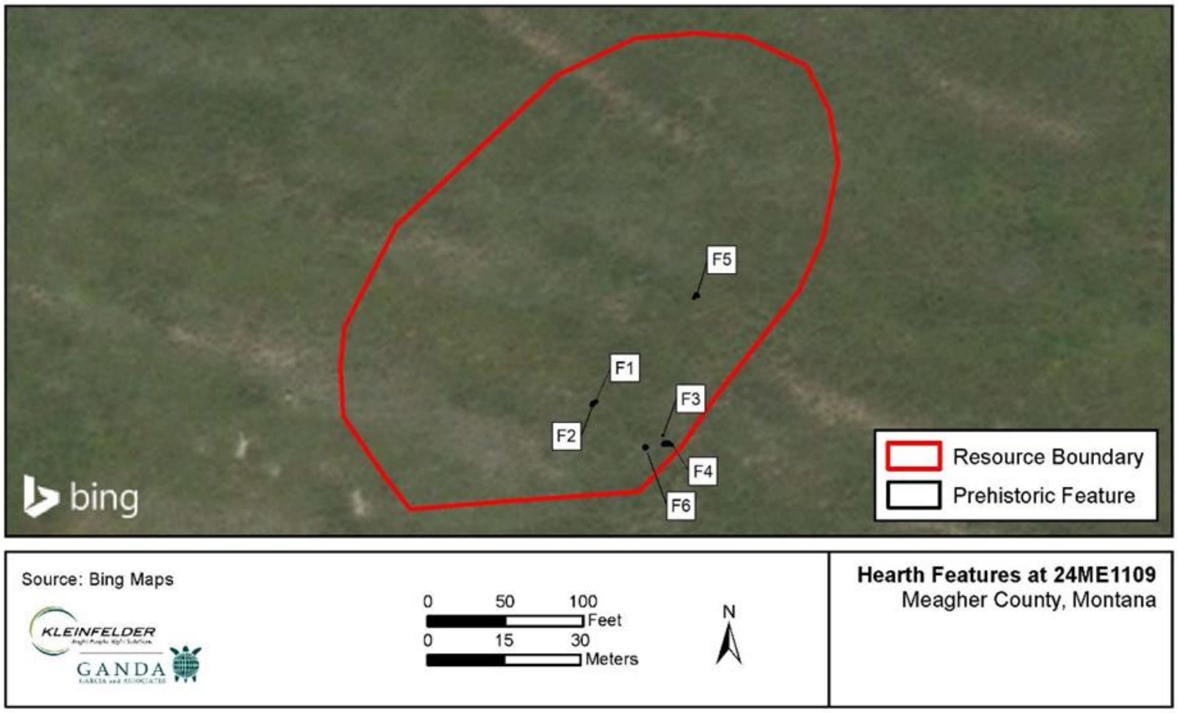


Figure 26: Hearth Features at site 24ME1109

Feature 1 (EU 14 and 17)

Feature 1 was initially encountered in the southern portion of unit 14 as a dark charcoal layer. The feature continued into the southern wall; where a second unit (EU 17) was opened to the south to further expose the feature. Oxidized, fire-reddened earth was present along the sides of the charcoal-stained earth creating a lip. No fire-affected rock was found associated with this feature and very little lithic debitage was present. The feature was generally ovular in shape and measured 62 x 20 cm and extended 15 to 26 cm bs (**Figure 27**). Feature 1 cut consisted of a loam soil intermixed with small amounts of charcoal. Layer 2 consisted of a silt loam, 1-3 cm thick, with a charcoal layer at the base of the feature.

Charcoal Sample 015 was excavated from Feature 1 at 15-26 cm bs from the eastern half of the feature. The sample produced a radiocarbon date of 2,220 +/- 30 BP. A second charcoal sample (017) from the western half of the feature produced a date of 2,280 +/- 30 BP.

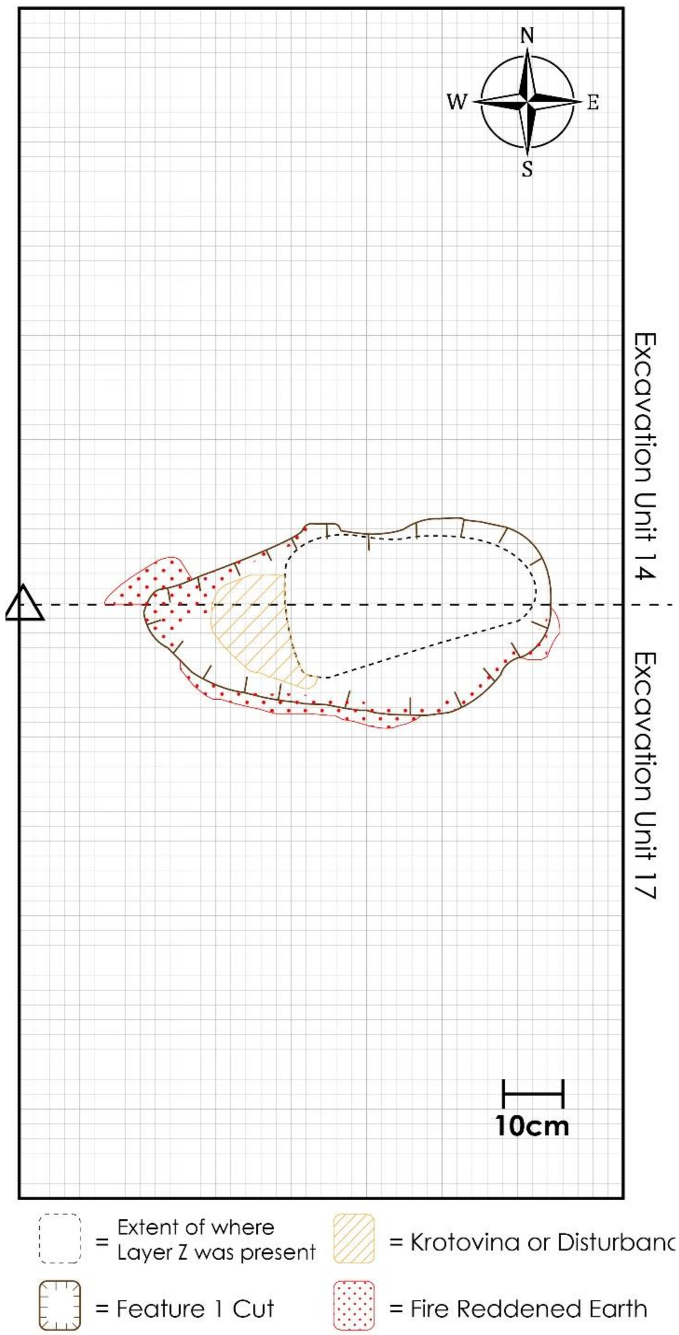


Figure 27: Sketch of Feature 1

Features 2A and 2B (EU 17 and 18)

Feature 2 (A and B) is a hearth feature with a generally oval shape measuring approximating 50 x 37 cm. It is located in the western half of EU 17 and the eastern half of EU 18, slightly overlapping Feature 1 (**Figures 30 and 31**). Feature 2A is a defined hearth pit with a distinct fine reddened pit cut located 12-21 cm bs. Feature 2A is cut into Feature 2B fill which is located at 14-29 cm bs. Feature 2B contained two large pieces of wood charcoal (samples 026 and 029), two small pieces of fire affected rock (one granitic and one local chert).

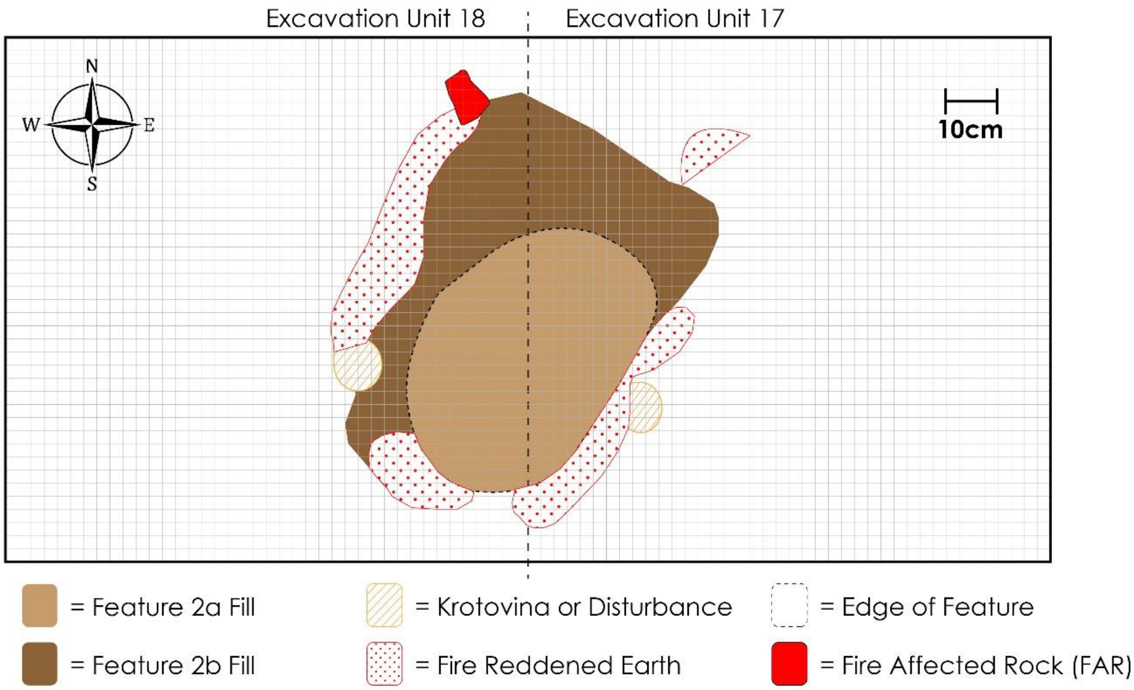
Four charcoal samples were submitted for analysis, two from each feature (2A and 2B). Sample 027 was recovered from the southern half of the Feature 2A bisection and produced a radiocarbon date of 2,220 +/- 30 BP. Sample 029 was removed from the northern half of the Feature 2A bisection and produced a date of 2,190 +/- 30 BP.

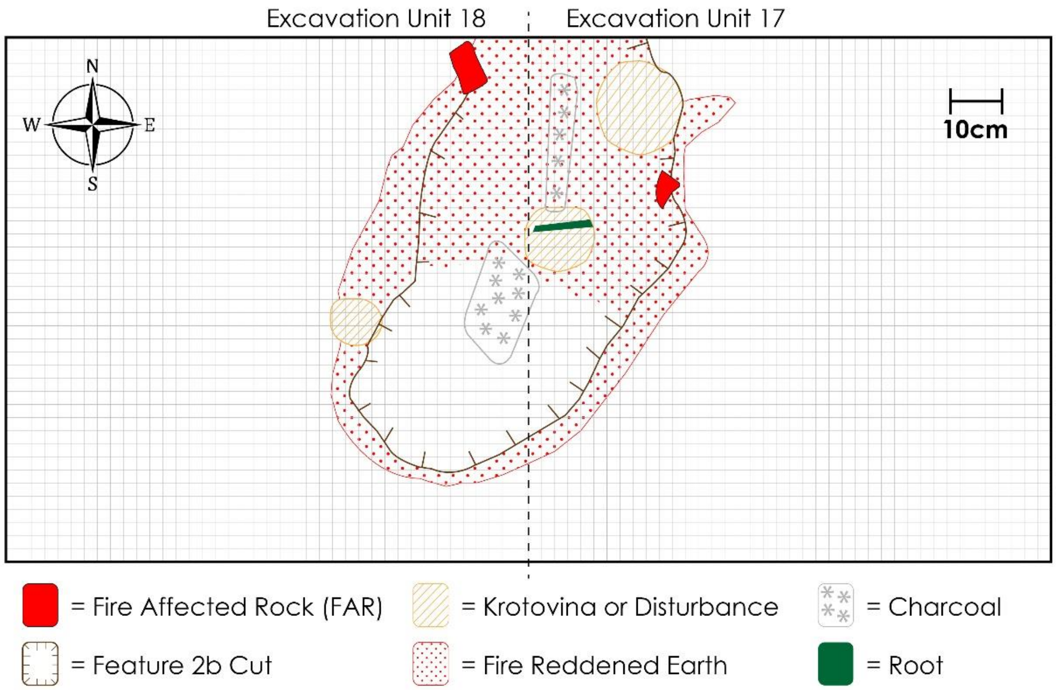
A large piece of burnt wood/charcoal (Sample 033) was located 22-27cm bs in Feature 2B, measuring approximately 22 cm long by 13 cm wide (**Figures 28** and **29**). The entire sample was removed and produced a radiocarbon date of 2,200 +/- 30 BP.

A second large piece of burnt wood/charcoal (Sample 026; "Footlong") was located 19-36 cm bs in Feature 2B, measuring approximately 27 cm long by 7 cm wide. The entire sample was removed and produced a radiocarbon date of 2,290 +/- 30 BP.

Feature 1 and 2, appeared to represent separate features during excavation. However, based on the radiocarbon results, these features (1 and 2) are likely form a single, large, disturbed hearth.

Figures 28 and 29: Large piece of charcoal (Sample 033) in Feature 2B.





Figures 30 and 31: Sketch of Feature 2A and Feature 2B

Feature 3 (EU 16 and 19)

Feature 3 was initially exposed in EU 16, at the location of MA 7, located just outside the southeastern site boundary (**Figure 32**). Charcoal was identified dispersed within the unit at 20-30 cm bs. A dense pocket of charcoal and a single, small piece of FAR was in the western center of the unit at approximate 20 cm bs. A density of small FAR, charcoal stained sediment, and fire-reddened earth was located in the southeastern corner of the unit.

An additional unit, EU 19, was opened immediately south of EU 16 to further expose the feature. Numerous small pieces of FAR were identified, starting at approximately 20 cm bs. The pocket of charcoal and red burnt earth continued into EU 19. Two large chert rocks were located in the southern portion of EU 19 which was later defined as Feature 4. There is no clear definition between features 3 and 4. Feature 3 appears to extend from approximately 20-35 cm bs, where the unit encountered weathered shale bedrock.

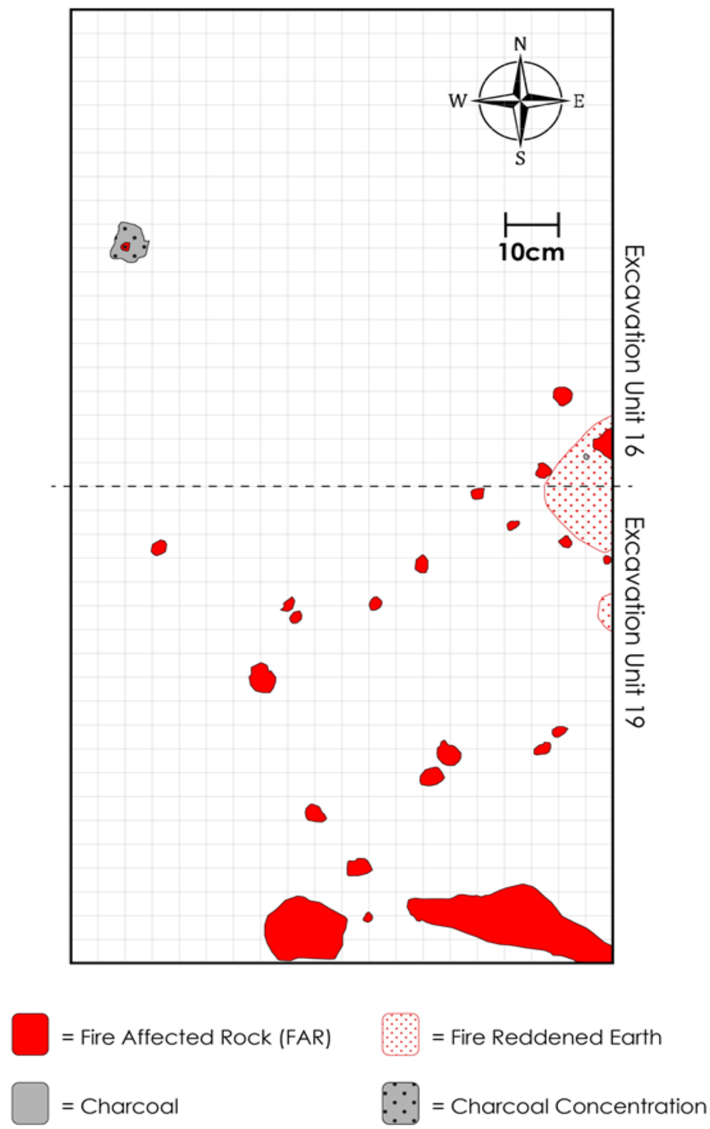


Figure 32: Sketch of Feature 3 and 4

Two charcoal samples from Feature 3 were submitted to Beta Analytics for radiocarbon analysis. Charcoal Sample 023 was identified in situ, in the southeastern corner of unit 16, 20-30 cm bs along with FAR. The sample produced a radiocarbon date of 1,320 +/- 30 BP.

Charcoal Sample 037 was excavated from the southern half of unit 19 at a depth of approximately 30 cm bs and was identified in situ along with FAR. The sample produced a radiocarbon date of 2,490 +/- 30 BP. It appears that this sample is associated with Feature 4, as it correlates with the C14 dates taken from that feature (see below).

Feature 4 (EU 19-21)

As described above, Feature 4 was identified in the southern portion of unit 19 in the vicinity of MA 7. Three additional excavation units (EU 20, 21, 22) were opened to uncover the entire feature (**Figures 33** and **34**). This feature contains the largest rocks identified subsurface during excavations at both 24ME1109 and 24ME163. In total, eight FAR (R#s) were identified with this feature. Specifically, the FAR identified (R1, R4, R5, and R8) are granitic while the remainder are chert. Also noteworthy, in EU 22 (FAR [R6]) and in EU 21 (FAR [R8]) refit into a single stone. The granitic rocks in this feature were the only granitic rocks identified within the site boundary, but such granitic rocks were observed on the surface within the mine boundary.

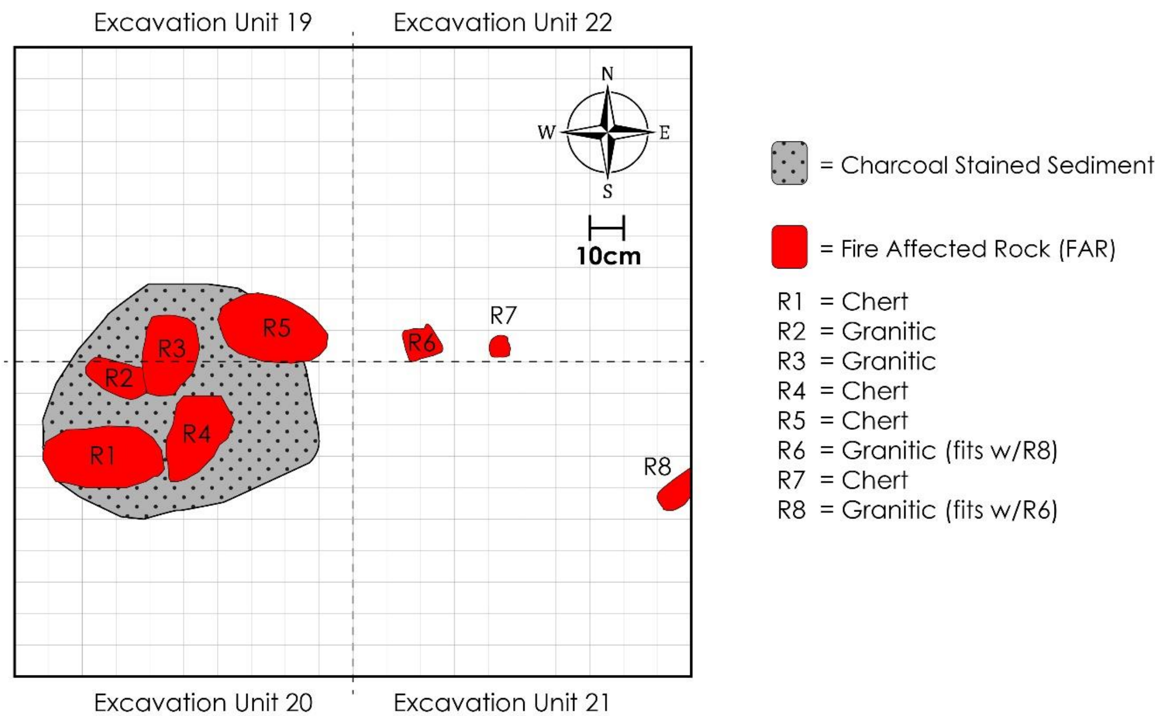


Figure 33: Sketch of Feature 4

Two charcoal samples from Feature 4 were submitted for radiocarbon analysis. Charcoal Sample 039 was identified in situ on the top of the feature at approximately 30 cm bs in EU 20. The sample produced a radiocarbon date of 2,510 +/- 30 BP. Charcoal sample 041 was also taken from EU 20, from beneath the FAR and within the feature, at a depth of approximately 49 cm bs. The sample produced a radiocarbon date of 3,540 +/- 30 BP.

It is likely that Charcoal Sample 037, initially associated with Feature 3, is actually associated with Feature 4. The sample was collected from the southern half of EU 19 at approximately 30 cm bs, where Features 3 and Feature 4 overlap. The sample's date of 2,490 +/- 30 BP corresponds with Feature 4's Charcoal Sample 039 date of 2,510 +/- 30 BP.

The wide range in dates from the top of the feature (2,510 BP) to the bottom of the feature (3,540 BP) indicated considerable reuse of this hearth over time.

Figure 34: Feature 4

Feature 5 (EU 33)

This feature is located in the central eastern portion of the site, with a slope to the northeast. The feature was identified within EU 33 at a depth of 20-28 cm bs, resting on the weathered shale bedrock. The feature consists of approximately eight small- to medium- sized chert FAR dispersed from the southwest corner to the north wall of the unit (see **Figures 35** and **36**). Charcoal was found lightly dispersed across the western half of the unit, and a dense circular pocket of charcoal measuring approximately 12 cm in diameter was found in the upper southwestern quadrant of the unit.

One charcoal sample from Feature 5 was submitted for radiocarbon analysis from the circular pocket of charcoal. The sample (043) produced a radiocarbon date of 4,900 +/- 30 BP. This feature produced the oldest date found in the entire Sheep Creek Quarry Archaeological District

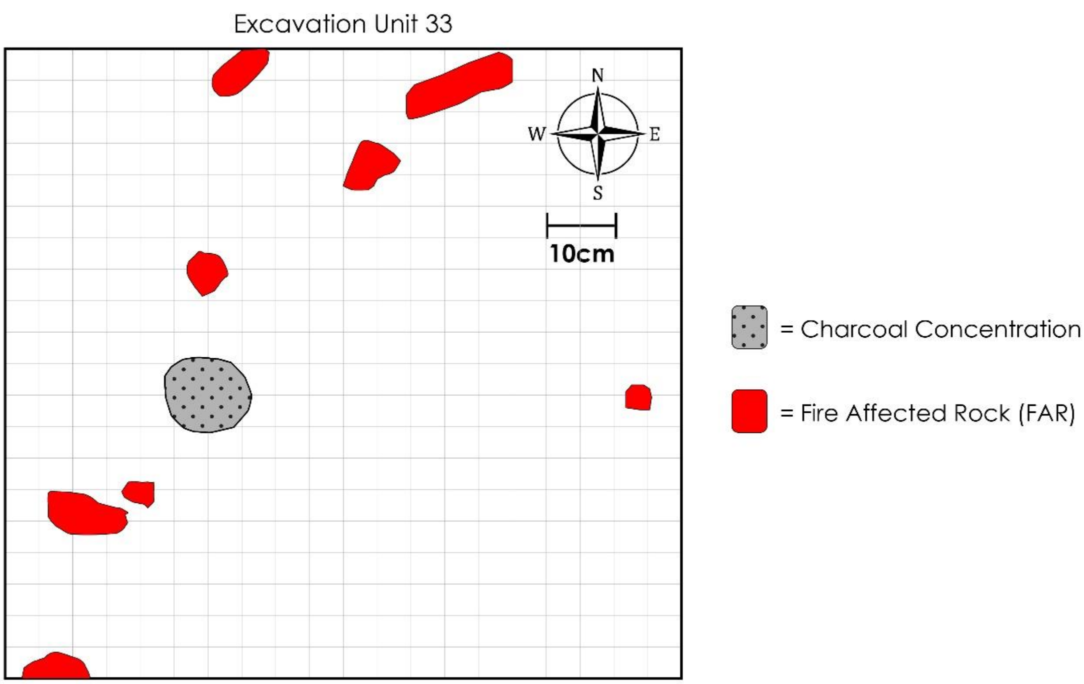


Figure 35: Sketch of Feature 5

Figure 36: Feature 5.

Feature 6 (EU 41, 45, 46, 47)

This feature was identified in EU 41, was generally circular in shaped, and measured approximately 70 cm in diameter (**Figure 37-39**). Three additional units, EU 45, 46 and 47 were excavated to fully expose the feature. The top of the feature was encountered at approximately 31 cm bs and produced a significant amount of charcoal and charcoal-stained sediment. An ashy layer of soil continued to approximately 48 cm bs. The feature was characterized by red, fire-oxidized soil, charcoal and charcoal-stained sediment, and ashy soil; the feature contained no FAR.

Two charcoal sample from Feature 6 were submitted to Beta Analytics for radiocarbon analysis from both the top and bottom of the feature. Charcoal Sample 044 was taken from the top charcoal layer of the feature at approximately 31 cm bs. The sample produced a radiocarbon date of 2,420 +/- 30 BP. Charcoal Sample 046 was taken from the bottom of the feature at approximately 40 cm bs from within the ashy soil. The sample produced a date of 3,210 +/- 30 BP.

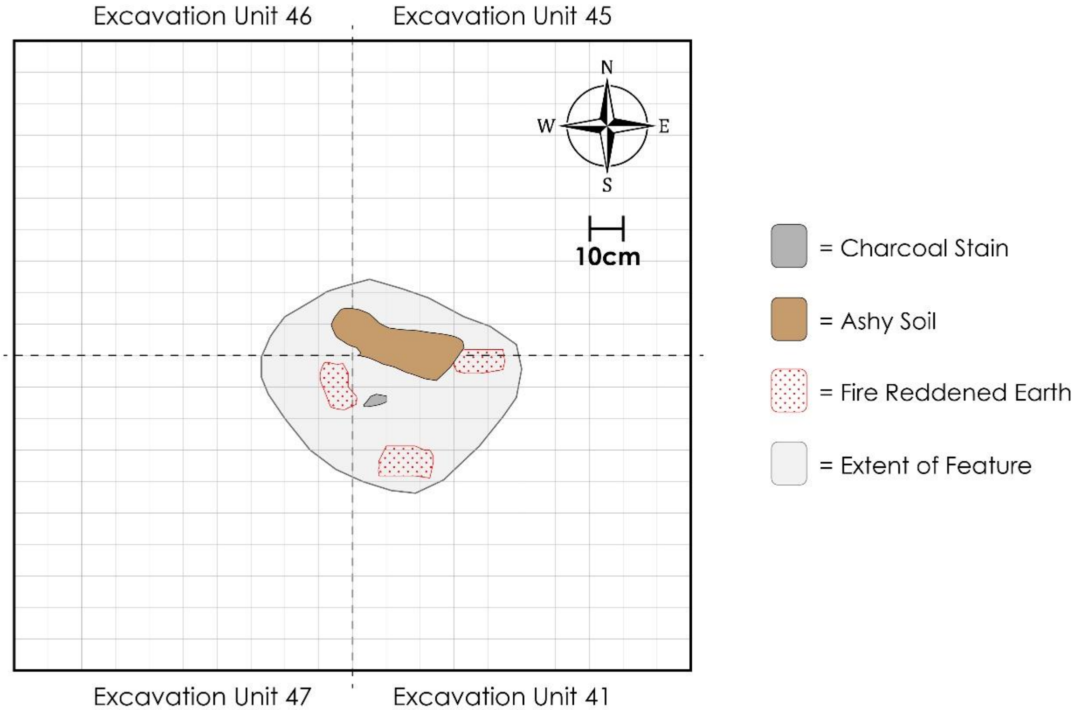


Figure 37: Sketch of Feature 6

Figure 38 (left): Top of Feature 6 showing charcoal stained sediment.

Figure 39 (right): Ashy soil in Feature 6.

7.4 Flake Stone Tool Analysis

The following section details the flaked stone identified during the data recovery of site 24ME1109. The flaked stone collection (**Table 12**) includes one projectile point, 26 bifaces, one uniface, seven flake tools, one core, and 3,523 flakes, flake fragments, and shatter. Local chert is the predominant toolstone, accounting for over 99% of the flaked stone assemblage. Seven obsidian flakes and nine quartzite flakes were also recovered.

Table 12. 24ME1109 Artifact Counts by Toolstone

Toolstone					
	Basalt	Chert	Obsidian	Quartzite	**Total**
Artifact Type					
Projectile Point		1			1
Bifaces		26			26
Uniface				1	1
Flake Tools	1	6			7
Core		1			1
Debitage		3,508	7	9	3,524

Projectile Point

The one projectile point (**Figure 40,** cat# 097) is an arrow-size lateral fragment with one remnant notch. It was made from a matte gray chert. Breakage may have initially been caused by bending during manufacture or use. On-site discard was followed by extensive post-depositional thermal damage, indicated by multiple spalls and fractures showing high luster. The complete morphology of the remnant notch is slightly obscured by a small break at the basal corner. Yet, its overall shape indicates it was side-notched, somewhat resembling the Late Prehistoric Plains Side-notched projectile point type (Tetra Tech 2020).

Figure 40: Projectile Point Fragment (Cat #097)

Bifaces

The 26 bifaces recovered were made using local chert (**Figures 41-44**). Twenty-five are obvious manufacture discards. While the majority (69%) are margin and end fragments, with four distal, two medial, and one proximal. One stage 1 biface was identified as complete and although not broken during manufacture, it was discarded on-site after minimal reduction, unacceptable for further reduction or transport (**Figure 42,** cat# 131). The other bifaces were manufacture failures predominantly discarded during early stages of percussion reduction, including ten stage 2 (38%) and eight stage 3 (31%) bifaces. In total, late-stage bifaces, most reduced by a combination of percussion and pressure reduction, include two stage 4 and two of the four indeterminate stage fragments. One biface was shaped by pressure reduction only, with minimal flake removals (**Figure 41,** cat# 016).

Stage 2 fragment size indicates that blanks selected for biface manufacture ranged from small flakes (**Figure 42,** cat# 132) to relatively large tabular cobbles (**Figure 44,** cat# 043). In fact, tabular cobbles, thick and thin, were commonly selected for biface manufacture. Two biface fragments show possible, but indeterminate, use wear; one of which, is a stage 2 manufacture failure (**Figure 41,** cat# 012). There are small unifacial flake scars present along the edge of one unifacially worked margin of one of these bifaces, indicating possible use after breakage. The other is a late-stage margin fragment with possible flaking use wear along its well-worked bifacial margin (**Figure 43,** cat# 194). This one was possibly not a manufacture failure, but possibly broken in use.

Uniface

A whole quartzite uniface was recovered from Unit 44 at 20 - 30 cm bs (**Figure 43,** cat# 168). This is a relatively large and heavy tool made on a simple interior flake blank by percussion flaking two steep unifacial margins. One use edge is along a straight lateral margin, while the other is along a convex end margin. Use wear is indeterminate, and difficult to see macroscopically on moderately grainy quartzite.

Figure 41: Bifaces at 24ME1109

Figure 42: Bifaces at 24ME1109

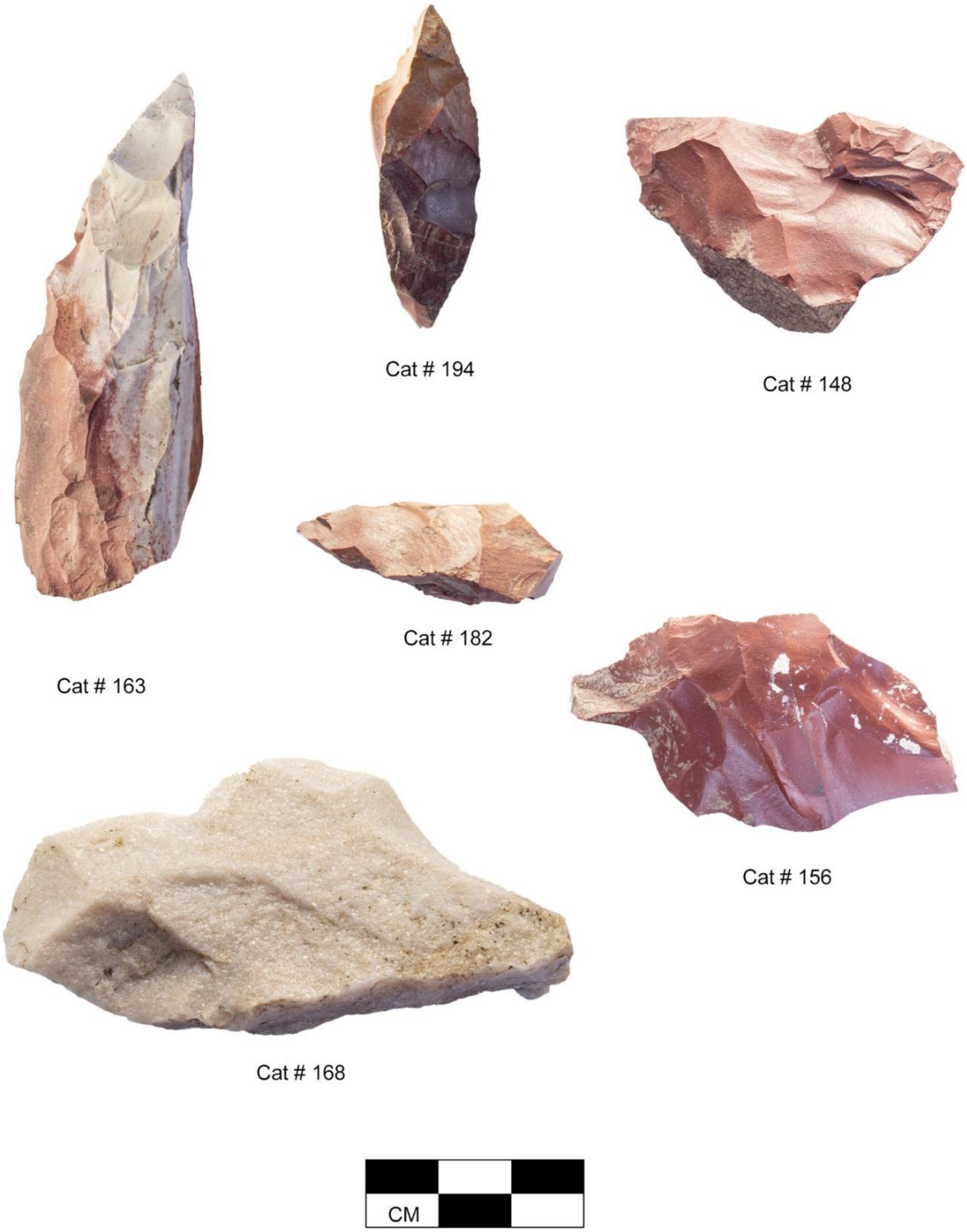


Figure 43: Bifaces and Quartzite Uniface at 24ME1109

Figure 44: Large Chert Biface from 24ME1109 (Cat #043)

Flake Tools

A total of seven flake tools were recovered, including six chert and one basalt (**Figure 45**). Most are whole or nearly complete (**Appendix B: Table B5**). Four have one use edge and three have two use edges. There is also one cortical flake, five simple interior flakes, and a complex interior flake were also selected for flake tool manufacture. All of the primary use edges are unifacial, indicating they were used predominantly for scraping. The three flake tools with secondary use edges include two with unifacial edges and one with a bifacial edge that indicates cutting use (**Figure 45,** cat# 116). Only one flake tool has a use edge that was intentionally modified by pressure (**Figure 45,** cat# 078). All other edge modifications resulted from use. The basalt flake tool stands out as made from non-local toolstone and was likely transported to the site as a curated flake tool (**Figure 45,** cat# 084). One other tool stands out as the largest in the collection (**Figure 45,** cat# 188). This tool is complete, with one robust unifacial convex use edge; and stepping with flaking use wear to the ventral face is distinct, indicating heavy scraping and/or cutting.

Figure 45: Flake Tools from 24ME1109

Core

The single chert core identified is whole, and consists of a large blocky cobble with two good multidirectional percussion flake removals (**Figure 46,** cat# 149). The toolstone is matte light pink with whiter bands and a red crystalline cortex. The toolstone is relatively good quality, but internal material flaws and crystalline inclusions may have hampered flake removals.

Figure 46: Core from 24ME1109

Debitage

The debitage collection from 24ME1109, including technologically diagnostic flakes, flake fragments, and pieces of shatter, is comprised of 3,508 chert, seven obsidian, and nine quartzite. Sorting diagnostic (predominantly whole) flakes by size grade during laboratory analysis shows that the majority of the debitage is ¼-in. size, falling through ½-in. mesh (**Table 13**). For this reason, only chert debitage is represented in the 1-in. and large 2-in. size grades.

Summary of Lithic Materials

Based upon the lithic analysis discussed above for site 24ME1109 the following assessment has been derived. In sum, the technological reduction profile for 1,291 diagnostic chert flakes (representing 37% of the analyzed collection) can be characterized by an overwhelming emphasis on percussion core reduction and the initial reduction of flake blanks (96%; **Table 14**). The high frequencies of cortical flakes and cortical flake fragments indicate cortical cobbles were being selected for core reduction. The small amount of percussion biface thinning flakes (4%) reflects the relatively low number of late-stage bifacial tools were manufactured on-site. The lack of pressure reduction (< 1%) may be the result of screening the excavated deposit through ¼-in. size mesh instead of through smaller ⅛-in. size mesh. At the same time, there is only a low frequency of pressure-flaked bifaces and flake tools in the collection. Hence, pressure reduction was probably infrequent on the site.

Obsidian and quartzite are only minimally present in the collection. Technologically diagnostic obsidian flakes include two simple interior flakes representing core/initial flake blank reduction, and one late pressure flake that by itself probably represents tool maintenance rather than manufacture. Four diagnostic quartzite flakes are simple flake fragments. Similar colored white quartzite was used to manufacture the large uniface in this collection (**Figure 43,** cat# 168).

Table 13. 24ME1109 Diagnostic Flake Size Grade Percentages

	2-Inch Size	1-Inch Size	½-Inch Size	¼-Inch Size
Chert	< 1%	4%	30%	66%
Obsidian*	---	---	---	100%
Quartzite**	---	---	25%	75%

(rounded percentages may not total 100%)
* only three diagnostic flakes
** only four diagnostic flakes

Table 14. 24ME1109 Reduction Technology Percentages for Diagnostic Debitage

	Percussion Core Reduction and Initial Flake Blank Reduction	Percussion Biface Thinning	Pressure Reduction
Chert	96%	4%	< 1%
Obsidian*	67%	---	33%
Quartzite**	100%	---	---

(rounded percentages may not total 100%)
* only three diagnostic flakes
** only four diagnostic flakes

7.5 Obsidian Studies

Seven obsidian flakes were submitted from site 24ME1109 for obsidian studies (**Table 16**). Six of the flakes were recovered in a 7-square meter block excavation near the southeastern site boundary (**Figure 47**). Of these, five flakes were identified from the Bear Gulch obsidian source in Idaho, approximately 280 km (174 miles) southwest of the Project area (**Figure 48**). One of the six flakes returned an unknown source identification. Yet, looking at the trace element scatter plot indicates the unknown is likely a Bear Gulch variant not represented in the Northwest Research Obsidian Studies Laboratory (NWR) database (Nyers 2021, **Appendix D**). Phenotypically, the Bear Gulch obsidian from 24ME1109 is relatively opaque, but brownish when backlit, with small phenocrysts. The unknown is the same. Therefore, the unknown is treated as Bear Gulch obsidian in this analysis.

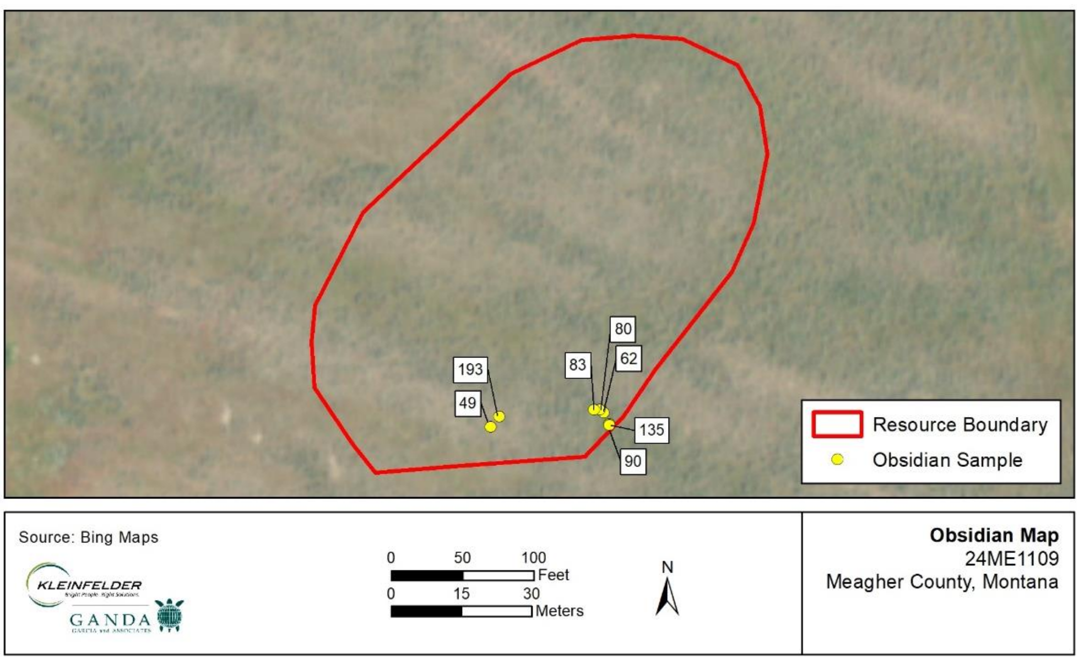


Figure 47: Obsidian Flakes from 24ME1109

All six flakes, being recovered from the same 7-square meter block exposure, likely represent the reduction of one or two obsidian artifacts, therefore the mean hydration value is interpreted as the most likely indicator of age. Obsidian hydration analysis of the six flakes returned a 3.1µ - 2.2µ range, with a 2.6µ hydration mean (**Table 15**). A 2.6µ hydration mean rim value on the Tahoe Sierra Hydration Curve equates to approximately 1,404 BP, within the early Late Prehistoric Period.

Because the flakes from the Clark Creek Cache, discussed in Chapter 5, are also Bear Gulch obsidian, we can use the Clark Creek Cache adjusted hydration rate formula for the Napa Valley obsidian source to further assess the use of the Tahoe Sierra Hydration Curve to interpret Black Butte Project hydration data. Use of EHT and rate adjustments as applied to the Clark Creek Cache data return an *adjusted* 3.0µ hydration mean for the 24ME1109 Bear Gulch sample, interpreted by the Napa Valley formula as 1,381 BP. This formula calculated mean age for the six 24ME1109 Bear Gulch flakes is very similar to the 1,404 BP mean age interpreted by using the Tahoe Sierra Hydration Curve.

One surface obsidian flake from the southern 24ME1109 site area was identified from the Obsidian Cliff source (**Table 15**). Hydration analysis measured two distinct rim values (**Table 16**). A 4.3µ rim value was measured on the body of the flake, with a 3.5µ rim value measured on the break. The 4.3µ rim value indicates the flake was manufactured approximately 3,364 BP during the end of the Middle Plains Archaic Tradition. The flake was then broken about 1,000 years later.

Table 15. Obsidian Studies Data – Source, Hydration Ranges, Means, and Variance

Site	Source	Count	Range	Age Range	Mean	Mean Age	SD	CV
24ME1109	Bear Gulch/ Unknown	6	3.1-2.2	1,932-1,018	2.6	1,404	0.34	0.13
24ME1109	Obsidian Cliff	1	N/A	N/A	3.5/4.3	2,380/3,364	N/A	N/A

Ranges and Means in Microns
Ages are approximate years before present (BP) based on the Tahoe Sierra Hypothetical Hydration Curve (Figure 7)
SD = Standard Deviation: a measure of the amount of variation of a set of values. A low standard deviation indicates that the values tend to be close to the mean.
CV = Coefficient of Variation: the ratio of the standard deviation to the mean, showing the extent of variability in relation to the mean of the population. A low CV indicates a close association.

Table 16. 24ME1109 Obsidian Studies Sample

Cat #	Unit	Depth (cm bs)	Description	Rim 1	Rim 2	Source
49	EU 16	10-20	Flake	2.8	---	Bear Gulch
62	EU 19	0-10	Flake	3.1	---	Bear Gulch
80	EU 21	30-40	Flake	2.2	---	Bear Gulch
83	EU 22	0-10	Flake	2.7	---	Bear Gulch
90	EU 19/EU 20	49-60	Flake	2.5	---	Bear Gulch
135	EU 36	0-10	Flake	2.3	---	Unknown
193	---	Surface	Flake	3.5	4.3	Obsidian Cliff

*Rim values in Microns; --- = no data/not applicable

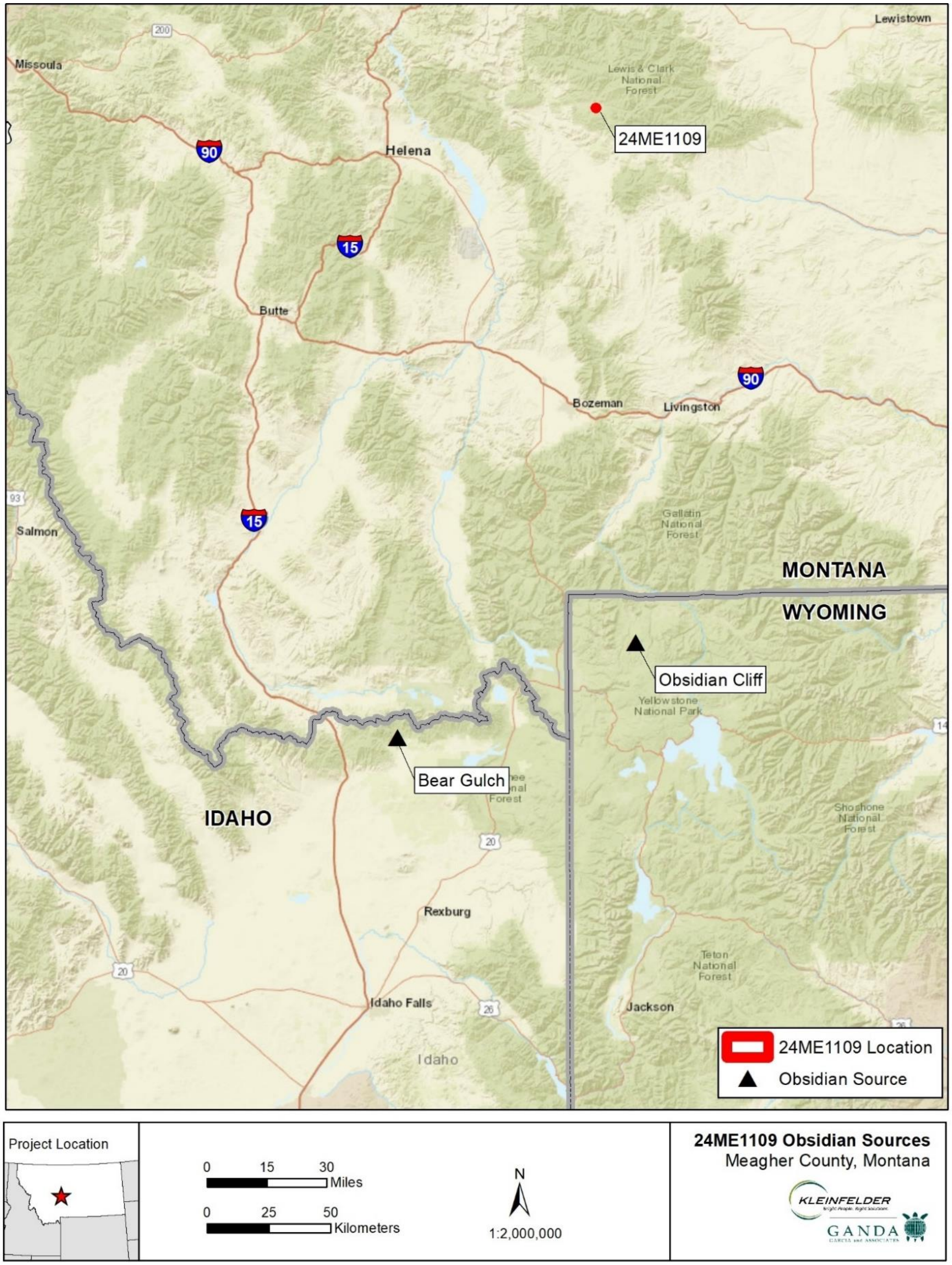


Figure 48: Obsidian Sources

8 Analysis of the Sheep Creek Chert

Lithic materials can be tricky materials to source. Some materials can be reliably attributed to their source by visual examination, but visual methods are not dependable and are often arbitrary and based on color. Research at a single quarry pit at Camp Baker, located in the same region as the Project area, exhibited a huge amount of variation in color, translucence, luster, texture, and structure, demonstrating the unreliability of basing chert sourcing on the lithics' appearance (Roll et al. 2005). Sheep Creek, which runs through the Project area, lies 11 miles east of the Smith River, in an area well known for its chert quarries including the Camp Baker Quarry and Dogget Quarry.

Chemistry-based methods including XRF and NAA have gained traction in their ability to source lithic materials. Measuring the elements present in chert can be used to identify chemical fingerprints in the chert and can thus trace unique sources (Roll et al. 2005). Research using the application of LA-ICP-MS has shown promise in chemically sourcing chert artifacts. Previous analyses of southwest Montana chert were conducted by the Archaeometry Laboratory within MURR department. Although the LA-ICP-MS results were mixed, researchers still believe sourcing through chemical analysis is a viable research direction.

8.1 Mitigation of the Sheep Creek District (24ME1111)

As part of a broader data recovery effort, mitigation for the District seeks to chemically characterize the chert sources sampled from within the site to determine if they can be distinguished from other local or regionally important sources (i.e., "fingerprinted") and/or if there is internal variation within the site. The broader aim is to build compositional profiles of local sources that may be used to determine provenance of chert artifacts in the future.

8.2 Previous Studies

Previous archaeological research in the region has attempted to distinguish chemical "fingerprints" of Montana chert samples for the purpose of chemically sourcing chert artifacts through the use of chemical testing (Roll et al. 2005). These efforts have been undertaken in attempts to identify the fingerprint of chert quarry sites in western Montana (Roll et al. 2005; Speakman 2003; Speakman and Glascock 2002). These efforts were encouraging and demonstrated chemical groupings within the dataset. Despite this success, comparative materials from the region were limited for the current study given that earlier studies employed different procedures for data collection. Eight western Montana chert samples were subjected to LA-ICP-MS testing (**Figure 49**); Distinct signature groups were determined for cherts from Avon Quarry, Lime Creek Quarry, South Everson Quarry, Logan Quarry, and Camp Baker Quarry. However, an undifferentiated group consisting of cherts from Camp Baker Quarry, Doggett Quarry, 24ME322, Devil's Eyebrow Quarry, and brown chert from Logan Quarry were determined to share a similar chemical signature. These results were somewhat surprising as the distances between these quarries is great enough to expect unique signatures from the various quarries.

Three chert quarries in the Smith River region have been subject to testing and have not resulted in the identification of a unique signature. However, three quarries in southwestern Montana have produced unique chemical signatures (see **Figure 49**).

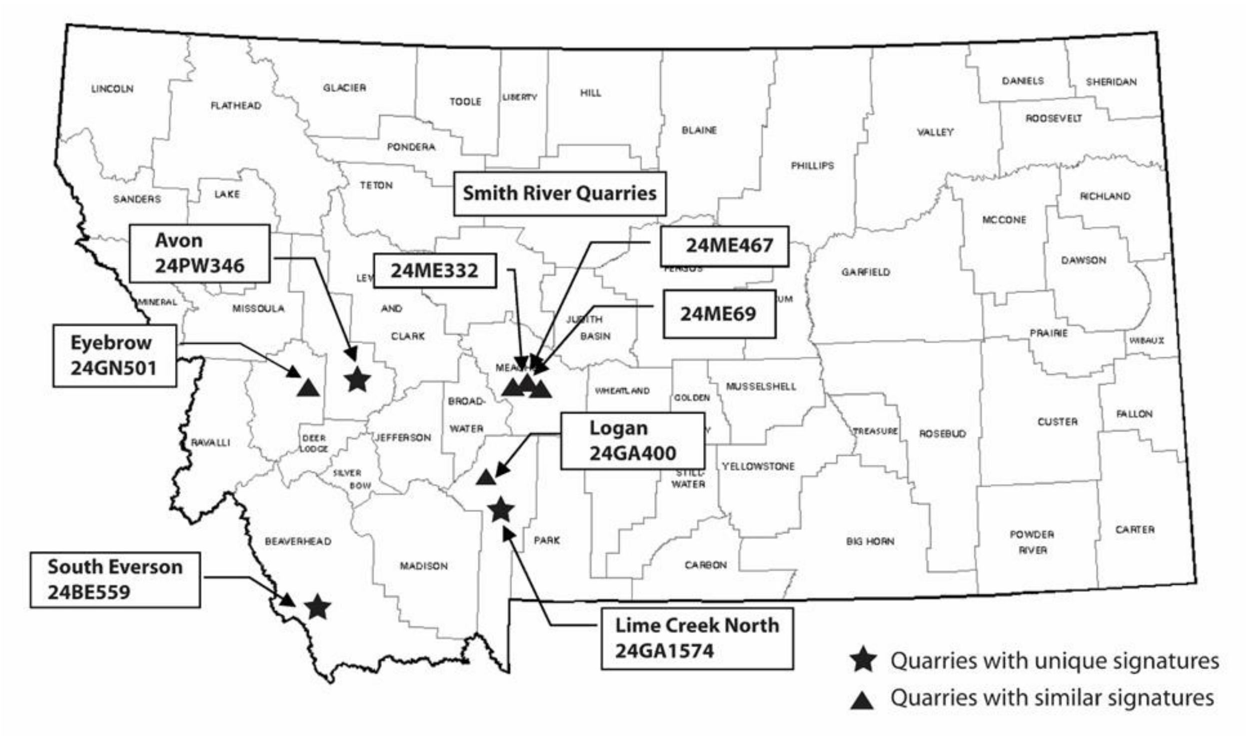


Figure 49: Prehistoric Quarries in Southwestern Montana

8.3 Field Methodology

Chert samples were collected from the District in July and August 2020 from ten of the thirteen lithic scatters recorded within the District (see **Table 17**; **Figure 50**). A total of 30 chert samples weighing at least 10 grams were collected. Three sites (24ME166, 24ME1106, and 24ME1110) were surveyed for suitable surface samples, but none meeting the minimum size requirements were observed; ground visibility was extremely poor within those site boundaries due to vegetation. Collected samples were weighed in the field to ensure they met the minimum size standards. Once selected, the sample was bagged and labeled, and the provenance was taken using GPS with submeter accuracy.

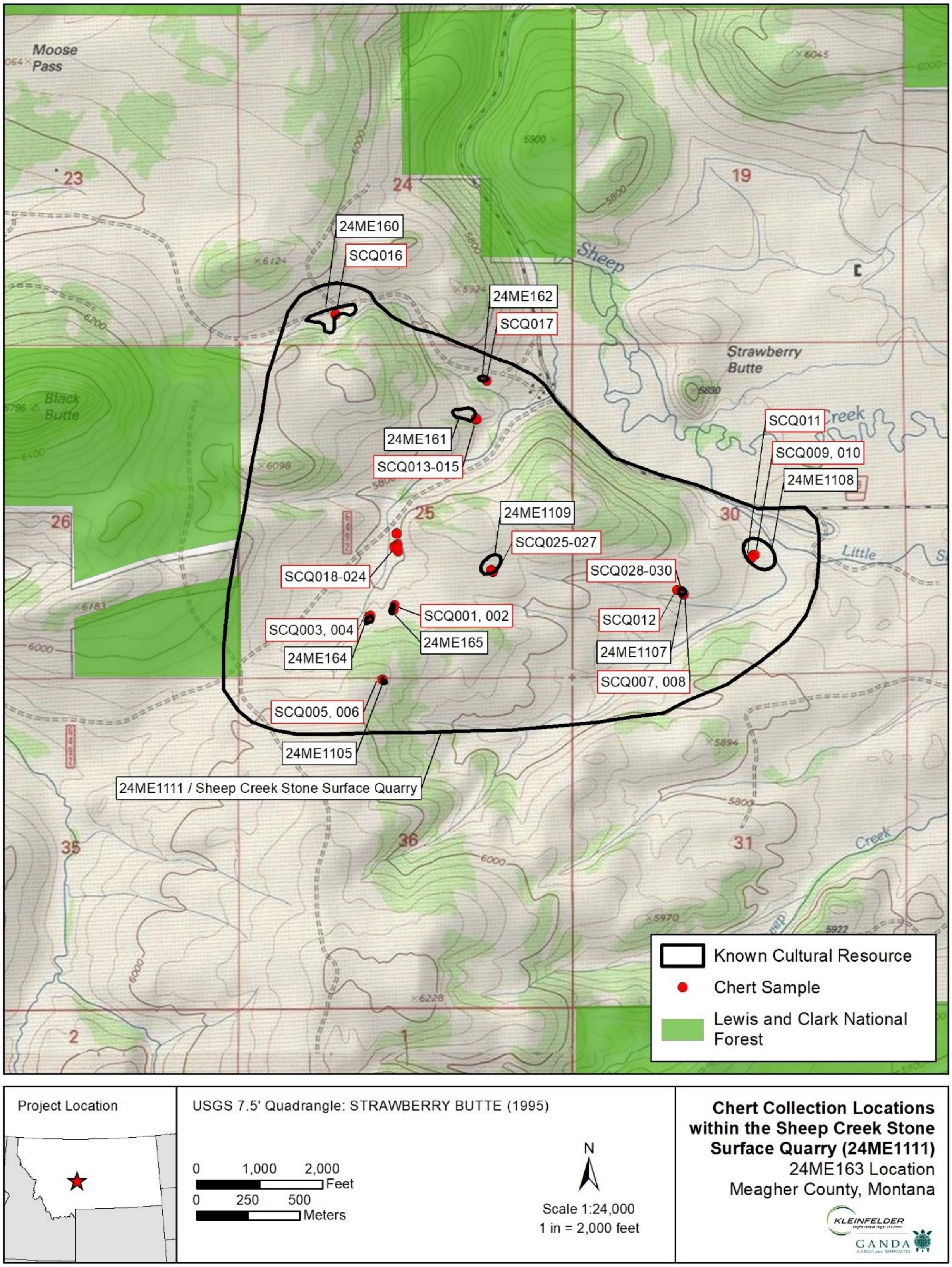


Figure 50: Chert Collection Locations

Table 17. Chert Samples Collected for Analysis

Analysis ID	Field ID	Site Number	Sample Description	Provenance
SCQ001	Sample 1	24ME165	Debitage	Surface
SCQ002	Sample 2	24ME165	Debitage	Surface
SCQ003	Sample 3	24ME164	Debitage	Surface
SCQ004	Sample 4	24ME164	Debitage	Surface
SCQ005	Sample 5	24ME1105	Debitage	30-40 cm bs
SCQ006	Sample 6	24ME1105	Debitage	20-30 cm bs
SCQ007	Sample 7	24ME1107	Debitage	Surface
SCQ008	Sample 8	24ME1107	Debitage	Surface
SCQ009	Sample 9	24ME1108	Debitage	Surface
SCQ010	Sample 10	24ME1108	Debitage	Surface
SCQ011	Sample 11	24ME1108	Debitage	Surface
SCQ012	Sample 12	24ME1107	Debitage	Surface
SCQ013	Sample 13	24ME161	Debitage	Surface
SCQ014	Sample 14	24ME161	Debitage	Surface
SCQ015	Sample 15	24ME161	Debitage	Surface
SCQ016	Sample 16	24ME160	Debitage	Surface
SCQ017	Sample 17	24ME162	Debitage	Surface
SCQ018	Sample 18	24ME163	Debitage	Surface
SCQ019	Sample 19	24ME163	Debitage	Surface
SCQ020	Sample 20	24ME163	Debitage	Surface
SCQ021	Sample 21	24ME163	Debitage	Surface
SCQ022	Sample 22	24ME163	Debitage	Surface
SCQ023	Sample 23	24ME163	Debitage	Surface
SCQ024	Sample 24	24ME163	Debitage	Surface
SCQ025	Sample 25	24ME1109	Debitage	Surface
SCQ026	Sample 26	24ME1109	Debitage	Surface
SCQ027	Sample 27	24ME1109	Debitage	Surface
SCQ028	Sample 28	24ME1107	Unworked Cobble	Surface
SCQ029	Sample 29	24ME1107	Unworked Cobble	Surface
SCQ030	Sample 30	24ME1107	Unworked Cobble	Surface

8.4 Laboratory Analysis

The NAA provides qualitative and quantitative multi-element analysis of major, minor, and trace elements in chert samples. Dr. Michael Glascock suggested the use of NAA analysis in addition to LA-ICP-MS analysis because when chemical concentrations are very low, there will be more elements below the detection limit with LA-ICP-MS than NAA. Additionally, NAA uses a larger sample than LA-ICP-MS so this analysis provides better overall average concentration for each sample. The MURR has examined over 3,000 chert source and artifact samples from around the world and, with the exception of a few projects using LA-ICP-MS, all other chert samples were subjected to NAA. By using both LA-ICP-MS and NAA, the Sheep Creek Quarry samples will be comparable to Roll's LA-

ICP-MS results, and together, the two methods should provide a more robust chemical fingerprint of the Sheep Creek cherts.

8.5 Results

The current sample is distinct from most of the chert samples within MURR's chert database for the Plains region. It is also easily distinguishable from the nearest comparative dataset (although of dissimilar materials) from eastern Montana (i.e., Roll's 2003 sample). The Euclidean distance search also demonstrated that the closest matches for the current dataset, although distant, tend to be from outcrops in central Colorado. This is certainly due to coincidental geological similarities that resulted in similar chemical composition, rather than any actual association between the samples. Overall, these comparative results are promising as they suggest that chert sources from southwestern Montana may be distinguished from other chert producing areas on the Plains. Results of both NAA and LA-ICP-MS analyses were suggestive of spatial patterning within the current dataset, with the NAA dataset more clearly demonstrating some level of possible differentiation between sources within the District itself (Goodwin and MacDonald 2021).

9 Heat Treatment Studies

As suggested by Peterson (Tetra Tech 2020), chert heat treatment was probably conducted on site. Although the fine grain quality of some of the chert produces a natural luster, the high luster noted on many flakes, one core, and several bifaces and flake tools in the current collection is indicative of successful heat treatment (**Appendices A and B**). It is possible that the hearth exposed at Site 24ME163 during the 2019 excavations by Tetra Tech in 2020 was used to heat treat chert. In contrast to the highly lustrous characteristics of heat-treated chert, potlids and crazing seen primarily in the debitage collection is indicative of post-depositional exposure to flame, but not from successful heat treatment. Natural surface fires across the site area could directly affect surface artifacts. In addition, hearth fires could cause discarded artifacts to come in direct contact with flame.

9.1 Knapping Replication and Heat Treatment Studies

The majority of the unmodified chert surface cobbles and boulders were collected from the vicinity of site 24ME1106 (**Figures 51 and 52**) to replicate procurement core reduction, producing prepared cores, flakes, and early-stage bifaces for heat treatment studies. Toolstone quality of the collected cobbles and boulders varies from poor to moderately good.

Figure 51: Unmodified chert surface cobbles

Figure 52: Site 24ME1106 where boulders for knapping were collected.

Demonstrating, that toolstone quality was typically not consistent throughout a single cobble. Most cobbles had internal flaws in the way of fracture planes and vugs. Structural consistency also varied from hard and homogenous to brittle and extremely fractured. The site surface at 24ME1106 is characterized by a sparse scatter of chert debitage amongst unworked colluvial cobbles and boulders (Peterson and Barnett 2015). The relative lack of debitage possibly reflects the generally low toolstone quality of the surface cobbles; in that, few of the cobbles were good enough quality for procurement and on-site core reduction. Surface flakes may be primarily assay debitage. Hence, our collection does not begin to match the wide variety of colors and textures seen in the archaeological collection; nor the diversity of chert toolstone that might be procured in the Project vicinity. Nevertheless, the replication results provide insights on local chert procurement and reduction.

The replication process involved twenty cobbles and two boulders for replication core reduction and heat treatment (replication notes given in **Appendix C**). A large igneous hammerstone was used during freehand percussion to reduce each cobble, attempting to access good quality toolstone and produce usable flake blanks. The boulders were initially broken up with metal sledgehammers to obtain smaller, blocky cobble-size chunks for core reduction. Hafted hammerstones “grooved mauls” were discovered at the Camp Baker Quarry, 24ME467 (Roll 2003), probably functioning as heavy sledgehammers for boulder reduction. Several of the cobbles yielded no usable toolstone. But most reduction resulted in prepared multidirectional and unidirectional cores, and a few good flakes, for heat treatment.

Heat treatment studies were conducted to identify heat treatment characteristics of the local chert to better interpret chert heat treatment within the Project area. Successful heat treatment results in increased reduction compliance, i.e., workability (Domanski and Webb 2007: 157), and is typically characterized by increased luster and sometimes color change. The outside of the heat-treated toolstone does not show luster change but can turn red. Increased luster is exposed on interior toolstone during the reduction of heat-treated cores and flakes.

Native American flint knappers would have heat-treated chert under a campfire, relying on experience to properly heat the toolstone to the desired temperature. Our heat treatment replication was conducted using a flint knapper's kiln and pyrometer (**Figure 52**). A previous heat treatment replication using local chert was conducted by Rennie (2020) in conjunction with previous excavations within the Black Butte Copper Mine Project area (Tetra Tech 2020). Rennie used a roaster oven, heated incrementally over four hours to a maximum of 450 degrees Fahrenheit (°F); where it was left to cook for another four hours. That heat treatment was unsuccessful, with no change in luster or color. Working from the results of Rennie's experiment, as well as previous experience with heat-treating similar quality chert, our kiln was filled with cores and flakes (**Figures 53** and **54**) and slowly heated to a maximum temperature of 550°F. Experience has shown that once the critical maximum temperature is attained, the chert will have been successfully heat treated and the kiln can be turned off for slow cooling. Prolonged cooking at the desired temperature is not necessary.

The kiln heat treatment to 550°F was successful. Yet, results vary depending on initial toolstone quality and the presence of internal flaws that caused failure during post heat treatment reduction. Nine replications were heat treated, including seven cores with their respective flakes, as well as two stage 2 bifaces. Many of the cores and the bifaces were yellowish brown, which turned red on their exterior during heat treatment (**Photo 54**). Gray toolstone did not turn red. Five (56%) of the replications showed increased interior luster, while four (44%) did not. Replications with increased luster also showed increased reduction compliance. Increased brittleness was noted for four (44%) of the replications. Increased brittleness often increases ease of flake removal but does not always equate to increased compliance. In fact, in these cases, increased brittleness typically led to breakage and reduction failure. One was a stage 2 biface that may have been overheated. It started out as fine-grain non-lustrous, turned very lustrous during heat treatment, but eventually shattered during percussion reduction with an igneous hammerstone.

Figure 53: Pyrometer and kiln.

Figures 54 and 55: Chert before (left) and after (right) heat treatment.

Probably the most successful case was Replication 17 (**Appendix C**), where a moderate grain changed to fine grain with increased luster and enhanced gray color creating a gray green tone (**Figure 56**). As a result, compliance to percussion reduction was significantly increased with this example. Yet, the toolstone remained relatively hard for pressure flaking. Light percussion with a sandstone hammerstone and an elk billet was better suited to bifacial flake removal, producing a small, nicely shaped early stage 3 biface ready for use or continued reduction (**Figure 57**).

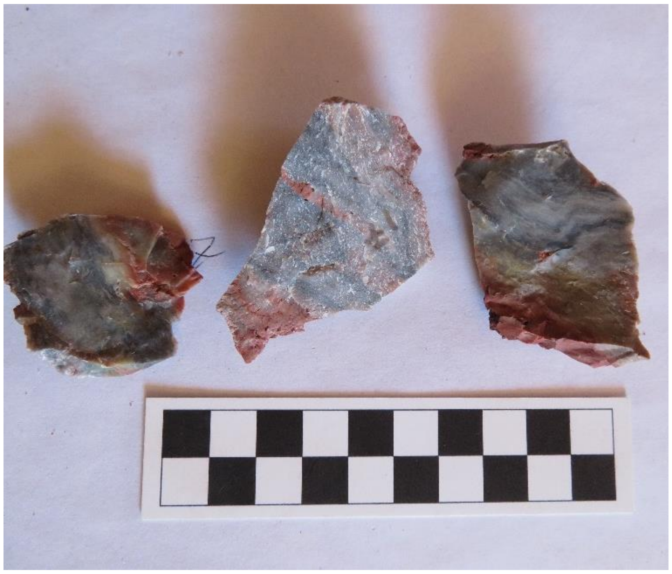


Figure 56: Replication 17

Figure 57: Replication 17, post heat treatment

In sum, moderate to fine grain good toolstone quality local cobbles will successfully heat treat at 550°F. Successful post-heat treatment reduction is dependent on general toolstone quality and material flaws, including the presence/absence of internal fracture planes and vugs. Large, hard hammerstones are necessary for initial cobble core reduction. Elk billets and smaller, softer hammerstones are preferred for post-heat treatment reduction to facilitate flake removal without shattering platforms and flake breakage.

10 Discussion and Site Interpretation

This section applies the results of all archaeological fieldwork completed for this Project and results from lithic analysis and special studies to interpret the Sheep Creek Quarry Archaeological District, and to answer research questions related to chronology and lithic technology and procurement, and chemical analysis of the Sheep Creek chert.

10.1 Chronology

A primary research question guiding this study relates to dates of prehistoric occupation. Fieldwork in 2020 at sites 24ME163 and 24ME1109 produced carbon-bearing hearth features suitable for radiocarbon dating and obsidian debitage appropriate for obsidian hydration analysis. Additionally, diagnostic tool fragments and two projectile point fragments were identified during data recovery efforts in the summer of 2020.

A total of nine hearths have been identified within the district, as summarized in **Table 18**. Remarkably, seven hearth features were encountered during the 2020 field season, each of which contained in situ charcoal deposits suitable for carbon dating. In 2019, two charcoal-bearing hearth features were identified during subsurface testing at 24ME163 and 24ME1105. Site 24ME1105 was determined to have intact subsurface deposits and is eligible for the NRHP individually and is a contributing member of the District; the site will be avoided during Phase 1 construction and was not subject to data recovery for this study.

Table 18. Summary of Radiocarbon Dates from Features from the Sheep Creek District

Site	Year Excavated	Feature	Date (BP)	Date Range
24ME163	2019	Hearth	3,215 +/- 20	1520 - 1430 BC
24ME1105	2019	Hearth	795 +/- 15	1210 - 1270 AD
24ME163	2020	Hearth, Feature 1	900 +/- 30 950 +/- 30	1039 - 1210 AD 1024 - 1155 AD
24ME163	2020	Hearth, Feature 2	930 +/- 30 900 +/- 30	1025 - 1165 AD 1039 - 1210 AD
24ME1109	2020	Hearth, Feature 1/2A/2B	2,220 +/- 30 2,280 +/- 30 2,220 +/- 30 2,190 +/- 30 2,200 +/- 30 2,290 +/- 30	375 - 203 BC 403 - 352 BC 375 - 203 BC 361 - 177 BC 366 - 186 BC 405 - 353 BC
24ME1109	2020	Hearth, Feature 3	1,320 +/- 30	652 - 722 AD

Site	Year Excavated	Feature	Date (BP)	Date Range
24ME1109	2020	Hearth, Feature 4	2,510 +/- 30 3,540 +/- 30	696 - 540 BC 1954 - 1767 BC
24ME1109	2020	Hearth, Feature 5	4,900 +/- 30	3715 - 3638 BC
24ME1109	2020	Hearth, Feature 6	2,420 +/- 30 3,210 +/- 30	556 - 402 BC 1532 - 1418 BC

10.1.1 Occupation Period at Site 24ME163

Data from 24ME163 reveals that site had multiple periods of occupation from the Middle Plains Period (5,000-3,000 BP) through the Late Prehistoric Period (1,500-300 BP). The two hearth features recovered during the 2020 excavation produced radiocarbon dates (900-950 BP) from the Late Prehistoric Period while the hearth excavated in 2019 produced a date in the Middle Plains Archaic (3,215 BP).

The single, small pressure-flaked indeterminate stage end fragment is probably the basal corner of a projectile point with a slightly concave base. Regional projectile points with similar basal morphology include the Duncan-Hanna and Pelican Lake types with temporal ranges from late Middle Plains Archaic Period to early Late Plains Period.

Four obsidian flakes were recovered during the 2020 data recovery efforts. One originates from Big Southern Butte, approximately 254 miles southwest of the Project area in southeast Idaho and three obsidian flakes originate from Obsidian Cliff, Wyoming, approximately 135 miles south of the Project area. Hydration rim values for the Obsidian Cliffs sample range from 5.9µ to 4.5µ, which is interpreted using the Tahoe Sierra Hydration Curve at 5,620 BP to 3,620 BP, with a 5.2µ mean interpreted at 4,588 BP. The Big Southern Butte sample has a 5.8µ rim value interpreted at 5,476 BP. Together the obsidian hydration data indicate the southern end of the site area was occupied at various times within a 2,000-year time frame spanning the transition from the Early to Middle Plains Archaic Tradition.

10.1.2 Occupation Period at Site 24ME1109

Similarly, data from site 24ME1109 reveals that the site has multiple periods of occupation from the Middle Plains Period through the Late Prehistoric Period. Five hearth features produced radiocarbon dates ranging from the 1,320 -4,900 BP, representing occupation during the Late Prehistoric, Late Plains Archaic, and Middle Plains Archaic periods.

A single projectile point from site 24ME1109 is an arrow-size lateral fragment with one remnant notch. It was made using a matte gray chert. Breakage may have initially been caused by bending during manufacture or use. On-site discard was followed by extensive post-depositional thermal damage, indicated by multiple spalls and fractures showing high luster. The complete morphology of the remnant notch is slightly obscured by a small break at the basal corner. Yet, its overall shape indicates it was side-notched, possibly resembling the Late Prehistoric Plains Side-notched projectile point type.

Obsidian hydration analysis of the six flakes recovered in a 7-square meter block excavation near the southeastern site boundary returned an approximate date of 1,404 BP, within the early Late Prehistoric Period. One surface obsidian flake gave an approximate date of 3,364 BP during the end of the Middle Plains Archaic Tradition. The flake was then broken about 1,000 years later.

10.2 Procurement Strategies and Lithic Technologies

As discussed in Chapter 4, procurement of raw materials is considered on a spectrum ranging between embedded procurement, occurring along with day-to-day activities, and disembedded/direct procurement, occurring as a dedicated task to acquire valuable raw materials. The diversity of flaked stone tools, cores, and debitage recovered at sites 24ME163 and 24ME1109 indicates a variety of activities occurred during probably multiple, short-term occupations. The presence of expedient and curated subsistence tools indicates residential activity and quarrying as an embedded task.

Procurement was relatively straight forward, relying on surface finds and freehand percussion core reduction of collected nodules to produce usable flakes. Quarry pit excavations, common at numerous regional sites (Hall and Wendel 2012b), were not observed at either site, or within the Sheep Creek District. Many of the selected cobbles were cortical, necessitating the removal and discard of numerous cortical flakes prior to the removal of usable flake blanks. Most of the useable flake blanks were probably transported off-site with only initial reduction to remove rough margins. At the same time, chert cores and flake blanks from possibly more distant source locations may have been imported for reduction. Discarded early-stage biface manufacture failures and low frequencies of early-stage biface thinning flakes at both sites indicate that some of the manufactured flake blanks were further reduced by percussion biface reduction to produce stage 2 and early stage 3 bifaces for transport offsite. The lack of late-stage biface fragments, as well as low frequencies of late-stage biface thinning flakes, indicate only a small number of bifaces were taken to stage 4 secondary thinning; and there are no stage 5 manufacture discards in the collection. A few flake blanks were used on site as flake tools.

The local chert toolstone was available in the vicinity as surface cobbles and boulders, eroding out of bedrock outcrops (Tetra Tech 2020). Size-grade analysis of the predominantly whole diagnostic flakes indicates that the local chert selected for reduction was typically cobble-size colluvial nodules and cobble-size blocky chunks broken off local boulders. Biface fragment size indicates that the flake blanks selected for further reduction were likely much larger than most of the debitage in the collection. Many of the ¼-in. size chert flakes likely resulted from the initial preparation of flake blanks and stage 2 biface reduction. Characteristics of the collected debitage indicate chert toolstone quality ranges from coarse-grain, fair quality with a matte surface to fine-grain, very siliceous good quality material. Chert color is predominantly red and yellowish brown, but variations include dark brown and purple to gray and white. Banding and mottling of two or more colors is common. Some of the coarse grain material is brittle, which typically works against successful tool manufacture.

During the 2020 excavations, a total of 19 tools, 4 cores, and 3,311 pieces of debitage were recovered from 24ME163; and 35 tools, 1 core, and 3,524 pieces of debitage were recovered from 24ME1109. Of the tools, the majority were expedient tools, but the presence of well-made, probably curated, unifaces and predominantly unmodified flake tools indicate a small amount of materials processing tasks were conducted in association with chert procurement. The arrow-size side-notched projectile point from 24ME1109 and the small pressure-flaked biface fragment from 24ME163, which might have been a discarded projectile point base, indicate at least a minimal amount of time devoted to toolkit maintenance to refurbish and haft projectile points. In addition, the small amounts of chalcedony, quartzite, and obsidian from distant sources represent the variety of nonlocal toolstone that comprised the flaked stone toolkit. The varied toolstone reflects a diversity of regional resource procurement strategies and possibly trade relationships.

Chert heat treatment was probably conducted on site. Although the fine grain quality of some of the chert produces a natural luster, the high luster noted on many flakes, one core, and several bifaces and flake tools in the current collection is indicative of successful heat treatment. It is possible hearths identified during excavations 2019 and 2020 were used for the heat treatment of chert. In contrast to the highly lustrous characteristics of heat-treated chert, potlids and crazing seen primarily in the debitage collection is indicative of post-depositional exposure to flame not successful heat treatment. Natural surface fires across the site area could directly affect surface artifacts. In addition, hearth fires could cause discarded artifacts to come in direct contact with flame.

10.3 Chemical Make-up of the Sheep Creek Chert

As discussed in detail in Chapter 8, 30 samples of chert collected from across the District were sent to the Archaeometry Laboratory within the MURR department to undergo LA-ICP-MS and NAA analysis.

Results indicated that the chert sample provided is distinct from most of the chert samples within MURR’s chert database for the Plains region. The chert is easily distinguishable from the nearest comparative dataset (although of dissimilar materials) from eastern Montana (i.e., Roll’s 2003 sample). The closest matches for the current dataset, although distant, tend to be from outcrops in central Colorado, certainly due to coincidental geological similarities that resulted in similar chemical composition, rather than any actual association between the samples. The comparative results are promising as they suggest that chert sources from southwestern Montana may be distinguished from other chert producing areas on the Plains. Results of both the NAA and LA-ICP-MS analyses were suggestive of spatial patterning within the current dataset, with the NAA dataset more clearly demonstrating some level of possible differentiation between sources within the District itself (Goodwin and MacDonald 2021).

10.4 Prehistoric Quarrying at Black Butte

Research within the District has revealed the quarry was utilized over an approximate 4,000-year period from the Middle Archaic Plains Period through the Late Prehistoric Period. The diversity of flaked stone tools, cores, and debitage recovered at sites 24ME163 and 24ME1109 indicates that quarrying and lithic reduction occurred along with subsistence activities occurred during multiple, short-term occupations. The sites were used as workshops and campsites, where the collected surface chert nodules were knapped and heat treated. Preliminary subsurface investigations in 2019 at site 24ME1105 identified a hearth along with many chert tertiary flakes suggests this site was also a workshop/habitation site. The recovery of nine hearths excavated within the District indicate at least short-term occupation, and were likely used for light, heat, cooking, and the heat treatment of chert.

The Black Butte region had a wealth of water, plant, animal, and raw stone material resources. The District represents an embedded strategy of procurement, where quarrying occurred in harmony with other activities, but chert procurement was the predominant on-site activity. Knapping activities primarily focused on core reduction to manufacture flake blanks and the initial reduction of flake blanks. Some of those flake blanks were turned into early- and late- stage bifaces and used as flake tools on site. Some cores, flake blanks, and early-stage bifaces were probably heat treated on site to increase compliance. The failures were left for us to find while successfully made cores, flake blanks, and bifaces were exported off-site for continued reduction, tool manufacture, and use elsewhere. The small amounts of obsidian, chalcedony, quartzite, lithics from distant sources represent the variety of nonlocal toolstone that comprised the flaked stone toolkit and reflects a diversity of regional resource procurement strategies and trade relationships. Given the presence of tools, specifically expedient tools with use wear, likely for food and/or minimal processing occurred while occupying workshops.

Smith River Prehistoric Quarries

The District represents a distinctive form of quarrying and procurement strategy compared to the other documented prehistoric chert quarries within a 20-mile radius. Archaeological investigations at Doggett Quarry (24ME69), Camp Baker (24ME467), and 24ME332 have identified numerous concentrations of quarry pits and evidence of subsurface exploration; in contrast to Sheep Creek Quarry, where no quarry pits were identified within the 1,600-acre Project area.

Materials identified at the Smith River quarries represent two activities, quarrying and initial roughing out of cores. Cultural constituents at Camp Baker consists primarily of lithics reduction and involved flake removal from blocks intended for subsequent modification at other locations; with no evidence of heat treatment of chert (Roll 2003). Preliminary investigations at Camp Baker reveal that the quarry was likely used as direct procurement method with the purpose of colleting the high-quality chert while other cultural activities and campsites were located elsewhere. This is dissimilar to the Sheep Creek Quarry where workshop sites and short-term occupation appear to be major components of prehistoric activity and where raw toolstone procurement occurred in concert with other activities.

11 Summary and Conclusions

Sandfire Resources America Inc. (Sandfire) began the permitted Phase 1 Development construction at the Black Butte Copper Project in the summer of 2020. Three prehistoric resources located within the first phase mine footprints were recommended eligible for inclusion in the NRHP, and avoidance of these resources was not feasible. Therefore, this study included mitigation and data recovery at the following three impacted cultural resource sites in 2020 prior to the start of the Phase 1 Development construction activities: the Sheep Creek Quarry Archaeological District (24ME1111) and sites 24ME163 and 24ME1109. Since the mine project is located on private land, other than designated wetland areas impacted by the mine facilities, there are no other Federal or State regulations that require cultural resource inventory work. However, Sandfire voluntarily contracted GANDA/Kleinfelder to perform the mitigation and data recovery work necessary to recover a sufficient set of data in order to preserve the prehistoric information for future researchers.

Chert samples were collected from across the District in the attempt to identity a unique chemical fingerprint of the Sheep Creek Chert. Results indicate that the Sheep Creek chert sample provided is distinct from most of the chert samples within MURR's chert database for the Plains region. Both the NAA and LA-ICP-MS analyses were suggestive of spatial patterning within the current dataset, with the NAA dataset more clearly demonstrating some level of possible differentiation between sources within the district itself.

Data recovery excavations were conducted at sites 24ME1109 and 24ME163, both contributing members of the District to mitigate for direct impacts to subsurface cultural deposits. Excavations at site 24ME163 identified two hearth features, 3,311 pieces of debitage, twelve bifaces including one projectile point fragment, six flake tools, and four cores. Radiocarbon dating of the charcoal recovered from the hearths and obsidian hydration dates of four obsidian flakes from 24ME163 reveals that the site had multiple periods of occupation from the Middle Plains Archaic Period (5,000-3,000 BP) through the Late Prehistoric Period (1,500-300 BP).

Excavation at site 24ME1109 resulted in the identification of five hearth features 3,543 pieces of debitage, one projectile point fragment, twenty-six bifaces, one uniface, seven flake tools, and one core. Radiocarbon dating of the charcoal recovered from the hearths and obsidian hydration dates from 24ME1109 reveals that site had multiple periods of occupation from the Middle Plains Archaic Period through the Late Prehistoric Period.

The Sheep Creek Stone Surface Quarry was used intensively by mobile hunter-gathers for its array of local resources from the Middle Plains Archaic through the Late Prehistoric Period. The procurement of raw toolstone materials, as part of an embedded procurement strategy, occurred in concert with other subsistence activities. Loci within the quarry were used as workshops and short-term campsites where early- and late- stage biface reduction, flake tool production, and on-site heat treatment of the chert occurred in conjunction with primary activity of core reduction to manufacture flake blanks for transport off site. Small amounts of chalcedony, quartzite, and obsidian from distant sources represent the variety of nonlocal toolstone that comprised the flaked stone toolkit and reflects a diversity of regional resource procurement strategies and possibly trade relationships. The ability to chemically source chert from quarry sites in Southwestern Montana will contribute to the understanding of the distributional range of toolstone and the understanding of prehistoric hunter-gather mobility patterns in the Northwestern Plains.

Based on previous work by Tetra Tech and cultural resource site mitigation plan discussions between Tetra Tech and SHPO, and the 2020 GANDA/Kleinfelder data recovery results, GANDA/Kleinfelder believes that sufficient mitigation work was completed at sites 24ME163 and 24ME1109 and allowed Sandfire to proceed with the Phase 1 mine construction activities over these areas. There are several other identified cultural resource inventory sites lying within the District that may be impacted by future mine construction which could require (on a voluntary basis) further evaluation for NRHP eligibility and mitigation if these sites cannot be avoided (see Table 2).

Management Recommendations

The data recovered from the Sheep Quarry Archaeological District, specifically sites 24ME163 and 24ME1109, provide notable contributions to the prehistoric record, primarily regarding lithic manufacture and lifeways of prehistoric hunter-gathers of the Northwestern Plains. GANDA/Kleinfelder considers cultural resource inventory sites 24ME163 and 24ME1109 to be fully mitigated as a result of all work done to date.

Avoidance is recommended for the eight unevaluated lithic scatters noted in Table 2 that are located within the District, some of which may be impacted by future mine construction activities. If avoidance is not possible, additional testing to determine eligibility for inclusion in the NRHP is recommended. It is recommended that, should further ground disturbing work be necessary for the mine Project within portions of the District that have not been recovered to date, that additional data recovery be completed.

There are two additional cultural resource inventory sites (24ME1105 and 24ME1111) that have had substantial work done to date and already been determined eligible for inclusion in the NRHP. These two sites could be impacted by future mine construction activities and will require additional mitigation work (on a voluntary basis) if avoidance is not possible. Even though a substantial amount of mitigation work has been completed on District site 24ME1111, the additional recommended data recovery work at the identified cultural resource sites lying within the District site could add valuable cultural resource knowledge of the region and is recommended.

12 References

Aaberg, Steven

1983. The Camper Baker Fishing Access Archaeological Investigations. Report No. ME 6 005906. On file at the Montana State Historic Preservation Office, Helena, MT.

Alt, David and Donald Hyndman

2000. Roadside Geology of Montana. Mountain Press Publishing Company, Missoula, MT.

Andrefsky Jr., William.

2005. Lithics; Macroscopic Approaches to Analysis. 2nd edition., revised. Cambridge University Press, Cambridge.

Barnett, Kyle

2011. Site form 24ME163 on file at the Montana State Historic Preservation Office, Helena, MT.

Beta Analytics

2020. Report of Radiocarbon Dating Analyses. On file at the Beta Analytics Testing Laboratory, Miami, FL.

Binford, Lewis R.

1979. Organization and Formation Processes: Looking at Curated Technologies. Journal of Anthropological Research 35:225-273.

Bloomer, William W., and Denise Jaffke

2012. Middle Archaic Interaction Spheres Interpreted from Toolstone Distributions in the Tahoe Sierra. *California Archaeology*, Volume 4, Number 2, pp. 225-246.

Bloomer, William W., Sharon A. Waechter and Susan Lindström

1997. Basalt Quarrying on Watson Creek: An Archaeological and Ethnographic Study in the Northern Lake Tahoe Basin. Volume 1: Report. Prepared for the U.S. Forest Service, Lake Tahoe Basin Management Unit, South Lake Tahoe, California.

Bryson, R.A., D.A. Barerreis, and W.M. Wendlund

1970. Glacial and Post-Glacial Climatic Changes. In Pleistocene and Recent Environments of the Central Plains, edited by W. Dort and J.K. Jones, pp. 53-74. Kansas University Press, Lawrence.

Bureau of Indian Affairs (BIA), Department of the Interior
2016. *Indian Land Areas Judicially Established 1978 and American Indian Reservations,* map scale 1:4,250,000, Lakewood, CO.

Callahan, Erret
1979. The Basics of Biface Knapping in the Eastern Fluted Point Tradition: A Manual for Flint Knappers and Lithic Analysts. Archaeology of Eastern North America 9(1):1-180.

Deaver, Kenneth and Lynelle A. Peterson
1999. Cultural Investigations Along the Montana Segment of the Express Pipeline Volume 8: Class I Investigations of Shallow Stone Feature Sites in Central Montana.

Deaver, Sherri
1983. Tipis: Their Distribution and Significance. In Archaeological Investigations on Northern Border Pipeline, Montana Segment, edited by Ken Deaver, 3:9.1- .41.

Domanski, Marian, and John Webb
2007. A Review of Heat Treatment Research. Lithic Technology, Volume 32, Number 2: 153-194.

Fisher, C., D. Pattie, and T. Hartson
2000. *Mammals of the Rocky Mountains*. Lone Pine Publishing, Edmonton, Alberta.

Frison, George C.
1991. *Prehistoric Hunters of the High Plains*. 2nd edition, revised. Academic Press, New York.

Goodwin, Whitney A. and Brandi L. MacDonald
2021. Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry and Neutron Activation Analysis of Chert from the Sheep Creek Stone Surface Quarry, Meagher County, Montana. On file at the Archaeometry Laboratory, Research Reactor Center University of Missouri.

Gregg, M.
1985. An Overview of the Prehistory of Western and Central North Dakota. *Bureau of Land Management Cultural Resource Series No. 1*. U.S. Dept. of the Interior, Bureau of Land Management, Montana State Office, Billings, MT.

Hall, Daniel S. and Ryan E. Wendel
2012a. Class III Cultural Resource Inventory, Dry Range – North Fork, Meagher County, Montana. Prepared by Western Cultural, Inc., Missoula, MT, for USDI Bureau of Land Management, Lewiston, MT. Hirst, K. Kris

2012b. Site form for 24ME467 On file at the Montana State Historic Preservation Office, Helena, MT.

Hirst, K. Kris
2019. The Anzick Clovis Site, Clovis-Aged Burial in American Northwest. Viewed online March 2020 at https://www.thoughtco.com/anzick-clovis-site-montana-usa-172047

Hruska, D.C.
1967. Geology of the Dry Range Area, Meagher County, Montana. M.S. thesis, Department of Geology, Montana College of Mineral Science and Technology, Butte.

Johnson, Todd.
2020. Summary Of Previously Recommended Cultural Resource Inventory Site 24ME1111 Mitigation Work, Black Butte Copper Project, Mt. Internal Memo. Unpublished.

Kelly, Christina E.
2000. Cost-Benefit Relationships at South Everson Creek Quarries, Master's Thesis. On File with the University of Montana.

Knight, George
1976. Site form for 24ME0069 on file at the Montana State Historic Preservation Office, Helena, MT.

Kornfeld, Marcel, George Frison, and Mary Lou Larsen
2010. Prehistoric Hunter-Gathers of the High Plains and Rockies. Third Edition. Taylor and Francis, London and New York.

MacDonald, Douglas H.
2012. *Montana Before History, 11,000 Years of Hunter-Gatherers in the Rockies and Plains*. Montana Press Publishing Co., Missoula, MT.

Martin, Thomas P.
1998. Archaeological Test Excavations at the Visitor Center Site: An Early Holocene Site in Lake Tahoe, California. Unpublished Master's thesis, Sonoma State University, Rohnert Park, California.

Michaletz, Joe.
2019. Sandfire/Tintina - Black Butte Magnetic Survey.

Montana Department of Environmental Quality (MDEQ)
2020a. Black Butte Copper Project Final Environmental Impact Statement.

2020b. Black Butte Copper Project Record of Decision.

Morrow, Carol A. and Richard W. Jefferies
1989.Trade or Embedded Procurement?: A Test Case from Southern Illinois. In Time, Energy and Stone Tools. Edited by R. Torrence, pp. 27-33. Cambridge University Press, Cambridge.

Mulloy, William T.
1958. A Preliminary Historical Outline for the Northwestern Plains. *University of Wyoming Publications* 22(1-2).

Nyers, Alex
2021. X-Ray Fluorescence Analysis of Obsidian Artifacts from Sites 24-ME-163 and 24-ME-1109, Meagher County, Montana. On file at the Northwest Research Obsidian Studies Laboratory.

Payne, G. F.
1973. Vegetative Rangeland Types in Montana, Bulletin 671. Montana Agricultural Experiment Station, Montana State University, Bozeman.

Peterson and Barnett.
2015. Site Form 24ME1105. On file at the Montana State Historic Preservation Office, Helena, MT.

Reeves, Brian O.K.
1973. The Concept of an Altithermal Cultural Hiatus in Northern Plains Prehistory. *American Anthropologist* 75 (5):1221-1253.

Rennie, Patrick J.
2020.Appendix A. Preliminary Assessment of Chipped Stone Items from Archaeological Site 24ME1105. In, Draft Mitigation of a Portion of Site 24ME163 and National Register Eligibility Testing at Four Lithic Scatters (24ME166, 24ME1105, 24ME1109, and 24ME1110) within the Proposed Black Butte Copper Mine, Meagher County, Montana. Presented by Tetra Tech, Helena, Montana, to Sandfire Resources America, Inc., White Sulphur Springs, Montana.

Rennie, Patrick J., and Leslie B. Davis
2016. The Clark Creek Cache in West-Central Montana. *Lithic Technology*, Volume 41, Number 1, pp. 1-18.

Riley, Leslie, M.
2004. Analysis of artifacts from Avon Valley, Montana. Master’s Thesis on file at the University of Montana.

Roll, Thomas E.
2003. The Camp Baker Quarry (24ME67): 2001. Prepared by the Department of Sociology and Anthropology, Montana State University, Bozeman, MT.

Roll, Thomas E., M. P. Neely, R. J. Speakman, and M. D. Glascock.
2005. Characterization of Montana Chert by LA-ICP-MS. In *Laser Ablation ICP-MS in Archaeological Research* edited by Robert J. Speakman and Michael D. Glascock, pp. 58-74, University of New Mexico Press, Albuquerque.

Sandfire America.
2018. Information Center. Found at https://blackbuttecopper.com/faqs/what-is-the-johnny-lee-deposit/.

Scheiber, Laura
2006. Skeletal Biology: Plains. In *Handbook of North American Indians, Volume 3: Environment, Origins, and Population*, edited by D.H. Ubelaker, pp. 595-609. Smithsonian Institution, Washington, D.C.

Schwab, David A.
2018. California Creek Quarry: Regional Perspective and UAS Mapping. Master's Thesis on file at the University of Montana.

1990. 24ME467 Site Record on file at the Montana State Historic Preservation Office, Helena, MT.

Secoy, F. R.
1953 Changing Military Patterns on the Great Plains. *Monographs of the American Ethnological Society, No. 21*. Augustin Publishers, Lucust Valley, NY.

Speakman, Robert J.
2003 LA-ICP-MS Analysis of Chert from Southwestern Montana. *Correspondence with*: Tom Roll. Archaeometry Laboratory, University of Missouri Research Reactor.

Speakman, Robert J. and Michael D. Glascock
2002. Laser Ablation ICP-MS Analysis of Chert from the Camp Baker Quarry Site (24ME467), Montana. Report prepared for: Tom Roll. Archaeometry Laboratory, University of Missouri Research Reactor.

Straight, J.
2014. 24ME0069 Update on file at the Montana State Historic Preservation Office, Helena, MT.

Swagerty, William R.
2001. History of the United States Plains Until 1850 in *Handbook of North American Indians, Volume 13, Part 1 of 2, Plains*. Edited by Raymond J. DeMallie, Smithsonian Institution, Washington, D.C.

Tetra Tech
2020. Draft Mitigation of a Portion of Site 24ME163 and National Register Eligibility Testing at Four Lithic Scatters (24ME166, 24ME1105, 24ME1109, and 24ME1110) within the Proposed Black Butte Copper Mine, Meagher County, Montana.

2018. Cultural Resource Inventory of the Hay Meadows Project Area, Meagher County, Montana.

2015.Cultural Resource Inventory of Proposed Mine Facilities and Access Roads within the Black Butte Copper Project Area, Meagher County, Montana. Included as Appendix I of the Black Butte Copper Mine Operating Permit (MOP) Application (Revision 3) document dated July 2017.

2013a. A Cultural Resource Inventory of 970 Acres in the Black Butte Copper Project Area, Meagher County, Montana.

2013b. Pedestrian Inventory and Testing for National Register Eligibility at Site 24ME163 in the Black Butte Copper Project Area, Meagher County, Montana.

2011. A Cultural Resource Inventory of 810 Acres in the Black Butte Copper Mine Project Area, Meagher County, Montana.

Thatcher, Jennifer J.
2021. Obsidian Hydration Analysis of Artifacts from Sites 24-ME-163 and 24-ME-1109, Meagher County, Montana. On file at Willamette Analytics, Inc.

Thomas, David H.
1970. Archaeology's Operational Imperative: Great Basin Projectile Points as a Test Case. *Los Angeles: University of California Archaeological Survey Annual Report* 12:27-60.

1981. How to Classify the Projectile Points from Monitor Valley, Nevada. *Journal of California and Great Basin Anthropology* 3:7.

APPENDIX A
Lithic Catalog for 24ME163

Appendix A: Lithic Catalog for 24ME163

Cat. = Catalog; EU= Excavation Unit; FLS= Flakes Stone Tool; g= gram(s); m= meter; ME= Meagher County; No= Number

Site No.	Cat. No.	Unit	Depth	Unit Size	Screen Size	Class	Description	Material	Count	Weight (g)	COMMENTS
24ME163	001	EU 1	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	8	19.0	---
24ME163	002	EU 1	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	26	14.4	---
24ME163	003	EU 1	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	100	100.0	---
24ME163	004	EU 1	30-40	1x1m	1/4 inch	FLS	Debitage	Chert	53	60.4	---
24ME163	005	EU 1	40-50	1x1m	1/4 inch	FLS	Debitage	Chert	22	40.4	---
24ME163	006	EU 1	50-60	1x1m	1/4 inch	FLS	Debitage	Chert	15	17.8	---
24ME163	007	EU 1	60-70	1x1m	1/4 inch	FLS	Debitage	Chert	21	57.9	---
24ME163	008	EU 1	70-80	1x1m	1/4 inch	FLS	Debitage	Chert	10	40.0	---
24ME163	009	EU 2	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	129	153.9	---
24ME163	010	EU 2	0-10	1x1m	1/4 inch	FLS	Debitage	Chalcedony	1	0.1	---
24ME163	011	EU 2	10-20	1x1m	1/4 inch	FLS	Biface	Chert	1	11.2	---
24ME163	012	EU 2	10-20	1x1m	1/4 inch	FLS	Biface	Chert	1	9.0	---
24ME163	013	EU 2	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	62	95.1	---
24ME163	014	EU 2	20-30	1x1m	1/4 inch	FLS	Biface	Chert	1	37.7	---
24ME163	015	EU 2	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	179	416.8	---
24ME163	016	EU 2	30-40	1x1m	1/4 inch	FLS	Debitage	Chert	167	192.4	---
24ME163	017	EU 2	40-50	1x1m	1/4 inch	FLS	Debitage	Chert	49	114.9	---
24ME163	018	EU 2	50-60	1x1m	1/4 inch	FLS	Biface	Chert	1	11.3	---
24ME163	019	EU 2	50-60	1x1m	1/4 inch	FLS	Flake Tool	Chert	1	1.8	---
24ME163	020	EU 2	50-60	1x1m	1/4 inch	FLS	Debitage	Chert	14	144.0	---
24ME163	021	EU 3	0-10	1x1m	1/4 inch	FLS	Uniface	Chert	1	7.1	---
24ME163	022	EU 3	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	14	44.0	---
24ME163	023	EU 3	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	67	75.4	---
24ME163	024	EU 3	20-30	1x1m	1/4 inch	FLS	Flake Tool	Chert	1	11.2	---
24ME163	025	EU 3	20-30	1x1m	1/4 inch	FLS	Flake Tool	Chert	1	2.4	---
24ME163	026	EU 3	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	70	119.2	---
24ME163	027	EU 3	20-30	1x1m	1/4 inch	FLS	Debitage	Chalcedony	1	1.7	---
24ME163	028	EU 3	30-40	1x1m	1/4 inch	FLS	Biface	Chert	1	12.9	---
24ME163	029	EU 3	30-40	1x1m	1/4 inch	FLS	Biface	Chert	1	5.8	---
24ME163	030	EU 3	30-40	1x1m	1/4 inch	FLS	Debitage	Chert	84	109.1	---
24ME163	031	EU 3	30-40	1x1m	1/4 inch	FLS	Debitage	Obsidian	1	0.2	---

Appendix A: Lithic Catalog for 24ME163

Site No.	Cat. No.	Unit	Depth	Unit Size	Screen Size	Class	Description	Material	Count	Weight (g)	COMMENTS
24ME163	032	EU 3	40-50	1x1m	1/4 inch	FLS	Core	Chert	1	155.4	---
24ME163	033	EU 3	40-50	1x1m	1/4 inch	FLS	Core	Chert	1	98.9	---
24ME163	034	EU 3	40-50	1x1m	1/4 inch	FLS	Debitage	Chert	40	111.0	---
24ME163	035	EU 4	0-10	1x1m	1/4 inch	FLS	Core	Chert	1	35.4	---
24ME163	036	EU 4	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	73	82.0	---
24ME163	037	EU 4	0-10	1x1m	1/4 inch	FLS	Debitage	Chalcedony	1	0.5	---
24ME163	038	EU 4	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	156	323.0	---
24ME163	039	EU 4	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	120	197.2	---
24ME163	040	EU 4	30-40	1x1m	1/4 inch	FLS	Biface	Chert	1	34.2	---
24ME163	041	EU 4	30-40	1x1m	1/4 inch	FLS	Debitage	Chert	193	338.3	---
24ME163	042	EU 4	30-40	1x1m	1/4 inch	FLS	Debitage	Obsidian	1	0.1	---
24ME163	043	EU 4	40-50	1x1m	1/4 inch	FLS	Biface	Chert	1	95.7	---
24ME163	044	EU 4	40-50	1x1m	1/4 inch	FLS	Biface	Chert	1	1.4	---
24ME163	045	EU 4	40-50	1x1m	1/4 inch	FLS	Debitage	Chert	112	167.4	---
24ME163	046	EU 5	0-10	1x1m	1/4 inch	FLS	Flake Tool	Chert	1	9.4	---
24ME163	047	EU 5	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	99	109.6	---
24ME163	048	EU 5	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	115	138.2	---
24ME163	049	EU 5	10-20	1x1m	1/4 inch	FLS	Debitage	Obsidian	2	3.3	---
24ME163	050	EU 5	10-20	1x1m	1/4 inch	FLS	Debitage	Quartzite	2	4.4	---
24ME163	051	EU 5	20-30	1x1m	1/4 inch	FLS	Flake Tool	Chalcedony	1	1.8	---
24ME163	052	EU 5	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	158	195.2	---
24ME163	053	EU 5	20-30	1x1m	1/4 inch	FLS	Debitage	Chalcedony	1	2.1	---
24ME163	054	EU 5	30-40	1x1m	1/4 inch	FLS	Biface	Chert	1	6.8	---
24ME163	055	EU 5	30-40	1x1m	1/4 inch	FLS	Debitage	Chert	122	123.0	---
24ME163	056	EU 5	40-50	1x1m	1/4 inch	FLS	Core	Chert	1	64.5	---
24ME163	057	EU 5	40-50	1x1m	1/4 inch	FLS	Debitage	Chert	74	161.7	---
24ME163	058	EU 6	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	23	30.7	---
24ME163	059	EU 6	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	232	175.5	Wet screened; Included 1/8-inch mesh flakes
24ME163	060	EU 6	10-20	1x1m	1/4 inch	FLS	Debitage	Chalcedony	1	0.2	---

Appendix A: Lithic Catalog for 24ME163

Site No.	Cat. No.	Unit	Depth	Unit Size	Screen Size	Class	Description	Material	Count	Weight (g)	COMMENTS
24ME163	061	EU 6	10-20	1x1m	1/4 inch	FLS	Flake Tool	Chert	1	0.2	Wet screened; Included 1/8-inch mesh flakes
24ME163	062	EU 6	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	353	348.1	Wet screened; Included 1/8-inch mesh flakes
24ME163	063	EU 6	30-40	1x1m	1/4 inch	FLS	Biface	Chert	1	5.0	Wet screened; Included 1/8-inch mesh flakes
24ME163	064	EU 6	30-40	1x1m	1/4 inch	FLS	Biface	Chert	1	0.2	---
24ME163	065	EU 6	30-40	1x1m	1/4 inch	FLS	Debitage	Chert	340	440.2	Wet Screened

APPENDIX B
Artifact Tables for 24ME163

Appendix B: Artifact Analysis Tables for 24ME163

Appendix Table A2. 24ME163 Uniface Data

Cat=catalog; CHT=chert; cmbs=centimeters below surface; CND=condition; CONV=convex; CORT=cortical flake; DORS=dorsal; EA=edge angle; EU=excavation unit; Imod=intentional modification; L Lat=Left Lateral; LTH=length; Mod=modification type; NME=number of modified edges; Pos=position on flake blank; Pres=Pressure; Shp=edge shape; SUR=surface; TH=thickness; TLS=toolstone; Uni=Unifacial; WHL=whole; WT=weight; WTH=width; 30-60=degrees

Cat #	Unit/ Depth	TLS	CND	WT (g)	LTH (mm)	WTH (mm)	TH (mm)	Blank	Break	NME	IMod 1	Pos 1	Sur 1	Shp 1	EA 1	Use 1	Mod 2	IMod 2	Pos 2	Sur 2	Shp 2	EA 2	Use 2
21	EU 3 10 cmbs	CHT	WHL	7.1	32.2	23.5	7.5	CORT	None	3	Pres	DST	DORS	CONV	30-60	STEP/ FK	Uni	Pres	L Lat	DORS	Straight	30-60	Crush/ Rounding

Comments: 3rd edge R Lat similar to L Lat, relatively steep almost 60 degrees

Appendix B: Artifact Analysis Tables for 24ME163

Appendix Table A3. 24ME163 Flake Tool Data

Cat=catalog; Bend=bending; BF=bifacial; CHT=chert; CONV=convex; CORT=cortical flake; CND=condition; CRUSH=crushing; D=depth; DST=distal; EA=edge angle; EBT=early biface thinning flake; FK=flaking; HT=heat treated; Imod=intentional modification; IND=indeterminate; L Lat=left lateral; LTH=length; Mod=modification; NME=number of modified edges; Pos=position on flake blank; Poss.=possible; prob=probably; PRX=proximal; R Lat=right lateral; Shp=edge shape; SIN=sinuous; SINT=simple interior flake; STEP=Stepping; SUR=surface; TH=thickness; TLS=toolstone; Uni=Unifacial; Vent=Ventral; WHL=whole; WT=weight; WTH=width; 30-60=degrees; --- =no data or not applicable

CAT #	Unit/ Depth (cmbs)	TLS	CND	WT (g)	LTH x WHT x TH (mm)	Blank	Break	NME	Mod 1	IMod 1	Pos 1	Sur 1	Shp 1	EA 1	Use 1	Mod 2	IMod 2	Pos 2	Sur 2	Shp 2	EA 2	Use 2	Comments
19	EU 2 50-60	CHT	DST	1.8	-25.1 -18.2x -3.9	CORT	Bend	1	BF	No	DST	Both	CONV	< 30	FK	---	---	---	---	---	---	---	Red, natural luster, opposite edge is cortical with a few small possible use or damage flake scars
24	EU 3 20-30	CHT	WHL	11.2	50.4 23.6 10.3	SINT	None	2	BF	No	DST	Both	CONV	30-60	FK	Uni	No	L Lat	Vent	Straight	> 60	FK	Yellow brown mottled, natural luster; possible cutting polish, 2nd edge short
25	EU 3 20-30	CHT	WHL	2.4	25.3 23.3 4.8	EBT	None	1	Uni	Pres	L Lat	Vent	Straight	30-60	IND	---	---	---	---	---	---	---	Banded red/brown prob natural luster
46	EU 5 0-10	CHT	WHL	9.4	40.9 29.3 8.8	CORT	None	1	Uni	IND	L Lat	Vent	Straight	> 60	FK	---	---	---	---	---	---	---	Relatively high luster; probable heat treatment ; red
51	EU 5 20-30	CHL	PRX	1.8	-18.6 -14.7 7.9	CORT	Perc	1	Uni	Pres	L Lat	DORS	SIN	> 60	CRUSH/ STEP	---	---	---	---	---	---	---	Probable intentionally truncated by Perc
61	EU 6 10-20	CHT	DST	0.2	-11.4 -10.8 -1.7	IND	Bend	2	Uni	No	R Lat	Vent	CONV	< 30	FK	Uni	No	L Lat	Vent	CONV	< 30	FK	Brown prob natural luster, use FK at tip; possible projection use, L Lat short use edge, R Lat continuous to break

Appendix B: Artifact Analysis Tables for 24ME163

Appendix Table A4. 24ME163 Core Data

CAT= Catalog; TLS= Toolstone; CHT=chert; CND=condition; END=undifferentiated end; IND=indeterminate; LTH=length; MRG=margin; Nat=natural NC=nearly complete; Tab=tabular; TH=thickness; WT=weight; WTH=width; Perc= percussion

Cat #	Unit	Depth (cm bs)	TLS	CND	WT (g)	LTH (mm)	WTH (mm)	TH (mm)	Blank	Break	Flaking	Type	Use Wear	Comments
32	EU 3	40-50	CHT	END	155.4	-77.8	-62.9	-39.0	Cobble	Bend	Perc	Multidirectional	None	Natural luster, gray and brown
33	EU 3	40-50	CHT	END	98.9	-72.1	-43.0	-35.7	IND	Bend	Perc	Multidirectional	None	Mottled red brown gray, natural luster
35	EU 4	0-10	CHT	NC	35.4	-55.9	40.4	11.6	Tab Cobble	Bend	Perc	Multidirectional	None	Mottled gray brown, poss. tool manufacture blank, high luster poss. HT
56	EU 5	40-50	CHT	MRG	64.5	-51.3	-33.3	-32.7	Cobble	Bend	Perc	Multidirectional	None	Red luster, one MRG with remnant removals

Appendix B: Artifact Analysis Tables for 24ME163

Appendix Table A5. 24ME163 Chert Debitage Data

CAT= Catalog; CNT=Count; CORT = cortical flake; CINT = complex interior flake; SINT = simple interior flake; LIN= Linear; SINT/CP = Simple Interior/Complex Platform; EP = Edge Preparation; EBT = Early Biface Thinning; LBT = Late Biface Thinning; EPR - Early Pressure; LPR = Late Pressure; PP = Platform Preparation/Pressure; SF = Simple Fragments; CF = Complex Fragments; CTF = Cortical Fragments; SH= Shatter; --- =no data or not applicable

Size grades represent the screen mesh size that will hold the debitage. Four size grades: 2 in., 1 in., ½ in., and ¼ in.

Cat	Unit	Depth (cmbs)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	PP	SF	CF	CTF	SH	Total	Comments
001	EU 1	0-10	1	1	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	matte red
001	EU 1	0-10	½	1	---	---	1	---	---	---	---	---	---	---	---		---	---	---	1	matte red
001	EU 1	0-10	¼	6	---	---	1	---	---	---	---	---	---	---	---	5	---	---	---	6	SINT is lustrous brown with VUG; others matte red and one mat brown
002	EU 1	10-20	½	2	---	---	---	---	---	---	---	---	---	---	---	2	---	---	---	2	matte yellow and red, both spall
002	EU 1	10-20	¼	24	---	1	6	---	2	---	---	---	---	---	---	10	---	1	4	24	red, brown, yellow, mostly matte
003	EU 1	20-30	1	1			1	---	---	---	---	---	---	---	---	---	---	---	---	1	matte red
003	EU 1	20-30	½	21	3	1	2	---	---		1	---	---	---	---	5	1	4	4	21	Prob nat luster on fine grain brown and red; some high luster poss. HT
003	EU 1	20-30	¼	78	---	---	25	---	5	1	1	---	---	---	---	41	1	1	3	78	A bit of high luster, some nat lust and mostly matte - color variation see material photo
004	EU 1	30-40	1	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	1	matte red
004	EU 1	30-40	½	11	---	---	3	---	2	---	---	---	---	---	---	4	2	---	---	11	some spalling, nat luster poss. high luster
004	EU 1	30-40	¼	41	2		11	---	1	5		---	---	---	---	18	2	1	1	41	one LBT is a MRG removal flake, mostly matte
005	EU 1	40-50	½	12	---	---	4	---	---	---	---	1	---	---	---	5		1	1	12	large LBT with lust poss. HT, a few nicely lustrous flakes
005	EU 1	40-50	¼	10	---	---	4	---	1	---	---		---	---	---	5		---	---	10	some luster
006	EU 1	50-60	½	5	---	---	2	---		---	---		---	---	---	3		---	---	5	---
006	EU 1	50-60	¼	10	---	---	4	---	1	---	---	2	---	---	---	2	1	---	---	10	one high luster might just be very silicious light brown material, or HT well

Appendix B: Artifact Analysis Tables for 24ME163

Cat	Unit	Depth (cmbs)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	PP	SF	CF	CTF	SH	Total	Comments
007	EU 1	60-70	1	1	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	spalled with red matte inside and nat lust outside
007	EU 1	60-70	½	11	1	---	1	---	---	---	1	1	---	---	---	6	1	---	---	11	Cortex gray purple stripped, BF thin nat lust, CF high lust, spalling
007	EU 1	60-70	¼	9	---	---	5	---	---	---	---	---	---		---	3	---	1	---	9	---
008	EU 1	70-80	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	1	hard to say nat or high lust
008	EU 1	70-80	½	5	---	---	2	---	1	---	---	---	---	---	---	2	---	---	---	5	SINT same poss. HT gray
008	EU 1	70-80	¼	4	---	---	3	---	---	---	---	---	---	---	---	1	---	---	---	4	SINT same poss. HT red
009	EU 2	0-10	1	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	red nat lust
009	EU 2	0-10	½	29	1	1	11	---	---	---	1	---	---	---	---	9	4	2	---	29	SINT fine grain brown diff luster on DORS
009	EU 2	0-10	¼	99	1		25	---	---	---	2	2	---	---	---	56	2	6	5	99	spalling one pot lid shatter
013	EU 2	10-20	1	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	1	pink matte
013	EU 2	10-20	½	18	1	1	9	---	---	---	---	1	---	---	---	4	1		1	18	white LBT, CF=core reduction with cortex, nat lust, some thermal damage
013	EU 2	10-20	¼	43	---	1	7	---	---	---	1	1	---	---	---	28	1	2	2	43	---
015	EU 2	20-30	1	8	2	---	3	---	---	---	---	---	---	---	---	3				8	one high luster olive HT
015	EU 2	20-30	½	40	1	2	10	---	1	---	2	1	---	---	---	14	1	7	1	40	usual mix
015	EU 2	20-30	¼	131	4	---	32	---	5	---	3	2	---	3	---	61	6	3	12	131	see photo
016	EU 2	30-40	1	2	1	---	1	---	---	---	---	---	---	---	---	---	---	---	---	2	---
016	EU 2	30-40	½	42	3	1	18	---	1	---	2	---	---	---	---	13	2	1	1	42	---
016	EU 2	30-40	¼	123	---	---	36	---	4	---	2	5	---	---	---	61	8	5	2	123	---
017	EU 2	40-50	1	2	---	---	1	---	---	---	---		---	---	---	---	---	---	1	2	---
017	EU 2	40-50	½	20	1		8	---	---	---	---	1	---	---	---	9	---	---	1	20	---
017	EU 2	40-50	¼	27	---	---	9	---	1	---	---	1	---	---	---	15	---	---	1	27	---
020	EU 2	50-60	1	2	---	---	1	---	---	---	---	---	---	---	---	---	1	---	---	2	CF high luster w poss. HT crenulations, big chunky off core
020	EU 2	50-60	½	7	---	---	3	---	1	---	---	---	---	---	---	3	---	---	---	7	---
020	EU 2	50-60	¼	5	---	---	3	---		---	---	---	---	---	---	2	---	---	---	5	---
022	EU 3	0-10	1	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	mottled red brown nat luster
022	EU 3	0-10	½	4	---	---	3	---	---	---	---	---	---	---	---	1	---	---		4	---
022	EU 3	0-10	¼	9	---	---	4	---	---	---	---	---	---	---	---	4	---	---	1	9	one high lust SINT
023	EU 3	10-20	1	1	---	---		---	---	---	---	---	---	---	---		---	---	1	1	---
023	EU 3	10-20	½	10	---	---	5	---	---	---	---	---	---	---	---	4	---	---	1	10	---
023	EU 3	10-20	¼	56	1	---	13	---	2	---	---	---	---	---	---	32	1	2	5	56	---

Appendix B: Artifact Analysis Tables for 24ME163

Cat	Unit	Depth (cmbs)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	PP	SF	CF	CTF	SH	Total	Comments
026	EU 3	20-30	1	3	1	---	2	---	---	---	---	---	---	---	---	---	---	---	---	3	one SINT fine grain translucent brown prob essentially chalcedony
026	EU 3	20-30	½	24	1	2	6	---	---	---	1	1	---	---	---	8	2	1	2	24	---
026	EU 3	20-30	¼	43	---	---	12	---	3	---	---	3	---	---	---	18	2	3	2	43	material photo
030	EU 3	30-40	1	2	---	---	1	---	---	---	---	---	---	---	---	1	---	---	---	2	SINT brown luster poss. HT, SF matte red
030	EU 3	30-40	½	22	4	---	5	---	1	1	---	---	---	---	---	8	2	1		22	one chalk white, most matte red
030	EU 3	30-40	¼	60	2	---	19	---	1	---	---	1	---	---	---	28	1	4	4	60	---
034	EU 3	40-50	1	3	1	---	1	---	---	---	---	---	---	---	---	1				3	one luster 2 matte
034	EU 3	40-50	½	17	---	---	6	---	---	---	---	---	---	---	---	7	2		2	17	matte majority
034	EU 3	40-50	¼	20	---	---	9	---	---	---	---	---	---	---	---	9	1	1		20	same
036	EU 4	0-10	½	17	---	---	3	---	1	---	---	---	---	---	---	8	2	2	1	17	---
036	EU 4	0-10	¼	56	---	---	14	---	1	---	1	---	---	---	---	34	1	1	4	56	---
038	EU 4	10-20	2	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	yellowish brown slight luster fine grain
038	EU 4	10-20	1	5	---	---	---	---	---	---	1	---	---	---	---	1	1	2		5	EBT is large MRG removal off large biface, others are core reduction
038	EU 4	10-20	½	49	5	3	18	---	---		4	2	---	---	---	16			1	49	---
038	EU 4	10-20	¼	101	2	---	29	---	4		1	1	---	---	---	45	11	7	1	101	---
039	EU 4	20-30	1	3		---	1	---	---	---	---	---	---	---	---	1	1	---	---	3	SINT dark brown high lust poss. HT, CF is a MRG removal
039	EU 4	20-30	½	41	2	---	16	---	4	---	1	---	---	---	---	11	3	1	3	41	some luster and some thermal damage
039	EU 4	20-30	¼	76	2	---	22	---	3	1	1	4	---	---	---	38		3	2	76	material photo
041	EU 4	30-40	2	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	brown, slight lust chalky white cortex
041	EU 4	30-40	1	4	2		1	---	1	---	---	---	---	---	---	---	---	---	---	4	SINT thermal damage
041	EU 4	30-40	½	57	---	---	17	---	1	---	3	2	---	---	---	26	2	3	3	57	EBT and SINT with cortex DORS, some thermal damage
041	EU 4	30-40	¼	131	---	---	34	---	5	---	2	2	---	---	---	79		2	7	131	---
045	EU 4	40-50	1	2	---	---	1	---		---	---	---	---	---	---			1		2	---
045	EU 4	40-50	½	32	2	3	7	---	---	---	2	---	---	---	---	15		3		32	3 high luster
045	EU 4	40-50	¼	78	3		21	---	1	---	4	1	---	---	---	44	1	2	1	78	small EBT relevant to small biface cat# 44; mat photo
047	EU 5	0-10	1	1	---	---	---	---	---	---	---	---	---	---	---	1	---			1	HT red over yellow brown inside, high luster

Appendix B: Artifact Analysis Tables for 24ME163

Cat	Unit	Depth (cmbs)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	PP	SF	CF	CTF	SH	Total	Comments
047	EU 5	0-10	½	21	4	---	5	---	---	---	---	---	---	---	---	7	---	2	3	21	poss. HT red over yellow sf minimal luster,
047	EU 5	0-10	¼	77	---	---	23	---	3	---	2	---	---	---	1	42	---	1	5	77	---
048	EU 5	10-20	½	24	---	2	5	---	1	---	2	2	---	---	---	7	---	1	4	24	LBT red high lust and matte yellow, thermal damage, one CINT poss. core MRG
048	EU 5	10-20	¼	91	2	---	14	---	3	---	1	2	---	---	---	58	4		7	91	some lust, some thermal damage, and prob HT thermal fractures
052	EU 5	20-30	1	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	1	pint matte
052	EU 5	20-30	½	43	3	2	17	---	1	---	---	2	---	---	---	14	2	1	1	43	---
052	EU 5	20-30	¼	114	1	---	35	---	2	---	---	2	---	---	---	60	1	4	9	114	material photo
055	EU 5	30-40	1	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	1	yellow matte
055	EU 5	30-40	½	24	3	1	9	---	---	---	1	---	---	---	---	8	1		1	24	one SINT fine grain matte red outside w yellow brown luster inside prob HT
055	EU 5	30-40	¼	97	2	---	24	---	2	---	---	1	---	---	---	58	4	2	4	97	---
057	EU 5	40-50	1	1	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	matte red yellow
057	EU 5	40-50	½	31	1	---	11	---	---	---	4	---	---	---	---	10	---	4	1	31	reddish brown SINT diff lust Vent lust DORS matte
057	EU 5	40-50	¼	42	---	---	11	---	---	1	2	---	---	---	---	22	1	2	3	42	material photo
058	EU 6	0-10	½	7	1	1	1	---	---	---	---	---	---	---	---	3	---	1		7	---
058	EU 6	0-10	¼	16	---	---	6	---	---	---		1	---	---	---	8	---	1	---	16	material photo
059	EU 6	10-20	1	4	1	1	2	---	---	---	---	---	---	---	---	---	---	---	---	4	---
059	EU 6	10-20	½	21	2	1	9	---	---	---	1		---	---	---	3	1	1	3	21	---
059	EU 6	10-20	¼	107	---	---	22	---	1	---	2	1	---	---	---	62	3	4	12	107	---
059	EU 6	10-20	⅛	100	---	---	16	---	---	---	---	1	1	---	---	69	1	2	10	100	material photo size graded, includes wet screened
062	EU 6	20-30	2	1	1	---		---	---	---	---		---	---	---	---	---	---	---	1	matte red brown
062	EU 6	20-30	1	5	1	---	1	---	---	---	---	1	---	---	---	---	2	---	---	5	---
062	EU 6	20-30	½	41	3	---	9	---	1	---	3	1	---	---	---	18		5	1	41	---
062	EU 6	20-30	¼	200	4	---	59	---	---	---	---	---	---	---	---	108	3	9	17	200	material photo size graded, wet screened
062	EU 6	20-30	⅛	106	1	---	29	---	1	---	---	---	---	2	1	61	1	4	6	106	pot lid SH,
065	EU 6	30-40	2	2	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2	matte yellow and slight luster red/brown and white cortex
065	EU 6	30-40	1	7	3	---	1	---	---	---	---	---	---	---	---	3	---	---	---	7	Luster brown cortical flakes, thermal damage matte red sf

Appendix B: Artifact Analysis Tables for 24ME163

Cat	Unit	Depth (cmbs)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	PP	SF	CF	CTF	SH	Total	Comments
065	EU 6	30-40	½	47	4	---	17	---	1		3	1	---	---	---	17	3	1		47	---
065	EU 6	30-40	¼	220	2	---	65	---	3	1	1	1	---	---	---	129	1	10	7	220	---
065	EU 6	30-40	⅛	64	---	---	1	---	---	---	---	1	1	---	---	53		1	7	64	material photo size graded, wet screened?
Total				3300	94	25	918	---	73	10	---	52	2	5	2	1652	95	131	182	3300	---

Appendix B: Artifact Analysis Tables for 24ME163

Table A6. 24ME163 Chalcedony Debitage Data

CAT= Catalog; CNT=Count; CORT = cortical flake; CINT = complex interior flake; SINT = simple interior flake; LIN= Linear; SINT/CP = Simple Interior/Complex Platform; EP = Edge Preparation; EBT = Early Biface Thinning; LBT = Late Biface Thinning; EPR - Early Pressure; LPR = Late Pressure; PP = Platform Preparation/Pressure; SF = Simple Fragments; CF = Complex Fragments; CTF = Cortical Fragments; SH= Shatter; --- =no data or not applicable

Size grades represent the screen mesh size that will hold the debitage. Four size grades: 2 in., 1 in., ½ in., and ¼ in.

Cat	Unit	D (cmbs)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
010	EU 2	0-10	¼	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---
027	EU 3	20-30	½	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---
037	EU 4	0-10	¼	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	flake scars to DORS on two MRGs look like damage
053	EU 5	20-30	½	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---
060	EU 6	10-20	¼	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---		1	---
Total				5	1	---	3	---	---	---	---	---	---	---	---	---	---	1	---	---	---	---	---

Appendix B: Artifact Analysis Tables for 24ME163

Table A7. 24ME163 Obsidian Debitage Data

CAT= Catalog; CNT=Count; CORT = cortical flake; CINT = complex interior flake; SINT = simple interior flake; LIN= Linear; SINT/CP = Simple Interior/Complex Platform; EP = Edge Preparation; EBT = Early Biface Thinning; LBT = Late Biface Thinning; EPR - Early Pressure; LPR = Late Pressure; PP = Platform Preparation/Pressure; SF = Simple Fragments; CF = Complex Fragments; CTF = Cortical Fragments; SH= Shatter; --- =no data or not applicable

Size grades represent the screen mesh size that will hold the debitage. Four size grades: 2 in., 1 in., ½ in., and ¼ in.

Cat	Unit	D (cmbs)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
031	EU 3	30-40	¼	1	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---
042	EU 4	30-40	¼	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---
049	EU 5	10-20	½	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	quartz inclusion
049	EU 5	10-20	¼	1	---	---	---	---	---	---	---	1	---	---	---	---	---	---	---	---	---	1	---
Total				4	---	1	1	---	---	---	---	1	---	---	---	---	---	1	---	---	---	4	---

Appendix B: Artifact Analysis Tables for 24ME163

Table A8. 24ME163 Quartzite Debitage Data

CAT= Catalog; CNT=Count; CORT = cortical flake; CINT = complex interior flake; SINT = simple interior flake; LIN= Linear; SINT/CP = Simple Interior/Complex Platform; EP = Edge Preparation; EBT = Early Biface Thinning; LBT = Late Biface Thinning; EPR - Early Pressure; LPR = Late Pressure; PP = Platform Preparation/Pressure; SF = Simple Fragments; CF = Complex Fragments; CTF = Cortical Fragments; SH= Shatter; --- =no data or not applicable

Size grades represent the screen mesh size that will hold the debitage. Four size grades: 2 in., 1 in., ½ in., and ¼ in.

Cat	Unit	Depth (cmbs)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
050	EU 5	10-20	½	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	1	pink, poss. hammerstone frag
050	EU 5	10-20	¼	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	pink, poss. hammerstone frag
Total				2	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	1	2	---

APPENDIX C
Lithic Catalog for 24ME1109

Appendix C: Lithic Catalog for 24ME1109

Cat. = Catalog; EU= Excavation Unit; FLS= Flakes Stone Tool; g= gram(s); m= meter; ME= Meagher County; No= Number

Site No.	Cat. No.	Unit	Depth	Unit Size	Screen Size	Class	Description	Material	Count	Weight (g)	COMMENTS
24ME1109	001	EU 1	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	3	1.8	---
24ME1109	002	EU 1	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	5	10.5	---
24ME1109	003	EU 1	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	5	4.2	---
24ME1109	004	EU 1	30-40	1x1m	1/4 inch	FLS	Debitage	Chert	4	20.1	---
24ME1109	005	EU 2	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	2	3.0	---
24ME1109	006	EU 2	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	4	4.0	---
24ME1109	007	EU 2	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	2	4.3	---
24ME1109	008	EU 3	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	6	3.5	---
24ME1109	009	EU 3	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	2	2.8	---
24ME1109	010	EU 4	0-10	1x1m	1/4 inch	FLS	Biface	Chert	1	8.7	---
24ME1109	011	EU 4	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	22	13.8	---
24ME1109	012	EU 4	10-20	1x1m	1/4 inch	FLS	Biface	Chert	1	5.2	---
24ME1109	013	EU 4	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	17	32.2	---
24ME1109	014	EU 5	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	55	62.4	---
24ME1109	015	EU 5	10-20	1x1m	1/4 inch	FLS	Biface	Chert	1	13.0	---
24ME1109	016	EU 5	10-20	1x1m	1/4 inch	FLS	Biface	Chert	1	2.6	---
24ME1109	017	EU 5	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	32	21.6	---
24ME1109	018	EU 6	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	37	44.6	---
24ME1109	019	EU 6	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	7	5.6	---
24ME1109	020	EU 7	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	19	43.3	---
24ME1109	021	EU 7	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	3	5.5	---
24ME1109	022	EU 8	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	8	23.5	---
24ME1109	023	EU 8	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	4	6.4	---
24ME1109	024	EU 8	10-20	1x1m	1/4 inch	FLS	Debitage	Quartzite	1	0.3	---
24ME1109	025	EU 8	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	1	1.1	---
24ME1109	026	EU 9	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	1	0.2	---
24ME1109	027	EU 10	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	3	2.4	---
24ME1109	028	EU 10	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	5	6.9	---

Appendix C: Lithic Catalog for 24ME1109

Site No.	Cat. No.	Unit	Depth	Unit Size	Screen Size	Class	Description	Material	Count	Weight (g)	COMMENTS
24ME1109	029	EU 11	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	2	22.6	---
24ME1109	030	EU 11	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	1	1.3	---
24ME1109	031	EU 12	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	5	7.5	No 0 - 10cm level
24ME1109	032	EU 12	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	1	17.5	---
24ME1109	033	EU 12	30-40	1x1m	1/4 inch	FLS	Debitage	Chert	1	2.2	---
24ME1109	034	EU 13	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	8	7.9	---
24ME1109	035	EU 13	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	17	20.2	---
24ME1109	036	EU 13	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	3	2.7	---
24ME1109	037	EU 13	30-40	1x1m	1/4 inch	FLS	Debitage	Chert	1	0.8	---
24ME1109	038	EU 14	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	11	9.4	---
24ME1109	039	EU 14	0-10	1x1m	1/4 inch	FLS	Debitage	Quartzite	1	0.3	---
24ME1109	040	EU 14	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	11	9.4	---
24ME1109	041	EU 14	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	2	0.8	---
24ME1109	042	EU 15	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	66	129.2	---
24ME1109	043	EU 15	10-20	1x1m	1/4 inch	FLS	Biface	Chert	1	148.1	---
24ME1109	044	EU 15	10-20	1x1m	1/4 inch	FLS	Biface	Chert	1	6.1	---
24ME1109	045	EU 15	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	25	68.9	---
24ME1109	046	EU 16	0-10	1x1m	1/4 inch	FLS	Flake Tool	Chert	1	1.1	---
24ME1109	047	EU 16	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	39	52.0	---
24ME1109	048	EU 16	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	50	90.3	---
24ME1109	049	EU 16	10-20	1x1m	1/4 inch	FLS	Debitage	Obsidian	1	0.2	---
24ME1109	050	EU 16	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	57	37.5	---
24ME1109	051	EU 16	30-40	1x1m	1/4 inch	FLS	Debitage	Chert	11	6.0	---
24ME1109	052	EU 17	0-10	1x1m	1/4 inch	FLS	Biface	Chert	1	21.5	---
24ME1109	053	EU 17	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	11	13.3	---
24ME1109	054	EU 17	0-10	1x1m	1/4 inch	FLS	Debitage	Quartzite	1	0.6	---
24ME1109	055	EU 17	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	11	13.2	---
24ME1109	056	EU 17	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	1	2.4	---
24ME1109	057	EU 18	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	20	36.4	---

Appendix C: Lithic Catalog for 24ME1109

Site No.	Cat. No.	Unit	Depth	Unit Size	Screen Size	Class	Description	Material	Count	Weight (g)	COMMENTS
24ME1109	058	EU 18	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	22	98.7	---
24ME1109	059	EU 18	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	2	1.3	---
24ME1109	060	EU 19	0-10	1x1m	1/4 inch	FLS	Biface	Chert	1	34.2	---
24ME1109	061	EU 19	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	39	51.8	---
24ME1109	062	EU 19	0-10	1x1m	1/4 inch	FLS	Debitage	Obsidian	1	0.5	---
24ME1109	063	EU 19	10-20	1x1m	1/4 inch	FLS	Biface	Chert	1	18.0	---
24ME1109	064	EU 19	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	62	127.1	---
24ME1109	065	EU 19	20-30	1x1m	1/4 inch	FLS	Biface	Chert	1	14.5	---
24ME1109	066	EU 19	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	76	316.8	---
24ME1109	067	EU 19	30-40	1x1m	1/4 inch	FLS	Debitage	Chert	9	11.0	---
24ME1109	068	EU 20	0-20	1x1m	1/4 inch	FLS	Flake Tool	Chert	1	18.2	---
24ME1109	069	EU 20	0-20	1x1m	1/4 inch	FLS	Debitage	Chert	129	126.4	---
24ME1109	070	EU 20	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	111	219.4	---
24ME1109	071	EU 20	20-30	1x1m	1/4 inch	FLS	Debitage	Quartzite	1	0.3	---
24ME1109	072	EU 20	30-40	1x1m	1/4 inch	FLS	Debitage	Chert	79	136.1	---
24ME1109	073	EU 20	30-40	1x1m	1/4 inch	FLS	Debitage	Quartzite	1	0.1	---
24ME1109	074	EU 21	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	72	122.0	---
24ME1109	075	EU 21	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	68	102.0	---
24ME1109	076	EU 21	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	62	155.7	---
24ME1109	077	EU 21	30-40	1x1m	1/4 inch	FLS	Biface	Chert	1	22.2	---
24ME1109	078	EU 21	30-40	1x1m	1/4 inch	FLS	Flake Tool	Chert	1	38.2	---
24ME1109	079	EU 21	30-40	1x1m	1/4 inch	FLS	Debitage	Chert	142	605.3	---
24ME1109	080	EU 21	30-40	1x1m	1/4 inch	FLS	Debitage	Obsidian	1	0.1	---
24ME1109	081	EU 21	30-40	1x1m	1/4 inch	FLS	Biface	Chert	1	1.6	---
24ME1109	082	EU 22	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	37	40.2	---
24ME1109	083	EU 22	0-10	1x1m	1/4 inch	FLS	Debitage	Obsidian	1	0.1	---
24ME1109	084	EU 22	10-20	1x1m	1/4 inch	FLS	Flake Tool	Basalt	1	16.9	---
24ME1109	085	EU 22	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	69	106.3	---
24ME1109	086	EU 22	20-30	1x1m	1/4 inch	FLS	Biface	Chert	1	5.7	---

Appendix C: Lithic Catalog for 24ME1109

Site No.	Cat. No.	Unit	Depth	Unit Size	Screen Size	Class	Description	Material	Count	Weight (g)	COMMENTS
24ME1109	087	EU 22	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	36	128.3	---
24ME1109	088	EU 22	30-40	1x1m	1/4 inch	FLS	Debitage	Chert	12	30.3	---
24ME1109	089	EU 19, 20, 21, 22	Feature 4	N/A	1/4 inch	FLS	Debitage	Chert	38	46.2	---
24ME1109	090	EU 19, 20, 21, 22	Feature 4	N/A	1/4 inch	FLS	Debitage	Obsidian	1	0.1	---
24ME1109	091	EU 23	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	4	26.5	---
24ME1109	092	EU 23	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	17	16.0	---
24ME1109	093	EU 23	10-20	1x1m	1/4 inch	FLS	Debitage	Quartzite	1	1.3	---
24ME1109	094	EU 23	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	1	0.7	---
24ME1109	095	EU 24	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	42	48.5	---
24ME1109	096	EU 24	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	20	29.5	---
24ME1109	097	EU 24	20-30	1x1m	1/4 inch	FLS	Projectile Point	Chert	1	0.9	---
24ME1109	098	EU 24	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	24	25.4	---
24ME1109	099	EU 24	30-40	1x1m	1/4 inch	FLS	Flake Tool	Chert	1	2.2	---
24ME1109	100	EU 24	30-40	1x1m	1/4 inch	FLS	Debitage	Chert	28	36.9	---
24ME1109	101	EU 24	40-50	1x1m	1/4 inch	FLS	Debitage	Chert	17	32.7	---
24ME1109	102	EU 24	50-60	1x1m	1/4 inch	FLS	Debitage	Chert	10	9.1	---
24ME1109	103	EU 25	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	14	17.2	---
24ME1109	104	EU 25	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	14	12.3	---
24ME1109	105	EU 25	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	14	25.8	---
24ME1109	106	EU 26	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	5	40.2	---
24ME1109	107	EU 26	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	7	15.1	---
24ME1109	108	EU 27	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	4	10.7	---
24ME1109	109	EU 27	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	1	2.8	---
24ME1109	110	EU 28	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	5	6.3	---
24ME1109	111	EU 28	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	3	4.6	---

Appendix C: Lithic Catalog for 24ME1109

Site No.	Cat. No.	Unit	Depth	Unit Size	Screen Size	Class	Description	Material	Count	Weight (g)	COMMENTS
24ME1109	112	EU 29	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	36	80.8	---
24ME1109	113	EU 29	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	10	32.9	---
24ME1109	114	EU 30	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	55	108.7	---
24ME1109	115	EU 30	0-10	1x1m	1/4 inch	FLS	Debitage	Quartzite	1	0.7	---
24ME1109	116	EU 30	10-20	1x1m	1/4 inch	FLS	Flake Tool	Chert	1	3.2	---
24ME1109	117	EU 30	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	22	62.4	---
24ME1109	118	EU 31	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	4	47.8	---
24ME1109	119	EU 32	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	5	4.9	---
24ME1109	120	EU 32	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	10	8.0	---
24ME1109	121	EU 33	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	3	1.9	---
24ME1109	122	EU 33	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	8	11.8	---
24ME1109	123	EU 33	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	1	9.5	---
24ME1109	124	EU 34	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	3	1.2	---
24ME1109	125	EU 34	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	3	10.2	---
24ME1109	126	EU 35	0-10	1x1m	1/4 inch	FLS	Biface	Chert	1	9.9	---
24ME1109	127	EU 35	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	50	73.8	---
24ME1109	128	EU 35	10-20	1x1m	1/4 inch	FLS	Biface	Chert	1	9.7	---
24ME1109	129	EU 35	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	29	47.3	---
24ME1109	130	EU 35	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	5	12.6	---
24ME1109	131	EU 36	0-10	1x1m	1/4 inch	FLS	Biface	Chert	1	34.8	---
24ME1109	132	EU 36	0-10	1x1m	1/4 inch	FLS	Biface	Chert	1	8.5	---
24ME1109	133	EU 36	0-10	1x1m	1/4 inch	FLS	Biface	Chert	1	5.9	---
24ME1109	134	EU 36	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	74	135.5	---
24ME1109	135	EU 36	0-10	1x1m	1/4 inch	FLS	Debitage	Obsidian	1	0.2	---
24ME1109	136	EU 36	10-20	1x1m	1/4 inch	FLS	Biface	Chert	1	40.2	---
24ME1109	137	EU 36	10-20	1x1m	1/4 inch	FLS	Biface	Chert	1	12.3	---
24ME1109	138	EU 36	10-20	1x1m	1/4 inch	FLS	Biface	Chert	1	9.4	---
24ME1109	139	EU 36	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	71	156.8	---
24ME1109	140	EU 36	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	67	110.2	---

Appendix C: Lithic Catalog for 24ME1109

Site No.	Cat. No.	Unit	Depth	Unit Size	Screen Size	Class	Description	Material	Count	Weight (g)	COMMENTS
24ME1109	141	EU 36	30-40	1x1m	1/4 inch	FLS	Debitage	Chert	59	281.3	---
24ME1109	142	EU 37	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	45	116.8	---
24ME1109	143	EU 37	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	49	77.2	---
24ME1109	144	EU 38	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	19	23.5	---
24ME1109	145	EU 38	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	23	28.7	---
24ME1109	146	EU 39	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	62	123.4	---
24ME1109	147	EU 39	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	61	277.4	---
24ME1109	148	EU 39	20-30	1x1m	1/4 inch	FLS	Biface	Chert	1	20.4	---
24ME1109	149	EU 39	20-30	1x1m	1/4 inch	FLS	Core	Chert	1	547.8	---
24ME1109	150	EU 39	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	73	356.6	---
24ME1109	151	EU 39	30-40	1x1m	1/4 inch	FLS	Debitage	Chert	14	109.6	---
24ME1109	152	EU 40	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	17	54.7	---
24ME1109	153	EU 40	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	8	42.2	---
24ME1109	154	EU 41	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	25	30.7	---
24ME1109	155	EU 41	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	36	44.6	---
24ME1109	156	EU 41	20-30	1x1m	1/4 inch	FLS	Biface	Chert	1	20.7	---
24ME1109	157	EU 41	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	19	37.2	---
24ME1109	158	EU 41	Feature 6 30-48	1x1m	1/4 inch	FLS	Debitage	Chert	8	34.7	---
24ME1109	159	EU 42	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	43	130.0	---
24ME1109	160	EU 42	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	19	21.5	---
24ME1109	161	EU 43	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	19	35.0	---
24ME1109	162	EU 43	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	22	70.2	---
24ME1109	163	EU 43	20-30	1x1m	1/4 inch	FLS	Biface	Chert	1	22.5	---
24ME1109	164	EU 43	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	1	1.2	---
24ME1109	165	EU 44	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	51	72.4	---
24ME1109	166	EU 44	0-10	1x1m	1/4 inch	FLS	Debitage	Quartzite	2	0.7	---
24ME1109	167	EU 44	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	30	75.1	---
24ME1109	168	EU 44	20-30	1x1m	1/4 inch	FLS	Uniface	Quartzite	1	66.0	---

Appendix C: Lithic Catalog for 24ME1109

Site No.	Cat. No.	Unit	Depth	Unit Size	Screen Size	Class	Description	Material	Count	Weight (g)	COMMENTS
24ME1109	169	EU 44	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	4	2.4	---
24ME1109	170	EU 45	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	18	45.8	---
24ME1109	171	EU 45	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	30	44.5	---
24ME1109	172	EU 45	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	32	315.6	---
24ME1109	173	EU 46	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	18	28.8	---
24ME1109	174	EU 46	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	17	10.7	---
24ME1109	175	EU 46	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	31	62.2	---
24ME1109	176	EU 47	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	30	28.5	---
24ME1109	177	EU 47	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	53	78.7	---
24ME1109	178	EU 47	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	27	47.5	---
24ME1109	179	EU 48	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	28	55.6	---
24ME1109	180	EU 48	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	38	36.2	---
24ME1109	181	EU 49	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	12	10.1	---
24ME1109	182	EU 50	0-10	1x1m	1/4 inch	FLS	Biface	Chert	1	5.6	---
24ME1109	183	EU 50	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	20	30.1	---
24ME1109	184	EU 51	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	17	13.4	---
24ME1109	185	EU 52	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	9	10.4	---
24ME1109	186	EU 53	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	19	30.7	---
24ME1109	187	EU 54	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	15	29.5	---
24ME1109	188	EU 55	0-10	1x1m	1/4 inch	FLS	Flake Tool	Chert	1	116.0	---
24ME1109	189	EU 55	0-10	1x1m	1/4 inch	FLS	Debitage	Chert	3	5.4	---
24ME1109	190	EU 55	10-20	1x1m	1/4 inch	FLS	Debitage	Chert	7	5.6	---
24ME1109	191	EU 55	20-30	1x1m	1/4 inch	FLS	Debitage	Chert	6	8.1	---
24ME1109	192	EU 55	30-40	1x1m	1/4 inch	FLS	Debitage	Chert	1	0.3	---
24ME1109	193	---	Surface	---	---	FLS	Debitage	Obsidian	1	0.4	Surface artifact A1
24ME1109	194	---	Surface	---	---	FLS	Biface	Chert	1	6.0	Surface artifact A2
24ME1109	195	EU 17	Fea. 2B	1x1m	1/4 inch	FLS	Debitage	Chert	1	90.0	Top of feature

APPENDIX D
Artifact Tables for 24ME1109

Appendix D: Artifact Analysis Tables for 24ME1109

Appendix Table B1. 24ME1109 Projectile Point Data

Cat= Catalog; TLS = toolstone; CHT = chert; CND = condition; LAT = lateral fragment; Bend/Thermal = bending and thermal damage; IND = indeterminate; MF = manufacture failure; R/M = reworked/maintenance

Cat #	Unit	Depth (cm bs)	TLS	CND	Type	Blank	Break	Flaking	MF	Use Wear	R/M	Comments
097	EU 24	20-30	CHT	LAT	ARW	IND	Bend/Thermal	Pressure	IND	IND	IND	Possible Plains Side-notched

Appendix Table B2. 24ME1109 Projectile Point Metric Data

Cat= Catalog; TLS = toolstone; CHT = chert; CND = condition; LAT = lateral fragment; WT = weight; ML = maximum length; AL = Axial length; STL = stem length; MW = maximum width; BW = basal width; NW = neck width; TH = thickness; DSA = distal shoulder angle; PSA = proximal shoulder angle; NOA = notch opening angle; MWP = maximum width position; BIR = basal indentation ratio; ARW= arrow; '--- = no data or not applicable

Cat #	Unit	Depth (bs)	TLS	CND	WT (g)	ML	AL	STL	MW	BW	NW	TH	DSA	PSA	NOA	MWP	BIR	Type
097	EU 24	20-30	CHT	LAT	0.9	-15.6	-15.6	---	-15.2	---	---	-3.6	200/---	150/---	50/---	---	---	ARW

Appendix D: Artifact Analysis Tables for 24ME1109

Appendix Table B3. 24ME1109 Biface Data

Cat=catalog; TLS=toolstone; CHT=chert; CM=centimeter; CND=condition; D=depth; EBT=early biface thinning flake; END=undifferentiated end; EU=excavation unit; G=gram; HT=heat treated; IND=Indeterminate; LTH=length; mat flaw=material flaw; MF=manufacture failure; mm=millimeters; MRG=margin; NC=nearly complete; Perc=percussion;; Pres=Pressure;; R/M=reworked/maintenance; TH=thickness; WT=weight; WTH=width; Bend=bending

Cat #	Unit	Depth (cm)	TLS	CND	WT (g)	LTH	WTH	TH	Blank	Break	Flaking	Stage	Shape	MF	Use Wear	R/M	Comments
010	EU 4	0-10	Chert	END	8.7	-18.7	-32.2	-12.1	IND	Bending	Perc/Pres	4	IND	Yes	No	No	reddish brown luster possibly natural
012	EU 4	10-20	Chert	END	5.2	-28.7	-23.3	-8.8	CORT	Bending	Percussion	2	IND	Yes	IND	No	gray and brown w/diff luster probably heat treated; unifacial microflaking along most worked edge could be post MF use
015	EU 5	10-20	Chert	END	13.0	-22.0	-49.5	-10.6	CORT	TBend	Percussion	3	IND	Yes	No	No	lustrous gray and brown, high luster; probably heat treated
016	EU 5	10-20	Chert	MED	2.6	-19.2	-25.7	5.0	Flake	Bending	Pressure	Pres Only	IND	Yes	No	No	gray low luster probably natural
043	EU 15	10-20	Chert	END	148.1	-100.8	-74.8	25.2	Tab Cobble	Bending	Percussion	2	IND	Yes	No	No	gray and brown low luster
044	EU 15	10-20	Chert	MRG	6.1	-27.7	-28.3	-8.7	Flake	Bend/Thermal	Percussion	2	IND	Yes	No	No	gray differential luster and curvilinear fracture and spall; heat treatment failure
052	EU 17	0-10	Chert	MED	21.5	-35.2	-54.0	-13.8	CORT	Bending	Percussion	2	IND	Yes	No	No	reddish brown gray band; poor quality matte probably tabular
060	EU 19	0-10	Chert	END	34.2	-52.2	-43.6	-16.0	CORT	Bending	Percussion	2	IND	Yes	No	No	red low luster probably tabular
063	EU 19	10-20	Chert	DST	18.0	-53.2	-36.0	-11.8	IND	Bend/Mat Flaw	Percussion	3	IND	Yes	No	No	red with luster; possibly heat treated
065	EU 19	20-30	Chert	DST	14.5	-48.3	-41.0	-9.3	CORT	Bending	Percussion	3	IND	Yes	No	No	red luster; possibly heat treated

Appendix D: Artifact Analysis Tables for 24ME1109

Cat #	Unit	Depth (cm)	TLS	CND	WT (g)	LTH	WTH	TH	Blank	Break	Flaking	Stage	Shape	MF	Use Wear	R/M	Comments
077	EU 21	30-40	Chert	END	22.2	-41.2	-43.3	-11.7	CORT	Bending	Percussion	2	IND	Yes	No	No	reddish brown low luster; probably not heat treated
081	EU 21	30-40	Chert	MRG	1.6	-24.9	-10.0	-9.8	IND	Bend/Mat Flaw	Perc/Pres	IND	IND	Yes	No	No	gray high luster; probably late stage
086	EU 22	20-30	Chert	MRG	5.7	-21.0	-31.1	-9.6	CORT	Bending	Percussion	2	IND	Yes	No	No	red matte probably post deb thermal spalling
126	EU 35	0-10	Chert	DST	9.9	-34.4	-38.8	-9.9	IND	Bend/Mat Flaw	Percussion	3	IND	Yes	No	No	reddish gray matte
128	EU 35	10-20	Chert	PRX	9.7	-25.5	-41.8	-9.1	IND	TBend	Percussion	3	IND	Yes	No	No	red low luster; probably not heat treated
131	EU 36	0-10	Chert	WHL	34.8	51.3	45.4	11.5	CINT	None	Percussion	1	Irregular	Yes	No	No	red and brown probably natural luster, minimal reduction to dorsal only
132	EU 36	0-10	Chert	MRG	8.5	-44.8	-21.0	-7.9	Flake	Bending	Percussion	2	IND	Yes	No	No	brown probably natural luster
133	EU 36	0-10	Chert	DST	5.9	-29.6	-27.0	-10.7	IND	Bending	Perc/Pres	IND	IND	Yes	No	No	red luster possibly stage 2 w/pressure margin prep
136	EU 36	10-20	Chert	MRG	40.2	-47.7	-37.7	-16.0	Tab Cobble	Bend/Mat Flaw	Percussion	2	IND	Yes	No	No	red luster; possibly heat treated
137	EU 36	10-20	Chert	END	12.3	-47.4	-28.8	-8.6	CORT	Bending	Percussion	3	IND	Yes	No	No	red low luster
138	EU 36	10-20	Chert	END	9.4	-31.4	-31.3	-10.4	CORT	Bending	Percussion	3	IND	Yes	No	No	red and brown luster; possibly heat treated
148	EU 39	20-30	Chert	END	20.4	-32.3	-48.3	-13.9	CORT	Bend/Mat Flaw	Percussion	2	IND	Yes	No	No	red luster
156	EU 41	20-30	Chert	MRG	20.7	-56.5	-30.4	-18.4	CORT	Outrepassé	Percussion	3	IND	Yes	No	No	red luster
163	EU 43	20-30	Chert	END	22.5	-73.7	-40.0	12.5	IND	Bend/Mat Flaw	Percussion	4	IND	Yes	No	No	matte red and lustrous gray, too thin in middle
182	EU 50	0-10	Chert	MRG	5.6	-36.7	-20.7	-8.3	IND	Bending	Percussion	IND	IND	Yes	No	No	red luster

Appendix D: Artifact Analysis Tables for 24ME1109

Cat #	Unit	Depth (cm)	TLS	CND	WT (g)	LTH	WTH	TH	Blank	Break	Flaking	Stage	Shape	MF	Use Wear	R/M	Comments
194	---	Surface	Chert	MRG	6.0	-45.7	-15.9	-11.4	IND	Bending	Perc/Pres	IND	IND	IND	IND	IND	dark red and brown with luster, late stage, nice, possibly use or post dep break

Appendix D: Artifact Analysis Tables for 24ME1109

Table B4. 24ME1109 Uniface Data

Cat=catalog; CHT=chert; cmbs=centimeters below surface; CND=condition; CONV=convex; CORT=cortical flake; DORS=dorsal; EA=edge angle; EU=excavation unit; Imod=intentional modification; L Lat=Left Lateral; LTH=length; Mod=modification type; NME=number of modified edges; Pos=position on flake blank; Pres=Pressure; Shp=edge shape; SUR=surface; TH=thickness; TLS=toolstone; Uni=Unifacial; WHL=whole; WT=weight; WTH=width; 30-60=degrees

Cat	Unit	Depth (cm)	TLS	CND	WT	LTH	WTH	TH	Blank	Break	NME	IMod 1	Pos 1	Sur 1	Shp 1	EA 1	Use 1	Mod 2	IMod 2	Pos 2	Sur 2	Shp 2	EA 2	Use 2
168	EU 44	20-30	QTZ	WHL	66.0	80.1	50.0	18.6	SINT	None	2	Percussion	Lateral	IND	Straight	> 60	IND	Unifacial	Percussion	END	IND	Convex	> 60	IND

Comment: White moderately grainy, hard to see use wear

Appendix D: Artifact Analysis Tables for 24ME1109

Appendix Table B5. 24ME1109 Flake Tool Data

Cat=catalog; Bend=bending; BF=bifacial; CHT=chert; BST= basalt; CONV=convex; CORT=cortical flake; CND=condition; CRUSH=crushing; D=depth; DST=distal; EA=edge angle; EBT=early biface thinning flake; FK=flaking; HT=heat treated; Imod=intentional modification; IND=indeterminate; L Lat=left lateral; LTH=length; Mod=modification; NME=number of modified edges; Pos=position on flake blank; PRX=proximal; R Lat=right lateral; Shp=edge shape; SIN=sinuous; SINT=simple interior flake; STEP=Stepping; SUR=surface; TH=thickness; TLS=toolstone; Uni=Unifacial; Vent=Ventral; WHL=whole; WT=weight; WTH=width; 30-60=degrees; --- =no data or not applicable

Cat #	Unit	Depth (cm bs)	TLS	CND	WT	LTH	WTH	TH	Blank	Break	NME	Mod 1	IMod 1	Pos 1	Sur 1	Shp 1	EA 1	Use 1	Mod 2	IMod 2	Pos 2	Sur 2	Shp 2	EA 2	Use 2	Comments
046	EU 16	0-10	CHT	NC	1.1	-20.7	14.8	4.2	SINT	Bend	2	Unifacial	No	L Lat	Dorsal	Concave	< 30	Flaking	Unifacial	No	R Lat	Dorsal	Convex	< 30	Flaking	Red luster, cortical platform
068	EU 20	0-20	CHT	WHL	18.2	48.3	38.5	7.8	SINT	None	2	Alt Unif	No	R Lat	Both	Convex	30-60	Flaking	Unifacial	No	Distal	Dorsal	Convex	30-60	Flaking	Brown low luster, possibly large flake blank
078	EU 21	30-40	CHT	END	38.2	49.7	-53.0	14.1	CORT	Bend	1	Unifacial	Pressure	Distal	Dorsal	Convex	30-60	IND	---	---	---	---	---	---	---	Yellowish brown matte
084	EU 22	10-20	BST	NC	16.9	53.9	-42.7	6.4	SINT	Bend	1	Unifacial	No	L Lat	Dorsal	Irreg. Convex	30-60	Flaking	---	---	---	---	---	---	---	Fine grain, cortical platform
099	EU 24	30-40	CHT	NC	2.2	-19.2	24.0	5.1	SINT	Bend	1	Unifacial	No	R Lat	Dorsal	Straight	30-60	Flaking	---	---	---	---	---	---	---	Red mottled gray luster possibly natural
116	EU 30	10-20	CHT	NC	3.2	-27.3	22.6	4.1	CINT	Bend	2	Unifacial	No	R Lat	Dorsal	Convex	< 30	Flaking	Bifacial	No	L Lat	Both	Convex	< 30	Flaking	Red and brown luster probably heat treated
188	EU 55	0-10	CHT	WHL	116.0	61.0	72.8	21.8	SINT	None	1	Unifacial	No	DL Lat	Ventral	Convex	> 60	Stepping/ Flaking	---	---	---	---	---	---	---	Brown natural luster, probably heavy use

Appendix D: Artifact Analysis Tables for 24ME1109

Appendix Table B6. 24ME1109 Core Data

CAT= Catalog; TLS= Toolstone; CHT=chert; CND=condition; END=undifferentiated end; IND=indeterminate; LTH=length; MRG=margin; NC=nearly complete; Tab=tabular; TH=thickness; WT=weight; WTH=width; Perc= percussion

Cat #	Unit	Depth	TLS	CND	WT	LTH	WTH	TH	Blank	Break	Flaking	Type	Use Wear	Comments
149	EU 39	20-30	Chert	WHL	547.8	131.5	72.6	62.0	Cobble	None	Percussion	Multidirectional	None	Light pink with whiter bands and mottling with red cortex

Appendix D: Artifact Analysis Tables for 24ME1109

Appendix Table B7. 24ME163 Chert Debitage Data

CAT= Catalog; CNT=Count; CORT = cortical flake; CINT = complex interior flake; SINT = simple interior flake; LIN= Linear; SINT/CP = Simple Interior/Complex Platform; EP = Edge Preparation; EBT = Early Biface Thinning; LBT = Late Biface Thinning; EPR - Early Pressure; LPR = Late Pressure; PP = Platform Preparation/Pressure; SF = Simple Fragments; CF = Complex Fragments; CTF = Cortical Fragments; SH= Shatter; --- =no data or not applicable

Size grades represent the screen mesh size that will hold the debitage. Four size grades: 2 in., 1 in., ½ in., and ¼ in.

Cat	Unit	Depth (cm)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
001	EU 1	0-10	½	1	---	---	---	---	---	---	---	1	---	---	---	---	---	---	---	---	---	1	brown
001	EU 1	0-10	¼	2	---	---	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2	reddish brown
002	EU 1	10-20	½	3	---	---	---	---	---	---	---	1	---	---	---	---	---	1	1	---	---	3	brown red
002	EU 1	10-20	¼	2	---	---	---	---	---	---	---	---	---	---	---	---	---	1	1	---	---	2	reddish brown and gray
003	EU 1	20-30	½	1	---	---	---	---	---	---	---	1	---	---	---	---	---	---	---	---	---	1	brown
003	EU 1	20-30	¼	4	---	---	2	---	---	---	---	---	---	---	---	---	---	1	---	1	---	4	brown and reddish brown
004	EU 1	30-40	1	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	brown
004	EU 1	30-40	½	3	---	---	2	---	---	---	---	---	---	---	---	---	---	1	---	---	---	3	brown and red
005	EU 2	0-10	½	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	brown
005	EU 2	0-10	¼	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	brown red
006	EU 2	10-20	½	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	yellowish brown
006	EU 2	10-20	¼	3	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	2	3	red and gray, thermal shatter
007	EU 2	20-30	½	2	---	---	1	---	---	---	---	---	---	---	---	---	---	---	1	---	---	2	red and gray
008	EU 3	0-10	½	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	light gray differential luster
008	EU 3	0-10	¼	5	---	---	1	---	---	---	---	---	---	---	---	---	---	3	1	---	---	5	light gray and brown and dark brown
009	EU 3	10-20	½	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	red
009	EU 3	10-20	¼	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	red
011	EU 4	0-10	½	4	---	---	2	---	---	---	---	---	---	---	---	---	---	1	---	1	---	4	light gray and brown
011	EU 4	0-10	¼	18	---	---	6	---	1	---	---	---	---	---	---	---	---	8	3	---	---	18	light gray nicely siliceous, brown, red, a bit of

Appendix D: Artifact Analysis Tables for 24ME1109

Cat	Unit	Depth (cm)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
																							luster and thermal damage
013	EU 4	10-20	½	6	---	---	1	---	---	---	---	---	---	---	---	---	---	---	2	3	---	6	light gray luster and dark red probably natural luster
013	EU 4	10-20	¼	11	---	1	4	---	1	---	1	---	---	---	---	---	---	3	1	---	---	11	same
014	EU 5	0-10	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	1	tabular light gray, damaged, probably natural luster
014	EU 5	0-10	½	10	2	---	3	---	1	---	---	---	---	---	---	---	---	3	---	1	---	10	gray, red, reddish brown, some thermal damage
014	EU 5	0-10	¼	44	1	---	9	---	---	---	---	1	---	---	---	---	---	22	1	1	9	44	same
017	EU 5	10-20	½	3	---	---	1	---	---	---	---	---	---	---	---	---	---	---	1	1	---	3	light gray luster, reddish gray
017	EU 5	10-20	¼	29	1	---	6	---	1	---	---	---	---	---	---	---	---	14	---	5	2	29	light gray one with high luster, red, brown
018	EU 6	0-10	½	10	---	---	1	---	---	---	1	---	---	---	---	---	---	7	---	---	1	10	light gray, red, thermal damage
018	EU 6	0-10	¼	27	1	---	9	---	---	---	---	---	---	---	---	---	---	16	---	---	1	27	same, light gray some high luster
019	EU 6	10-20	½	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	1	light gray luster
019	EU 6	10-20	¼	6	---	---	2	---	---	---	---	---	---	---	---	---	---	2	1		1	6	light gray luster, reddish brown
020	EU 7	0-10	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	1	red gray banded possibly thermal spall
020	EU 7	0-10	½	8	---	---	2	---	---	---	---	---	---	---	---	---	---	4	---	---	2	8	red gray thermal damage
020	EU 7	0-10	¼	10	1	---	1	---	1	---	---	---	---	---	---	---	---	7	---	---	---	10	same some luster and brown
021	EU 7	10-20	½	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	1	mottled brown probably natural luster
021	EU 7	10-20	¼	2	---	---	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2	pink and brown matte
022	EU 8	0-10	1	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	pink

Appendix D: Artifact Analysis Tables for 24ME1109

Cat	Unit	Depth (cm)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
022	EU 8	0-10	½	3	---	---	---	---	---	---	---	---	---	---	---	---	---	3	---	---	---	3	gray, red gray, brown translucent
022	EU 8	0-10	¼	4	---	---	1	---	---	---	---	---	---	---	---	---	---	3	---	---	---	4	white, red gray, translucent white
023	EU 8	10-20	½	2	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	1	---	2	red translucent natural luster and pinkish brown thermal damage
023	EU 8	10-20	¼	2	---	---	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2	pink gray banded thermal damage
025	EU 8	20-30	½	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	grayish orange pink probably differential luster and some cortex
026	EU 9	0-10	¼	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	dark brown probably natural luster
027	EU 10	0-10	¼	3	---	---	2	---	---	---	---	---	---	---	---	---	---	1	---	---	---	3	red and gray, gray matte and gray luster
028	EU 10	10-20	½	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	pink light brown
028	EU 10	10-20	¼	4	---	---	---	---	---	---	---	---	---	---	---	---	---	4	---	---	---	4	yellow brown, pink brown, red
029	EU 11	0-10	1	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	red with grayish orange pink banded matte
029	EU 11	0-10	¼	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	1	yellow brown luster with pink cortex probably heat treated
030	EU 11	10-20	½	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	1	gray translucent
031	EU 12	10-20	½	2	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	2	red matte and natural luster
031	EU 12	10-20	¼	3	---	---	1	---	---	---	---	---	---	---	---	---	---	2	---	---	---	3	gray possibly ht and red/brown mottle matte
032	EU 12	20-30	1	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	blocky red matte
033	EU 12	30-40	½	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	reddish brown matte

Appendix D: Artifact Analysis Tables for 24ME1109

Cat	Unit	Depth (cm)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
034	EU 13	0-10	½	2	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	2	white matte, red gray thermal spall
034	EU 13	0-10	¼	6	---	---	1	---	---	---	---	---	---	---	---	---	---	3	1	---	1	6	gray luster, red browns matte
035	EU 13	10-20	½	4	1	---	1	---	---	---	---	---	---	---	---	---	---	1	1	---	---	4	gray luster w/crystally cortex possibly internal vein, pinkish whites matte
035	EU 13	10-20	¼	13	---	---	4	---	1	---	---	---	---	---	---	---	---	5	2	1	---	13	dark reds pinks lustrous gray
036	EU 13	20-30	½	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	pinkish red natural luster
036	EU 13	20-30	¼	2	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	1	---	2	darker pinkish red
037	EU 13	30-40	¼	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	dark pinkish red natural lust
038	EU 14	0-10	½	2	---	1	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	2	dark brown luster cint possibly uniface manufacture failure, red white matte
038	EU 14	0-10	¼	9	1	---	1	---	---	---	---	---	---	---	---	---	---	6	---	1	---	9	dark red cort over pink gray, gray and pinks, one high lust blue gray banded possibly exotic
040	EU 14	10-20	½	3	---	---	1	---	---	---	---	---	---	---	---	---	---	2	---	---	---	3	brown matte, dark red, gray high luster thermal damage
040	EU 14	10-20	¼	8	---	---	1	---	---	---	---	---	---	---	---	---	---	4	---	3	---	8	reds pinkish gray, grayish brown crystally cortex
041	EU 14	20-30	¼	2	---	---	1	---	---	---	---	---	---	---	---	---	---		---	---	1	2	gray luster and gray matte
042	EU 15	0-10	½	25	3	1	8	---	---	---	---	---	---	---	---	---	---	5	---	5	3	25	mostly reds, dark brown, luster on the nicer pieces, see material photo

Appendix D: Artifact Analysis Tables for 24ME1109

Cat	Unit	Depth (cm)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
042	EU 15	0-10	¼	41	---	---	7	---	---	---	---	---	---	---	---	---	---	23	2	3	6	41	same more grays, some luster, see material photo
045	EU 15	10-20	1	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	red pinkish gray banded crystally veins vugs natural luster, see material photo
045	EU 15	10-20	½	9	---	---	7	---	2	---	---	---	---	---	---	---	---	---	---	---	---	9	mostly pinkish and some browns, high luster and natural luster, see material photo
045	EU 15	10-20	¼	15	---	---	4	---	---	---	---	---	---	---	---	---	---	7	---	3	1	15	same and white, see material photo
047	EU 16	0-10	1	2	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	1	---	2	white matte and orangish red matte
047	EU 16	0-10	½	6	---	---	3	---	---	---	---	---	---	---	---	---	---	---	---	2	1	6	red, grays, natural luster matte and thermal damage
047	EU 16	0-10	¼	31	1	---	10	---	---	1	---	---	---	---	---	---	---	14	---	2	3	31	typical, some luster, mostly matte
048	EU 16	10-20	1	3	1	---	---	---	---	---	---	---	---	---	---	---	---	1	1	---	---	3	red and gray matte, cf core reduction blocky frag, see material photo
048	EU 16	10-20	½	8	---	1	1	---	---	---	---	---	---	---	---	---	---	3	---	3	---	8	cint translucent clear light brown nice but probably natural lust core red, lust dark brown, red lust, gray
048	EU 16	10-20	¼	50	2	---	18	---	---	---	---	1	---	---	---	---	---	26	---	1	2	50	lbt is orange translucent white luster, otherwise same,

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Cat	Unit	Depth (cm)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
																							see material photo
050	EU 16	20-30	½	9	---	---	1	---	---	---	---	---	---	---	---	---	---	5	1	1	1	9	mostly dark reds, some luster and some thermal damage
050	EU 16	20-30	¼	48	2	---	13	---	---	---	---	---	---	---	---	---	---	24	2	4	3	48	same, light gray sf with differential luster
051	EU 16	30-40	½	3	1	---	1	---	---	---	---	---	---	---	---	---	---	---	---	1	---	3	reds
051	EU 16	30-40	¼	8	---	---	5	---	---	---	---	---	---	---	---	---	---	2	---	---	1	8	reds and one gray
053	EU 17	0-10	½	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	1	banded reds thermal
053	EU 17	0-10	¼	10	---	---	1	---	---	---	---	---	---	---	---	---	---	8	---	---	1	10	reds and grays, gray luster
055	EU 17	10-20	½	3	---	---	1	---	---	---	---	---	---	---	---	---	---	1	---	---	1	3	dark red and grays, thermal shatter
055	EU 17	10-20	¼	8	---	---	2	---	---	---	---	---	---	---	---	---	---	2	---	2	2	8	grays reds thermal damage
056	EU 17	20-30	½	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	matte grainy red beige
057	EU 18	0-10	½	5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	3	2	5	grays and one red
057	EU 18	0-10	¼	15	2	---	6	---	1	---	---	---	---	---	---	---	---	4	---	2	---	15	same
058	EU 18	10-20	1	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2	2	thick blocky tabular red beige banded cortical
058	EU 18	10-20	½	2	1	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2	cort mottled white olive red, and red gray
058	EU 18	10-20	¼	18	---	---	7	---	---	---	---	1	---	---	---	---	---	6	---	2	2	18	reds grays thermal shatter
059	EU 18	20-30	½	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	1	cortical reds
059	EU 18	20-30	¼	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	red luster
061	EU 19	0-10	1	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	light gray matte
061	EU 19	0-10	½	6	---	---	3	---	---	---	---	---	---	---	---	---	---	1	---	2		6	reds and sf light gray thermal damaged high luster

Appendix D: Artifact Analysis Tables for 24ME1109

Cat	Unit	Depth (cm)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
061	EU 19	0-10	¼	32	---	---	13	---	1	---	---	---	---	---	---	---	---	14	1	---	3	32	reds, some grays, shatter thermal
064	EU 19	10-20	1	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	red tabular
064	EU 19	10-20	½	16	1	1	5	---	---	---	---	---	---	---	---	---	---	3	2	2	2	16	reds and some grays with high luster, cint possibly manufacture fail
064	EU 19	10-20	¼	45	2	---	11	---	1	---	---	---	---	---	---	---	---	25	2	---	4	45	same see material photo for this level
066	EU 19	20-30	2	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	1	yellow brown red grainy tabular spalled possibly natural
066	EU 19	20-30	1	3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	2	---	3	cf red out yellow inside but looks like thermal damage or failure, tabular red ctf
066	EU 19	20-30	½	17	1	---	5	---	1	---	1	---	---	---	---	---	---	3	---	1	5	17	mostly reds natural lust, see mat photo
066	EU 19	20-30	¼	56	2	---	17	---	---	---	---	---	---	---	---	---	---	28	4	2	3	56	same see photo
067	EU 19	30-40	½	3	---	---	1	---	---	---	---	---	---	---	---	---	---	2	---	---	---	3	red
067	EU 19	30-40	¼	6	---	---	1	---	---	---	---	---	---	---	---	---	---	5	---	---	---	6	red and one high luster gray mottled red probably thermal damage possibly failed heat treatment
069	EU 20	0-20	1	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	matte orangish red
069	EU 20	0-20	½	29	2	2	13	---	---	---	---	---	---	---	---	---	---	3	1	7	1	29	reds and grays, some luster
069	EU 20	0-20	¼	99	2	---	32	---	---	---	---	---	---	---	---	---	---	42	2	13	8	99	same see level material photo
070	EU 20	20-30	1	6	---	---	---	---	---	---	---	---	---	---	---	---	---	1		5		6	red matte
070	EU 20	20-30	½	23	2	---	4	---	---	---	1	---	---	---	---	---	---	6		10		23	same, luster yellow brown ventral red

Appendix D: Artifact Analysis Tables for 24ME1109

Cat	Unit	Depth (cm)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
																							cortical dorsal frag
070	EU 20	20-30	¼	82	2	---	29	---	---	---	---	---	---	---	---	---	---	35	3	6	7	82	same, mostly red, some high luster gray, cf probably biface thinning and a few in earlier levels
072	EU 20	30-40	1	4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	4		4	red matte blocky tabular
072	EU 20	30-40	½	12	1	---	4	---	---	---	---	---	---	---	---	---	---	2	2	3	---	12	red and lustrous gray, white matte with blue mottle
072	EU 20	30-40	¼	63	4	---	18	---	---	---	---	---	---	---	---	---	---	32	---	4	5	63	same
074	EU 21	0-10	1	2	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	2	red
074	EU 21	0-10	½	17	4	---	4	---	---	---	---	---	---	---	---	---	---	3	2	3	1	17	reds and grays with luster
074	EU 21	0-10	¼	53	1	1	18	---	---	---	---	---	---	---	---	---	---	28	---	3	2	53	reds and grays
075	EU 21	10-20	1	3	---	---	2	---	---	---	---	---	---	---	---	---	---	1	---	---	---	3	dark reddish brown natural luster and pinkish white matte
075	EU 21	10-20	½	16	---	---	4	---	---	---	---	---	---	---	---	---	---	5	---	3	4	16	reds pinks grays
075	EU 21	10-20	¼	49	4	---	16	---	---	---	---	---	---	---	---	---	---	23	---	3	3	49	same
076	EU 21	20-30	1	6	1	1	---	---	---	---	---	---	---	---	---	---	---	1	---	3	---	6	blocky olive and tabular red, one sf luster grayish brown ventral matte dorsal; possibly heat treatment fail
076	EU 21	20-30	½	8	---	1	1	---	---	---	---	1	---	---	---	---	---	1	---	4	---	8	gray lbt luster possibly natural, reds
076	EU 21	20-30	¼	48	---	1	12	---	---	---	---	---	---	---	---	---	---	22	1	6	6	48	red cortex over high lust gray frag
079	EU 21	30-40	2	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	yellowish brown matte block
079	EU 21	30-40	1	6	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	5	---	6	sint red cort yellow brown

Appendix D: Artifact Analysis Tables for 24ME1109

Cat	Unit	Depth (cm)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
																							ventral but low luster, pinkish diff lust, blocky yellow brown, tab red
079	EU 21	30-40	½	41	11	2	10	---	---	---	1	1	---	---	---	---	---	10	---	6	---	41	see material photo, green, cint lustrous red core red and lbt, gray high luster ebt
079	EU 21	30-40	¼	94	5	---	25	---	---	---	4	1	---	1	---	---	---	46	1	6	5	94	mostly reds, see photo, red pressure and red and pink biface reduction luster
082	EU 22	0-10	½	8	---	---	2	---	---	---	---	---	---	---	---	---	---	3	---	1	2	8	reds, some gray
082	EU 22	0-10	¼	29	2	---	9	---	---	---	---	---	---	---	---	---	---	11	---	4	3	29	reds, some gray
085	EU 22	10-20	½	20	2	---	3	---	---	---	---	1	---	---	---	---	---	6	---	4	4	20	reds, grays, plus yellow yellow brown w/a bit of red, lbt red lust
085	EU 22	10-20	¼	49	---	---	14	---	1	---	---	---	---	---	---	---	---	25	1	3	5	49	reds and gray w/high luster
087	EU 22	20-30	1	3	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2	---	3	cort is yellow brown matte, ctf are red and gray tabular, gray w/thermal damage
087	EU 22	20-30	½	12	---	---	7	---	---	---	---	---	---	---	---	---	---	3	---	2	---	12	reds, pinkish luster, mottled white
087	EU 22	20-30	¼	21	2	---	7	---	---	---	---	---	---	---	---	---	---	11	---	---	1	21	reds, whites, grays
088	EU 22	30-40	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	poor quality light brown
088	EU 22	30-40	½	5	1	1	1	---	1	---	---	---	---	---	---	---	---	1	---	---	---	5	interesting mottled gray brown sintcp, mottled pinkish, red and pink brown
088	EU 22	30-40	¼	6	---	---	1	---	---	---	---	---	---	---	---	---	---	3	1	1	---	6	reds

Appendix D: Artifact Analysis Tables for 24ME1109

Cat	Unit	Depth (cm)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
089	F4	N/A	½	10	1	---	5	---	---	---	---	---	---	---	---	---	---	2	---	2	---	10	reds and one matte white, thermal damage, some luster
089	F4	N/A	¼	28	1	9	---	---	---	---	---	---	---	---	---	---	---	14	---	2	2	28	reds, gray w/luster thermal damage
091	EU 23	0-10	1	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	red cort outside gray inside, but natural
091	EU 23	0-10	½	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	red
091	EU 23	0-10	¼	2	---	---	1	---	---	---	---	---	---	---	---	---	---	1	---	---	---	2	white
092	EU 23	10-20	½	4	---	---	2	---	---	---	---	---	---	---	---	---	---	1	---	1	---	4	red, red gray, gray w/lust, yellowish white
092	EU 23	10-20	¼	13	---	---	---	---	---	---	---	---	---	---	---	---	---	7	---	1	5	13	reds, grays, thermal shatter
094	EU 23	20-30	¼	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	red mottled w/gray
095	EU 24	0-10	½	8	1	---	2	---	---	---	---	---	---	---	---	---	---	1	---	4	---	8	red luster, tabular gray thermal shatter
095	EU 24	0-10	¼	34	1	---	7	---	2	---	---	---	---	---	---	---	---	19	---	1	4	34	
096	EU 24	10-20	1	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	red gray banded matte
096	EU 24	10-20	½	5	---	---	2	---	---	---	---	---	---	---	---	---	---	2	---	1		5	reds
096	EU 24	10-20	¼	14	---	---	4	---	---	---	---	---	---	---	---	---	---	6	---	---	4	14	reds grays
098	EU 24	20-30	1	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	red gray banded matte
098	EU 24	20-30	½	3	---	---	2	---	---	---	---	---	---	---	---	---	---	---	---	1	---	3	white yellow matte, red brown luster, gray high luster
098	EU 24	20-30	¼	20	---	---	5	---	---	---	---	---	---	---	---	---	---	11	---	2	2	20	reds some grays
100	EU 24	30-40	½	10	2	---	3	---	---	---	1	---	---	---	---	---	---	2	---	2	---	10	Gray w/high luster, red, dark brown
100	EU 24	30-40	¼	18	---	---	5	---	---	---	---	---	---	---	---	---	---	10	---	2	1	18	reds grays
101	EU 24	40-50	1	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	gray high luster

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Cat	Unit	Depth (cm)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
101	EU 24	40-50	½	6	---	---	2	---	---	---	---	---	---	---	---	---	---	2	---	1	1	6	red, brown, red gray banded, gray
101	EU 24	40-50	¼	10	---	---	---	---	---	---	---	---	---	---	---	---	---	5	---	2	3	10	red and gray
102	EU 24	50-60	½	4	---	---	1	---	---	---	---	---	---	---	---	---	---	1	---	2	---	4	dark brown, red gray banded
102	EU 24	50-60	¼	6	---	---	2	---	---	---	---	---	---	---	---	---	---	1	---	1	2	6	reds, pinks, gray
103	EU 25	0-10	½	6	---	---	3	---	---	---	1	---	---	---	---	---	---	1	---	---	1	6	reds
103	EU 25	0-10	¼	8	1	---	2	---	---	---	---	---	---	---	---	---	---	3	---	1	1	8	mostly grays
104	EU 25	10-20	½	3	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	1	1	3	red, gray, gray w/red cort
104	EU 25	10-20	¼	11	---	---	4	---	---	---	---	---	---	---	---	---	---	5	---	2	---	11	reds, grays, translucent red
105	EU 25	20-30	1	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	red matte rough
105	EU 25	20-30	½	3	---	---	---	---	---	---	---	---	---	---	---	---	---	1	1	1	---	3	reds gray
105	EU 25	20-30	¼	10	1	---	4	---	---	---	---	---	---	---	---	---	---	5	---	---	---	10	reds grays
106	EU 26	0-10	1	1	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	brown luster waxy really nice material, edge damage probably not use; see material photo
106	EU 26	0-10	½	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	gray matte
106	EU 26	0-10	¼	3	---	---	---	---	---	---	---	---	---	---	---	---	---	3	---	---	---	3	browns, dark gray translucent
107	EU 26	10-20	½	3	---	---	1	---	---	---	---	---	---	---	---	---	---	2	---	---	---	3	browns and red
107	EU 26	10-20	¼	4	---	---	1	---	---	---	---	---	---	---	---	---	---	2	1	---	---	4	dark purple, reds and brown
108	EU 27	0-10	½	3	2	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	3	brown, red
108	EU 27	0-10	¼	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	brown
109	EU 27	10-20	½	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	gray matte
110	EU 28	0-10	½	3	1	---	1	---	---	---	---	---	---	---	---	---	---	1	---	---	---	3	brown and red
110	EU 28	0-10	¼	2	---	---	1	---	---	---	---	---	---	---	---	---	---	1	---	---	---	2	brown and red banded
111	EU 28	10-20	½	2	---	---	---	---	---	---	---	---	---	---	---	---	---	2	---	---	---	2	red and yellow brown
111	EU 28	10-20	¼	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	1	brown

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Cat	Unit	Depth (cm)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
112	EU 29	0-10	1	2	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	1	2	red pink mottle, gray thermal damage
112	EU 29	0-10	½	13	2	---	3	---	---	---	---	---	---	---	---	---	---	3	---	3	2	13	mostly grays matte
112	EU 29	0-10	¼	21	1	---	13	---	---	---	---	---	---	---	---	---	---	5	---	1	1	21	same, some luster, see photo
113	EU 29	10-20	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	1	gray thermal damage
113	EU 29	10-20	½	6	1	---	1	---	---	---	---	---	---	---	---	---	---	2	---	1	1	6	gray, brown, pinkish white
113	EU 29	10-20	¼	3	---	---	1	---	---	---	---	---	---	---	---	---	---	1	---	---	1	3	gray and red
114	EU 30	0-10	1	2	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	2	brown cort natural lust and red natural lust frag
114	EU 30	0-10	½	17	2	---	4	---	---	---	1	1	---	---	---	---	---	7	1	1	---	17	mostly reds but nice banded browns and mottled reds, luster probably mostly natural
114	EU 30	0-10	¼	36	---	---	12	---	---	---	---	---	---	---	---	---	---	18	---	2	4	36	same
117	EU 30	10-20	1	1		---	1	---	---	---	---	---	---	---	---	---	---		---	---	---	1	chalky cortical terminaturalion and white patina over caramel brown, made a nice core face
117	EU 30	10-20	½	6	2	---		---	---	---	---	---	---	---	---	---	---	4	---	---	---	6	nice mottled banded red browns, mostly natural lust and high lust thermal damage
117	EU 30	10-20	¼	15	---	---	4	---	---	---	---	---	---	---	---	---	---	11	---	---	---	15	same
118	EU 31	0-10	1	1	1	---		---	---	---	---	---	---	---	---	---	---		---	---	---	1	tabular red mottled white with some remnant bifacial margin removals and damage
118	EU 31	0-10	½	1	---	---	1	---	---	---	---	---	---	---	---	---	---		---	---	---	1	red and white banded matte
118	EU 31	0-10	¼	2	---	---	1	---	---	---	---	---	---	---	---	---	---	1	---	---	---	2	red and a brown

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Cat	Unit	Depth (cm)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
119	EU 32	0-10	½	1	---	---		---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	red matte
119	EU 32	0-10	¼	4	1	---	2	---	---	---	---	---	---	---	---	---	---	1	---	---	---	4	reds browns
120	EU 32	10-20	½	2	---	---		---	---	---	---	---	---	---	---	---	---	1	---	---	1	2	red thermal damage high luster sf and brown grainy matte ctf
120	EU 32	10-20	¼	8	1	---	3	---	---	---	---	---	---	---	---	---	---	4	---	---	---	8	red browns
121	EU 33	0-10	½	1	---	---		---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	grainy light brown
121	EU 33	0-10	¼	2	---	---		---	---	---	---	---	---	---	---	---	---	2	---	---	---	2	white mottled w red and grainy light brown
122	EU 33	10-20	½	2	---	---	1	---	---	---	---	---	---	---	---	---	---	1	---	---	---	2	red/brown luster possibly heat treatment and olive brown red, both damaged, possibly recent
122	EU 33	10-20	¼	6	---	---	2	---	---	---	---	---	---	---	---	---	---	3	---	---	1	6	red and brown
123	EU 33	20-30	1	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	brown white mottled banded, edge damage
124	EU 34	0-10	¼	3	---	---	---	---	---	---	---	---	---	---	---	---	---	3	---	---	---	3	reds gray
125	EU 34	10-20	1	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	red brown banded natural luster
125	EU 34	10-20	¼	2	---	---	---	---	---	---	---	---	---	---	---	---	---	2	---	---	---	2	gray brown, red
127	EU 35	0-10	½	11	2	---	3	---	---	---	---	---	---	---	---	---	---	1	---	1	4	11	reds, grays and browns, natural lust, see photo
127	EU 35	0-10	¼	39	---	---	9	---	---	---	---	---	---	---	---	---	---	15	---	4	11	39	same and thermal shatter
129	EU 35	10-20	1	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	red probably tabular
129	EU 35	10-20	½	2	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	1	2	red gray and yellow brown
129	EU 35	10-20	¼	26	---	---	5	---	---	---	---	---	---	---	---	---	---	14	---	---	7	26	reds grays
130	EU 35	20-30	½	3	1	---	---	---	---	---	---	---	---	---	---	---	---	1	---	1	---	3	cort mottled red white w damage probably not use natural lust

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Cat	Unit	Depth (cm)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
130	EU 35	20-30	¼	2	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	1	---	2	brown and gray
134	EU 36	0-10	1	3	1	---	1	---	---	---	---	---	---	---	---	---	---	---	---	1	---	3	red and brown
134	EU 36	0-10	½	18	4	1	3	---	---	---	2	---	---	---	---	---	---	6	---	2	---	18	mostly red, gray w cort and high lust, which might just be weathering shine evidenced by a recent scar
134	EU 36	0-10	¼	53	4	---	14	---	---	---	1	1	---	1	---	---	---	21	1	4	6	53	same, pressure bif thinning red and lust gray/brown, see photo
139	EU 36	10-20	1	4	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2	---	4	red, orange brown, gray
139	EU 36	10-20	½	11	---	---	3	---	---	---	---	---	---	---	---	---	---	2	---	4	2	11	reds, grays and banded mottled purple/brown
139	EU 36	10-20	¼	56	7	---	8	---	2	---	---	---	---	---	---	---	---	29	---	6	4	56	see photo
140	EU 36	20-30	1	2	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	2	orange red matte and red luster
140	EU 36	20-30	½	19	7	2	2	---	---	---	1	---	---	---	---	---	---	4	1	2	---	19	mostly reds
140	EU 36	20-30	¼	46	3	---	19	---	---	---	1	---	---	---	---	---	---	19	---	4	---	46	mostly reds
141	EU 36	30-40	1	6	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	4	---	6	red tabular and chunky
141	EU 36	30-40	½	21	2	1	6	---	---	---	---	---	---	---	---	---	---	4	1	5	2	21	mostly reds luster
141	EU 36	30-40	¼	32	2	---	7	---	1	---	---	1	---	---	---	---	---	15	---	2	4	32	reds and grays
142	EU 37	0-10	1	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2	---	2	chunky light brown and red
142	EU 37	0-10	½	5	---	---	---	---	---	---	---	---	---	---	---	---	---	3	---	1	1	5	browns and pinkish red
142	EU 37	0-10	¼	38	---	---	6	---	---	---	---	---	---	---	---	---	---	25	---	---	7	38	reds grays browns
143	EU 37	10-20	1	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	yellowish white brown mottled red natural lust
143	EU 37	10-20	½	14	1	---	4	---	---	---	---	---	---	---	---	---	---	1	---	1	7	14	reds browns grays
143	EU 37	10-20	¼	34	2	---	4	---	2	---	---	---	---	---	---	---	---	20	---	2	4	34	same

Appendix D: Artifact Analysis Tables for 24ME1109

Cat	Unit	Depth (cm)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
144	EU 38	0-10	½	8	---	---	---	---	---	---	1	1	---	---	---	---	---	2	---	2	2	8	gray, pinkish, reds browns
144	EU 38	0-10	¼	11	---	---	2	---	1	---	---	---	---	---	---	---	---	6	---	1	1	11	browns reds
145	EU 38	10-20	½	7	---	---	4	---	---	---	---	---	---	---	---	---	---	---	---	2	1	7	reds pinkish gray brown
145	EU 38	10-20	¼	16	---	---	6	---	---	---	---	---	---	---	---	---	---	8	1	---	1	16	same
146	EU 39	0-10	1	1	---	---		---	---	---	---	---	---	---	---	---	---	---	---	1	---	1	tabular red
146	EU 39	0-10	½	18	3	---	5	---	---	---	---	---	---	---	---	---	---	4	---	2	4	18	reds mostly, light brown and olive gray
146	EU 39	0-10	¼	43	---	---	13	---	1	---	---	1	---	---	---	---	---	21	1	2	4	43	lbt is reddish brown and white high luster and small, reds browns grays
147	EU 39	10-20	1	3	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2	---	3	cort brownish gray high lust, red tab ctf
147	EU 39	10-20	½	20	8	---	6	---	---	---	---	---	---	---	---	---	---	3	1	2	---	20	cort red red over yellowish brown gray, reds browns pinkish gray
147	EU 39	10-20	¼	38	2	---	8	---	1	---	1	1	---	---	---	---	---	19	---	2	4	38	reds grays browns
150	EU 39	20-30	1	6	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	4	1	6	cint gray red luster cortical layers, red tabular frags
150	EU 39	20-30	½	16	4	---	2	---	---	---	---	1	---	---	---	---	---	5	---	3	1	16	lbt mottled pinkish white luster, reds grays
150	EU 39	20-30	¼	51	3	---	16	---	---	---	---	2	---	---	---	---	---	24	1	3	2	51	mostly reds
151	EU 39	30-40	1	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	mottled gray brown natural lust
151	EU 39	30-40	½	4	1	---	---	---	---	---	---	---	---	---	---	---	---	2	---	1	---	4	red and gray
151	EU 39	30-40	¼	9	1	---	3	---	---	---	---	---	---	---	---	---	---	5	---	---	---	9	same
152	EU 40	0-10	1	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	red probably natural lust
152	EU 40	0-10	½	9	3	1	2	---	---	---	---	---	---	---	---	---	---	1	---	2	---	9	reds grays browns

Appendix D: Artifact Analysis Tables for 24ME1109

Cat	Unit	Depth (cm)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
152	EU 40	0-10	¼	7	---	---	---	---	---	---	---	---	---	---	---	---	---	6	---	---	1	7	mostly shaley grays
153	EU 40	10-20	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	1	red tabular
153	EU 40	10-20	½	2	---	---	---	---	---	---	---	---	---	---	---	---	---	2	---	---	---	2	red and pinkish brown
153	EU 40	10-20	¼	5	1	---	---	---	---	---	---	---	---	---	---	---	---	2	---	2	---	5	reddish browns, browns and gray
154	EU 41	0-10	½	8	2	---	---	---	---	---	---	---	---	---	---	---	---	2	---	1	3	8	grays reds thermal damage
154	EU 41	0-10	¼	17	---	---	2	---	---	---	---	---	---	---	---	---	---	11	---	---	4	17	reds pinkish reds brown gray
155	EU 41	10-20	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	1	red tabular
155	EU 41	10-20	½	7	1	---	2	---	---	---	---	---	---	---	---	---	---	1	---	1	2	7	chalky white, reds, luster gray
155	EU 41	10-20	¼	28	---	---	9	---	1	---	---	---	---	---	---	---	---	12	---	3	3	28	reds browns
157	EU 41	20-30	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	1	red tab possibly remnant manufacture fail
157	EU 41	20-30	½	7	---	---	1	---	1	---	---	---	---	---	---	---	---	4	---	---	1	7	mostly grays
157	EU 41	20-30	¼	11	---	---	3	---	---	---	---	---	---	---	---	---	---	6	---	2	---	11	grays reds
158	EU 41	Feature 6 30-48	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	1	blocky reddish and light brown banded
158	EU 41	Feature 6 30-48	½	3	2	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	3	red
158	EU 41	Feature 6 30-48	¼	4	1	---	3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	4	red
159	EU 42	0-10	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	1	tabular red cort over yellow brown interior
159	EU 42	0-10	½	9	---	---	5	---	---	---	---	---	---	---	---	---	---	1	---	2	1	9	mostly reds and a mottled red in gray
159	EU 42	0-10	¼	33	---	---	10	---	---	---	1	3	---	---	---	---	---	9	1	4	5	33	mostly reds, bif thinning red
160	EU 42	10-20	½	7	1	---	2	---	---	---	---	---	---	---	---	---	---	2	---	2	---	7	red and gray
160	EU 42	10-20	¼	12	---	---	6	---	---	---	---	---	---	---	---	---	---	5	---	---	1	12	reds and a couple gray
161	EU 43	0-10	½	5	---	---	1	---	---	---	---	---	---	---	---	---	---	1	1	2	---	5	red and white and light gray

Appendix D: Artifact Analysis Tables for 24ME1109

Cat	Unit	Depth (cm)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
161	EU 43	0-10	¼	14	3	---	2	---	---	---	---	---	---	---	---	---	---	9	---	---	---	14	same
162	EU 43	10-20	1	2	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2	tabular red
162	EU 43	10-20	½	5	3	---	1	---	---	---	---	---	---	---	---	---	---	1	---	---	---	5	primarily grays one luster
162	EU 43	10-20	¼	15	---	---	3	---	---	---	2	---	---	---	---	---	---	6	1	2	1	15	reds grays, pretty banded potlid shatter
164	EU 43	20-30	½	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	1	reddish gray thermal
165	EU 44	0-10	½	11	---	1	1	---	---	---	1	---	---	---	---	---	---	1	---	6	1	11	reds grays browns, ctf chunky to flake and tab
165	EU 44	0-10	¼	39	1	---	11	---	1	---	1	---	---	---	---	---	---	11	---	11	3	39	same with a translucent orange
167	EU 44	10-20	1	3	1	---	---	---	---	---	---	---	---	---	---	---	---	1	---	1	---	3	red and two gray, sf thermal
167	EU 44	10-20	½	3	---	---	2	---	---	---	---	---	---	---	---	---	---	1	---	---	---	3	orange brown, gray red banded, pretty orange squares in gray high lust
167	EU 44	10-20	¼	24	---	---	9	---	---	---	---	---	---	---	---	---	---	13	---	1	1	24	grays, red and browns
169	EU 44	20-30	½	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	red
169	EU 44	20-30	¼	3	---	---	1	---	---	---	---	---	---	---	---	---	---	2	---	---	---	3	red and gray
170	EU 45	0-10	1	2	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	2	red
170	EU 45	0-10	½	2	1	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	2	red
170	EU 45	0-10	¼	14	1	---	4	---	---	---	---	---	---	---	---	---	---	4	---	1	4	14	reds grays
171	EU 45	10-20	1	2	z	---	1	---	---	---	---	---	---	---	---	---	---	1	---	---	---	2	red
171	EU 45	10-20	½	3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	3	3	red and grainy brown
171	EU 45	10-20	¼	25	3	---	4	---	---	---	---	---	---	---	---	---	---	14	---	2	2	25	reds grays
172	EU 45	20-30	2	2	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	2	tabular gray and coarse grainy red
172	EU 45	20-30	1	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	1	2	red tabular and chunky orange

Appendix D: Artifact Analysis Tables for 24ME1109

Cat	Unit	Depth (cm)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
																							brown grainy shatter
172	EU 45	20-30	½	5	---	---	2	---	---	---	---	---	---	---	---	---	---	1	---	2	---	5	pinkish gray, olive white, red, gray red tab shatter
172	EU 45	20-30	¼	23	---	---	10	---	1	---	---	---	---	---	---	---	---	8	---	1	3	23	reds grays
173	EU 46	0-10	½	7	---	---	---	---	1	---	1	---	---	---	---	---	---	2	1	2	---	7	reds brown, nice lustrous gray cf
173	EU 46	0-10	¼	11	---	---	2	---	1	---	---	---	---	---	---	---	---	5	1	---	2	11	reds grays
174	EU 46	10-20	½	2	---	---	1	---	---	---	---	---	---	---	---	---	---	---	1	---	---	2	reds
174	EU 46	10-20	¼	15	---	---	6	---	---	---	---	---	---	---	---	---	---	8	---	---	1	15	reds grays white
175	EU 46	20-30	1	2	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	2	red
175	EU 46	20-30	½	7	1	---	1	---	---	---	---	---	---	---	---	---	---	4	---	1	---	7	red, red/gray mottle
175	EU 46	20-30	¼	22	1	---	8	---	1	---	1	---	---	---	---	---	---	7	---	4	---	22	reds grays
176	EU 47	0-10	½	7	1	---	2	---	1	---	---	---	---	---	---	---	---	---	---	3	---	7	yellow brown, gray, red
176	EU 47	0-10	¼	23	1	---	5	---	---	---	---	---	---	---	---	---	---	14	---	---	3	23	same
177	EU 47	10-20	1	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	yellow white
177	EU 47	10-20	½	17	---	---	3	---	---	---	---	---	---	---	---	---	---	7	1	2	4	17	reds grays, cf is red core reduction chunk
177	EU 47	10-20	¼	35	1	---	7	---	1	---	---	---	---	---	---	---	---	23	---	1	2	35	grays reds
178	EU 47	20-30	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	1	pinkish red core reduction
178	EU 47	20-30	½	10	1	---	2	---	---	---	---	---	---	---	---	---	---	4	3	---	---	10	pinkish reds, cf are core reduction reds and pinkish
178	EU 47	20-30	¼	16	---	---	5	---	1	---	---	---	---	---	---	---	---	8	---	---	2	16	reds grays
179	EU 48	0-10	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	1	gray
179	EU 48	0-10	½	7	3	---	1	---	1	---	---	---	---	---	---	---	---	1	---	1	---	7	reds grays
179	EU 48	0-10	¼	20	1	---	10	---	1	---	---	---	---	---	---	---	---	8	---	---	---	20	mostly grays
180	EU 48	10-20	½	9	3	---	1	---	1	---	---	---	---	---	---	---	---	3	---	---	1	9	mostly grays, thermal pot lid shatter
180	EU 48	10-20	¼	29	1	---	6	---	2	---	---	---	---	---	---	---	---	16	---	2	2	29	same

Appendix D: Artifact Analysis Tables for 24ME1109

Cat	Unit	Depth (cm)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
181	EU 49	0-10	½	2	---	---	1	---	---	---	---	---	---	---	---	---	---	1	---	---	---	2	brown
181	EU 49	0-10	¼	10	1	---	2	---	---	---	---	---	---	---	---	---	---	6	---	1	---	10	reds mostly and brown
183	EU 50	0-10	½	9	---	---	3	---	---	---	---	---	---	---	---	---	---	2	---	3	1	9	reds browns
183	EU 50	0-10	¼	11	---	---	3	---	1	---	---	---	---	---	---	---	---	5	---	2	---	11	reds gray brown
184	EU 51	0-10	½	3	---	---	2	---	---	---	---	---	---	---	---	---	---	1	---	---	---	3	browns and pinkish white
184	EU 51	0-10	¼	14	---	---	4	---	2	---	---	---	---	---	---	---	---	5	---	---	3	14	reds browns
185	EU 52	0-10	½	2	---	---	1	---	---	---	---	---	---	---	---	---	---	1	---	---	---	2	reddish brown
185	EU 52	0-10	¼	7	---	---	---	---	---	---	---	---	---	---	---	---	---	4	---	1	2	7	reds brown
186	EU 53	0-10	½	11	1	---	3	---	---	---	1	---	---	---	---	---	---	5	---	1	---	11	mottled red/brown, gray
186	EU 53	0-10	¼	8	---	---	3	---	---	---	---	---	---	---	---	---	---	3	---	---	2	8	reds and browns
187	EU 54	0-10	½	6	1	---	2	---	---	---	---	---	---	---	---	---	---	3	---	---	---	6	browns grayish and reddish
187	EU 54	0-10	¼	15	1	---	4	---	---	---	---	---	---	---	---	---	---	10	---	---	---	15	browns and reds
189	EU 55	0-10	½	2	---	---	---	---	---	---	---	---	---	---	---	---	---	1	1	---	---	2	brown and a red
189	EU 55	0-10	¼	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	reddish brown
190	EU 55	10-20	½	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	1	red in gray
190	EU 55	10-20	¼	6	---	---	2	---	---	---	---	---	---	---	---	---	---	3	---	---	1	6	reds and browns
191	EU 55	20-30	½	4	---	---	2	---	---	---	---	1	---	---	---	---	---	1	---	---	---	4	browns and gray, but lbt is dark red probably natural lust
191	EU 55	20-30	¼	2	---	---	1	---	---	---	---	---	---	---	---	---	---	---	1	---	---	2	dark gray and lustrous light brown
192	EU 55	30-40	¼	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	reddish brown
195	EU 17	Fea. 2B	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	chunky gray and brown
Total																						3508	

Appendix D: Artifact Analysis Tables for 24ME1109

Appendix Table B8. 24ME1109 Obsidian Debitage Data

CAT= Catalog; CNT=Count; CORT = cortical flake; CINT = complex interior flake; SINT = simple interior flake; LIN= Linear; SINT/CP = Simple Interior/Complex Platform; EP = Edge Preparation; EBT = Early Biface Thinning; LBT = Late Biface Thinning; EPR - Early Pressure; LPR = Late Pressure; PP = Platform Preparation/Pressure; SF = Simple Fragments; CF = Complex Fragments; CTF = Cortical Fragments; SH= Shatter; --- =no data or not applicable

Size grades represent the screen mesh size that will hold the debitage. Four size grades: 2 in., 1 in., ½ in., and ¼ in.

Cat	Unit	Depth	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
049	EU 16	10-20	¼	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	brownish relatively opaque with small phenocrysts looks brittle
062	EU 19	0-10	¼	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	brownish relatively opaque with small phenocrysts
080	EU 21	30-40	¼	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	brownish relatively opaque with small phenocrysts
083	EU 22	0-10	¼	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	brownish relatively opaque with small phenocrysts, medial linear blade
090	F4	N/A	¼	1	---	---	---	---	---	---	---	---	---	1	---	---	---		---	---	---	1	brownish relatively opaque with small phenocrysts
135	EU 36	0-10	¼	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	brownish relatively opaque with small phenocrysts looks brittle
193	---	Surface	¼	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	black relatively opaque but gray translucent on edge

Appendix D: Artifact Analysis Tables for 24ME1109

Appendix Table B9. 24ME1109 Quartzite Debitage Data

CAT= Catalog; CNT=Count; CORT = cortical flake; CINT = complex interior flake; SINT = simple interior flake; LIN= Linear; SINT/CP = Simple Interior/Complex Platform; EP = Edge Preparation; EBT = Early Biface Thinning; LBT = Late Biface Thinning; EPR - Early Pressure; LPR = Late Pressure; PP = Platform Preparation/Pressure; SF = Simple Fragments; CF = Complex Fragments; CTF = Cortical Fragments; SH= Shatter; --- =no data or not applicable

Size grades represent the screen mesh size that will hold the debitage. Four size grades: 2 in., 1 in., ½ in., and ¼ in.

Cat	Unit	Depth (cm)	Size	CNT	CORT	CINT	SINT	LIN	SINTCP	EP	EBT	LBT	EPR	LPR	NPR	BP	PP	SF	CF	CTF	SH	Total	Comments
024	EU 8	10-20	¼	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	white
039	EU 14	0-10	¼	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	white
054	EU 17	0-10	¼	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	white
071	EU 20	20-30	¼	1	---	---	---	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	white
073	EU 20	30-40	¼	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	white
093	EU 23	10-20	½	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	white
115	EU 30	0-10	¼	1	---	---	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	white
166	EU 44	0-10	¼	2	---	---	1	---	---	---	---	---	---	---	---	---	---	1	---	---	---	1	white

APPENDIX E
Knapping and Heat Treatment Studies Catalog

Black Butte Knapping and Heat Treatment Study Notes

By: William (Bill) Bloomer, M.A., RPA

Heat treatment batch #1 conducted on 11/16/20 for 14 hours to 550° (F). Kiln was turned off as soon as the desired 550° (F) temperature was attained. Cooled for 24 hours. Test reductions occurred on 11/18-22/20. Results recorded below with cobble reduction notes for individual cobbles.

11/03/2020
Cobbles 1, 2, 3 and 4 are blocky and angular.

Cobble 1
Fine grain dark yellowish brown, matte to low natural luster.
Hard rock. Internal flaws and planes. Difficult to remove even flakes.
Produced a unidirectional core and a few poorly shaped flakes for heat treatment.

HT: 550° turned outside red, as well as any internal vugs or planes where hot air could penetrate. Otherwise, interior increased luster with enhancing of yellowish brown. Compliance increased with removal of larger and more evenly fractured flakes.

Cobble 2
Moderately coarse grain yellowish brown, matte.
Hard with few internal flaws, so the flakes run further and evenly.
But the toolstone is not good quality.
Produced flakes for heat treatment. The multidirectional core is probably not a good heat treatment candidate.

HT: heat treated core and flakes. Brown turned red all the way through the core. Compliance increased because the material turned brittle and possibly turned moderately coarse grain to moderately fine grain but did not really increase toolstone quality. In fact, after one good flake removal from a previously unrecognized moderately fine grain area, the core split in two and failed.

Cobble 3
Many internal flaws causing primarily shatter.

Cobble 4
Banded moderately coarse grain yellowish brown and moderately coarse to fine grain light gray, matte. Hard. Internal flaws making it hard to remove good flakes. Not good toolstone. Produced a few flakes for heat treatment and a multidirectional core that may not be a good heat treatment candidate.

HT: heat treatment of core and flakes turned outside red, and also turned most interior yellowish brown to red. Banded gray did not turn color. Luster was not increased, nor was grain structure changed. Brittleness increased to allow easier removal of flakes, but I wouldn’t necessarily call in increased compliance. Overall still not good toolstone.

11/04/2020
Cobbles 5, 6, 7 and 8 are blocky and angular.

Cobble 5
Poor material. Produced only poor flake fragments, shatter and no good core.

Cobble 6
Looked fine grain and lustrous on the red and yellowish brown weathered cortex. Inside transitions from moderately coarse grain light yellowish brown to moderately coarse grain light gray to fine grain dark yellowish brown. All matte. Distinct banding in some areas, while mottled in others. Produced flakes for heat treatment. The unidirectional core is probably poor heat treatment material, especially at its distal end where the originally observed fine grain red and yellowish brown weathered cortex is actually internally flawed with vugs. Red toolstone is minimal, primarily on the cortical surface.

HT: heat treatment turned outside and most of interior red. Minimal grain or internal luster change. Only the small areas of yellowish brown finer grain interior material showed any luster increase. Minimal part of the rock. Flakes removed more easily, but still not good toolstone.

Cobble 7
Poor material. Produced only poor flake fragments, shatter and no good core.

Cobble 8
Primarily coarse grain light gray poor toolstone. Small pockets of fine grain pale yellowish brown toolstone. One cortical flake produced that is a heat treatment candidate. Core was split on flaws and poor material.
11/13/20

Cobble 9
Primarily fine grain dark yellowish brown with light gray mottling. Red cortex, weathered lustrous, removed to expose yellowish brown interior. Relatively tabular cobble, lending itself to bifacial reduction. Matte to natural moderately lustrous inside. Produced a stage 2 biface for heat treatment. Natural flaws and vugs limit reduction prior to heat treatment. A few good flakes produced for heat treatment.

HT: 550° turned the outside flake scars exposed during stage 2 reduction from yellowish brown to red. Heat treatment increased luster and improved compliance to percussion reduction using both hammerstone and elk antler billets. In fact, the hammerstone was too hard and exposed the brittle nature of the toolstone, probably increased brittleness after heat treatment. The elk antler was much more controlled at removing larger longer flakes. Late stage 2 reduction well under way when the biface broke in half on a vug; possibly initiated from end shock.

Cobble 10
Blocky, primarily moderate coarse grain light gray poor toolstone with a moderately coarse grain yellowish brown band. Cobble split and reduction failed.

11/14/2020

Cobble 11
Relatively tabular brown, fine grain lustrous weathered cortex, fine grain matte interior. Weathered and unconsolidated cortical layer removed producing a lot of small flakes, fragments and shatter to get to more homogenous interior and relatively good quality toolstone. Produced a stage 2 biface ready for heat treatment. Further reduction may have resulted in breakage before heat treatment improved compliance and chance for manufacture success. No good flakes for heat treatment.

HT: This stage 2 turned very brittle and percussion reduction with a hammerstone broke the toolstone into shatter. Outside very red and inside very lustrous brown.

Cobbles 12, 13 and 14
Yellowish brown angular, red thick tabular and blocky brown, respectively. Weathered cortex on cobble 13 looked fine grain and promising, but the other two didn’t look very siliceous. All three turned out to be non-siliceous and basically would not flake, but just broke apart on internal fracture planes and unconsolidated material.

Cobble 15
Small relatively tabular, brown and yellowish brown matte predominantly moderate grain (small fine grain pockets). Poor toolstone quality. Began a stage 2 biface that failed with a margin collapse on internal fracture and nonhomogeneous material quality. Cortex didn’t look like good toolstone. Stage 2 no good and there are no good flakes for heat treatment.

Cobble 16
Small tabular, red to brown to yellowish brown. Cortex weathered fine grain with luster, but interior is moderate grain, unconsolidated with internal plane material flaws. Poor material, no good flakes and not a good core.

Cobble 17
Hard blocky, predominantly light gray moderate to fine grain matte and relatively homogenous. Yellowish brown less siliceous fractured cortical layer on one face. Removed a few good flakes for heat treatment and the core might be a good candidate for heat treating a mass of toolstone.

HT: 550° turned moderate grain into fine grain with increased luster and enhanced the gray color creating a gray green tone. Brown turned red and red increased in vibrance. Compliance to percussion reduction was significantly increased. Pressure flaking: still hard material for pressure flaking. Light percussion with sandstone hammer and elk billet was better suited to bifacial flake removal, producing a small nicely shaped early stage 3 biface.

Boulder 18

Elongate angular heavy boulder. Mottled red and yellowish brown. Had potential, but coarse grain interior is poor toolstone. It is homogenous with few internal planes. So, several large flakes were removed and two will be heat treated. Yet, the toolstone quality is poor.

Boulder 19

Relatively square heavy boulder with few acceptable platforms. Brown and yellowish brown coarse grain matte poor toolstone. Two flakes removed for heat treatment.

HT: heat treated one flake. Turned red outside and inside. No luster, yet compliance increased enough to allow the manufacture of a stage 2 biface using percussion; elk billet, igneous hammerstone and sandstone hammerstone.

11/15/2020

Cobble 20

Angular, relatively tabular, Dark yellowish brown fine grain to moderately coarse grain. Cortex weathered lustrous and smooth. One end was better toolstone than the opposite end. Good flakes removed from fine grain portion of core. Multidirectional core and flakes available for heat treatment. Some interior flaws, vugs and fracture planes.

Cobble 21

Angular good looking lustrous and smooth red and yellowish brown cortex. Red and yellowish brown fine grain interior at one end and moderately coarse grain poor toolstone at other end. Poor toolstone end broke away during reduction. A few internal fracture planes in fine grain material. Multidirectional fine grain core end fragment retained with three flakes for heat treatment.

HT: heat treatment turned outside and interior red. Fine grain area was actually very small. Percussion reduction split the core in two on rough internal non-lustrous coarse grain, with no good flake removals.

Cobble 22

Blocky light gray, cortex looks moderately coarse grain, rough and probably poor quality. Interior is relatively homogenous moderately coarse grain with some fracture planes. Produced multidirectional core and a few flakes.

APPENDIX F
Obsidian X-Ray Florescence Report

X-Ray Fluorescence Analysis of Obsidian Artifacts from Sites 24-ME-163 and 24-ME-1109, Meagher County, Montana

Alex J. Nyers
Northwest Research Obsidian Studies Laboratory

Eleven obsidian artifacts from 24-ME-163 (n=4) and 24-ME-1109 (n=7), Meagher County, Montana, 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 2020-101.

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 2020a). 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 three known obsidian sources, Bear Gulch (N=5), Big Southern Butte (N=1), and Obsidian Cliff (N=4). One sample could not be correlated with any obsidian sources within the NWROSL source database. The locations of the sites 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. Analyzed artifacts are shown in Figure 3.

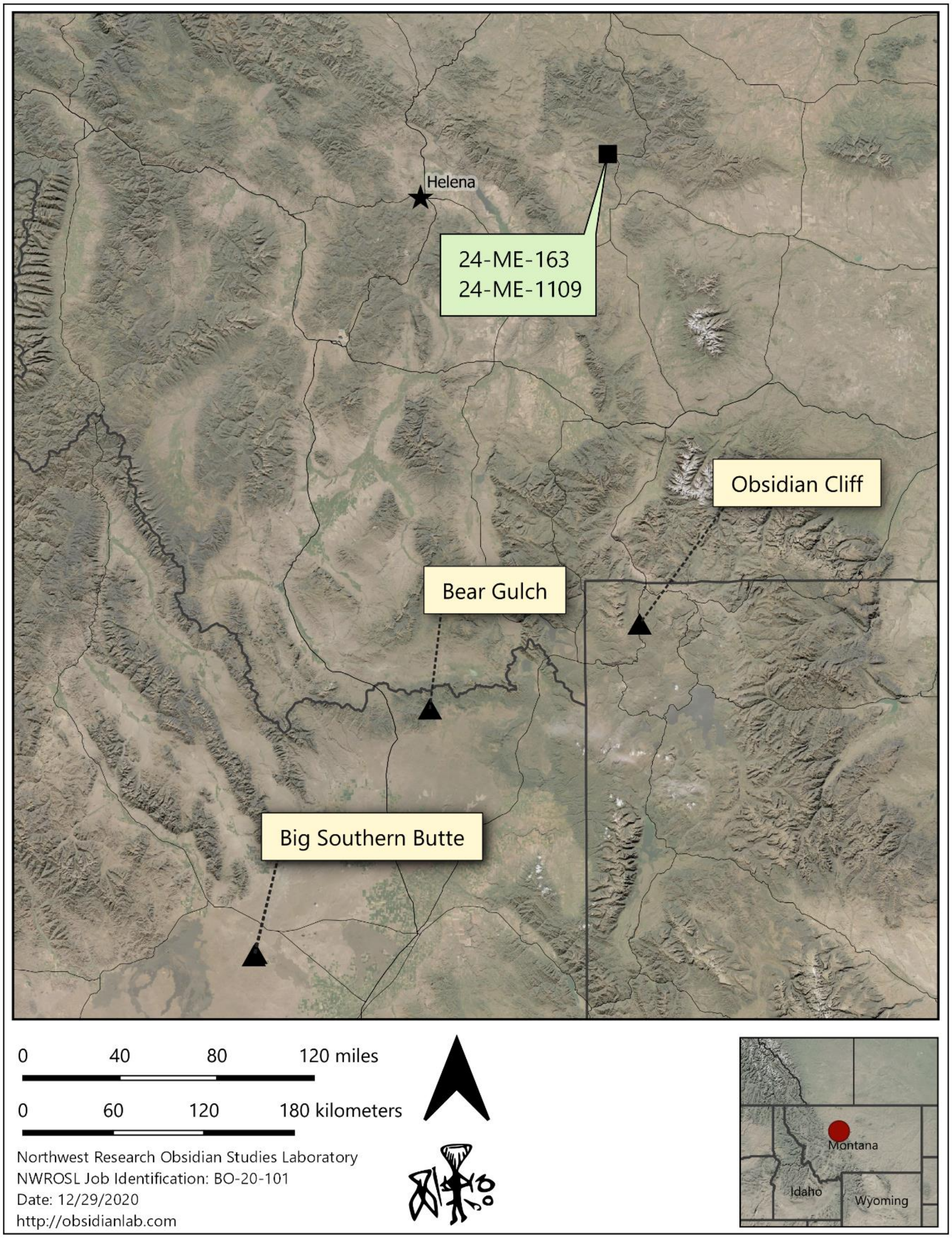


Figure 1 - Locations of the project site and sources of the obsidian artifacts. The black triangles in the map above designate the location of the identified sources.

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

	SITES ANALYZED MEAGHER COUNTY, MONTANA		
GEOCHEMICAL SOURCE	**24-ME-163**	**24-ME-1109**	**TOTAL**
Bear Gulch	-	5	5
Big Southern Butte	1	-	1
Obsidian Cliff	3	1	4
Unknown	-	1	1
TOTAL	**4**	**7**	**11**

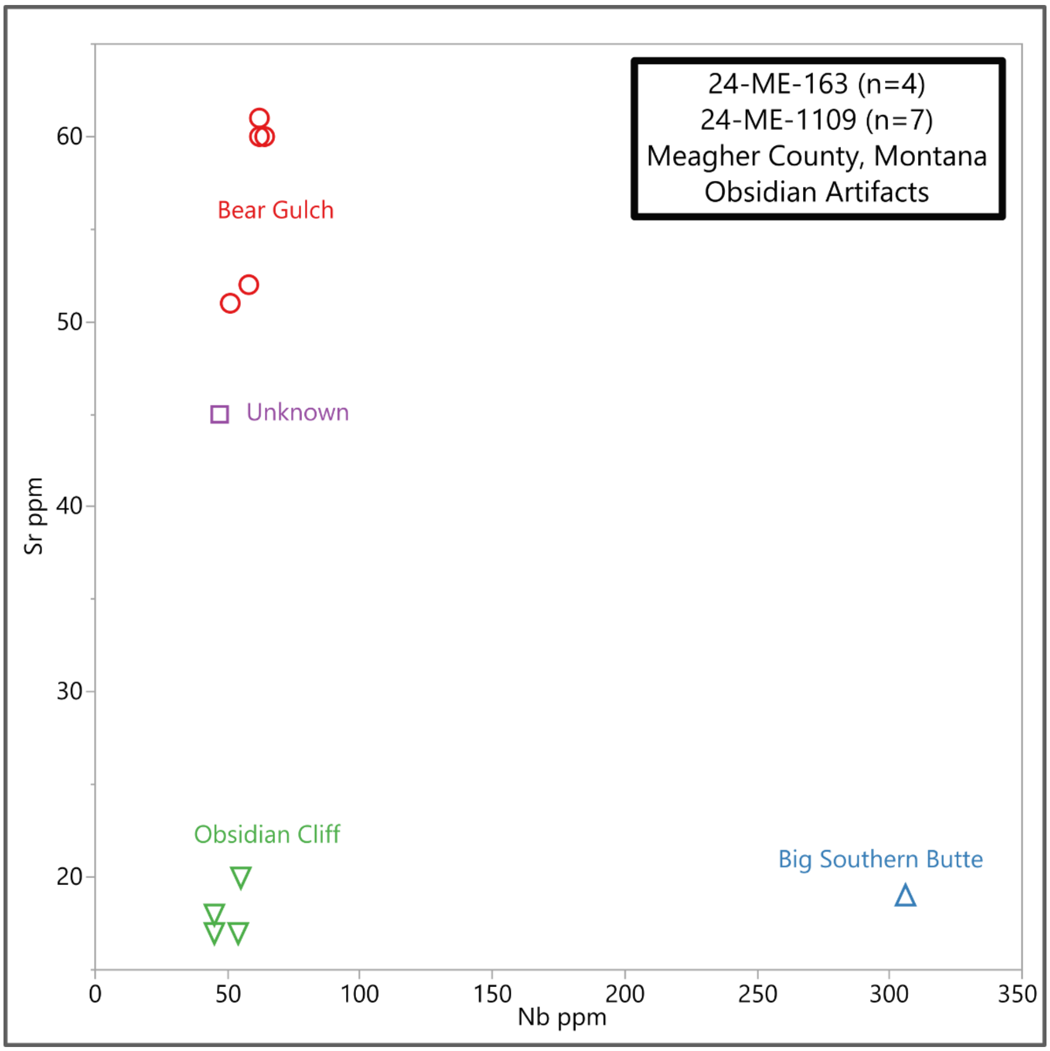


Figure 2 - Scatterplot of niobium (Nb) plotted versus strontium (Sr) for analyzed artifacts.

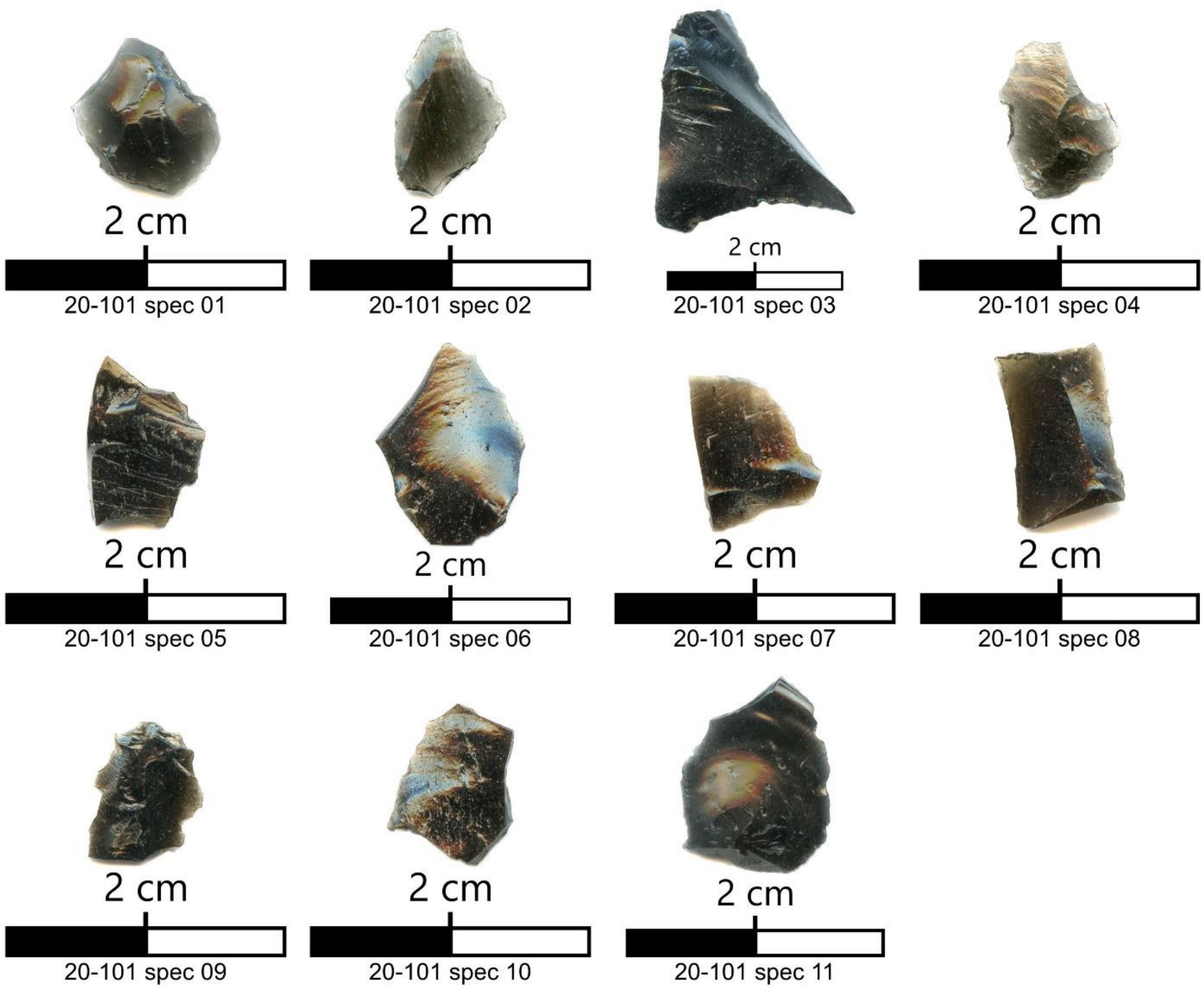


Figure 3 - Analyzed obsidian artifacts.

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 2020b).

References Cited

Northwest Research Obsidian Studies Laboratory
2020a Northwest Research Obsidian Studies Laboratory World Wide Web Site (www.obsidianlab.com).

2020b 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: Sites 24-ME-163 and 24-ME-1109, Meagher County, Montana

			Trace Element Concentrations						
Site	Specimen No.	Catalog No.	Rb	Sr	Y	Zr	Nb	Ba	Geochemical Source
24-ME-163	1	31	346	19	246	370	306	NM	Big Southern Butte *
			± 5	2	4	4	4	NM	
24-ME-163	2	42	171	17	77	199	53	NM	Obsidian Cliff *
			± 3	2	3	4	3	NM	
24-ME-163	3	49	165	16	64	186	49	ND	Obsidian Cliff?
			± 3	2	2	4	3	ND	
24-ME-163	4	49	292	20	80	192	55	NM	Obsidian Cliff *
			± 4	2	3	4	3	NM	
24-ME-1109	5	49	179	61	49	342	62	NM	Bear Gulch *
			± 4	3	2	4	3	NM	
24-ME-1109	6	62	199	60	51	333	64	617	Bear Gulch
			± 5	3	2	4	3	59	
24-ME-1109	7	80	82	51	46	289	51	NM	Bear Gulch? *
			± 2	3	2	4	3	NM	
24-ME-1109	8	83	144	52	49	313	58	NM	Bear Gulch? *
			± 3	3	2	4	3	NM	
24-ME-1109	9	90	129	60	49	320	62	NM	Bear Gulch? *
			± 3	3	2	4	3	NM	
24-ME-1109	10	135	51	45	36	246	47	NM	Unknown obsidian *
			± 1	3	2	4	3	NM	
24-ME-1109	11	193	290	17	74	198	54	ND	Obsidian Cliff
			± 1	3	2	4	3	ND	
NA	RGM-1	RGM-1	150	105	28	228	12	881	RGM-1 Reference Standard
			± 4	3	2	4	3	48	

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

APPENDIX G
Obsidian Hydration Analysis Report

Obsidian Hydration Analysis of Artifacts from Sites 24-ME-163 and 24-ME-1109, Meagher County, Montana

Jennifer J. Thatcher
Willamette Analytics Report 2020-101
Prepared for Jessica Neal,
Kleinfelder, Inc.,
Auburn, California,
January 15, 2021

Willamette Analytics, LLC
1141 SW Sunset Drive
Corvallis, OR 97333
www.willanalytics.com

Willamette Analytics Report 2020-101

Obsidian Hydration Analysis of Artifacts from Sites 24-ME-163 and 24-ME-1109, Meagher County, Montana

Jennifer J. Thatcher
Willamette Analytics, LLC

Introduction

Eleven obsidian artifacts from sites 24-ME-163 (n=4) and 24-ME-1109 (n=7), Meagher County, Montana, were submitted for obsidian hydration analysis. The samples were prepared and analyzed at Willamette Analytics, LLC in Corvallis, Oregon, under the accession number 2020-101.

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 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, Stevenson et al. 2019), and there is no assurance that artifacts recovered from similar provenances or locales have shared thermal and cultural histories.

Results

The 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 2021). The results of that study are summarized in Table 1, and are presented in Table A-1 in the Appendix. The locations of the sites and the obsidian sources are shown in Figure 1.

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

OBSIDIAN SOURCE	**HYDRATION RIM MEASUREMENTS (MICRONS)***		**TOTAL**
	24-ME-163	**24-ME-1109**	
Bear Gulch	--	2.2, 2.5, 2.7, 2.8 3.1	**5**
Big Southern Butte	5.8	--	**1**
Obsidian Cliff	4.5 5.3, 5.9	***3.5*** 4.3	**5**
Unknown	--	2.3	**1**
TOTAL	**4**	**8**	**12**

* Bold italics indicate a second (multiple) rim on an artifact.

Hydration rims were successfully identified and measured on all 11 of the artifacts that were submitted for hydration analysis. Multiple hydration rims (more than one hydration rim with distinctly different rim widths) were identified on one of the artifacts, suggesting possible recycling or reuse behaviors, or post-depositional damage.

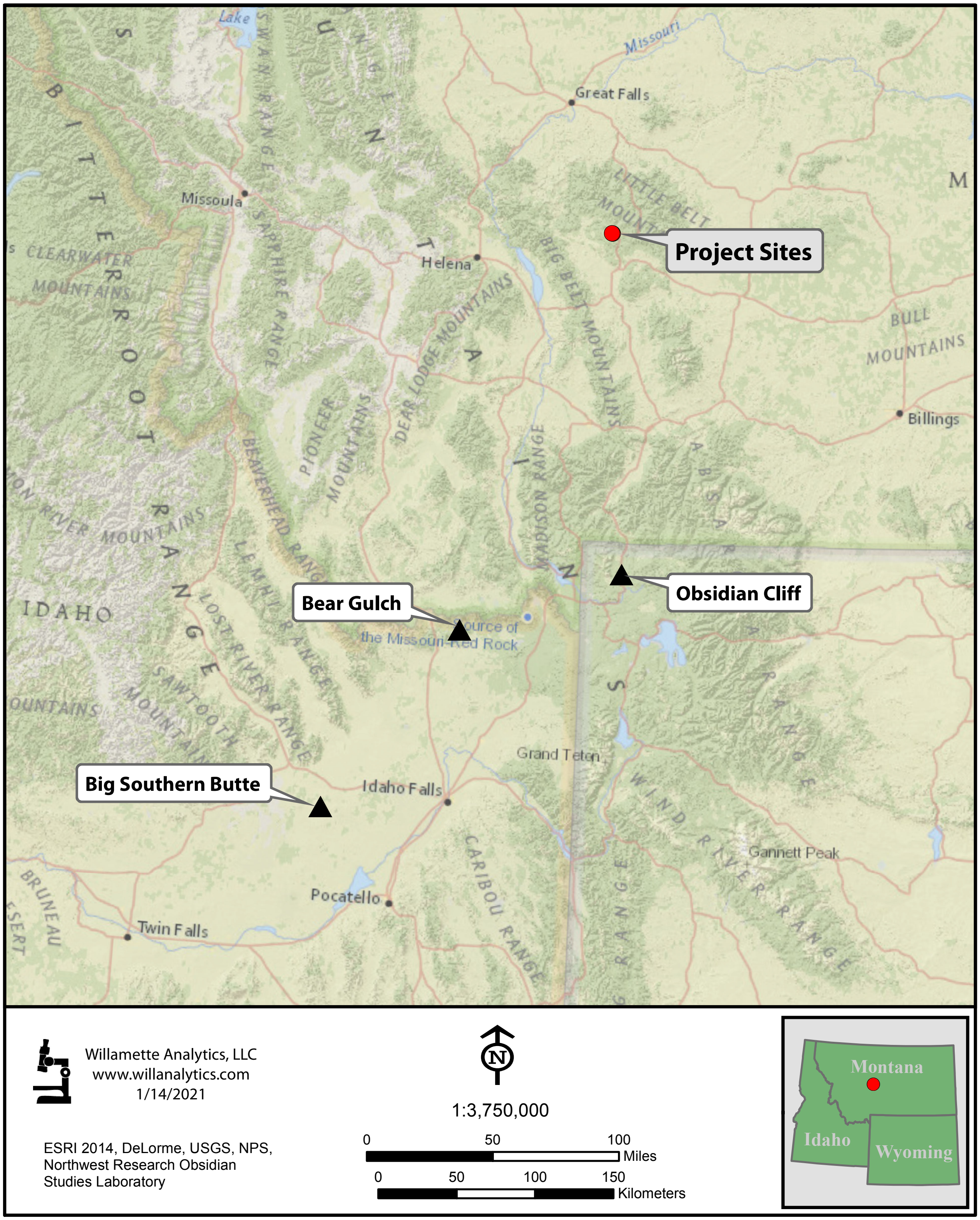


Figure 1. Location of the project sites and the obsidian sources identified in the current study.

References Cited

Anovitz, Lawrence M., J. Michael Elam, Lee R. Riciputi, and David R. Cole
1999 The Failure of Obsidian Hydration Dating: Sources, Implications, and New Directions. *Journal of Archaeological Science* 26:735-752.

Liritzis, Ioannis and Nikolaos Laskaris
2011 Fifty Years of Obsidian Hydration Dating in Archaeology. *Journal of Non-Crystalline Solids* 357:2011-2023.

Liritzis, Ioannis
2015 Obsidian Hydration Dating. In *Encyclopedia of Scientific Dating Methods,* edited by W. Jack Rink and Jeroen W. Thompson, pp. 609-623. Encyclopedia of Earth Science Series. Springer Dordrecht, New York.

Meighan, Clement W.
1981 Progress and Prospects in Obsidian Hydration Dating. In *Obsidian Dates III*, edited by Clement W. Meighan and Glenn S. Russell, pp. 1-9. University of California Institute of Archaeology Monograph No. 6, Los Angeles, California.

Meighan, Clement W.
1983 Obsidian Dating in California. *American Antiquity* 48:600-609.

Nyers, Alex J.
2021 *X-Ray Fluorescence Analysis of Obsidian Artifacts from Sites 24-ME-163 and 24-ME-1109, Meagher County, Montana.* Report 2020-101 prepared for Kleinfelder Inc., Auburn, California, by Northwest Research Obsidian Studies Laboratory, Corvallis, Oregon.

Rogers, Alexander K.
2008 Obsidian Hydration Dating: Accuracy and Resolution Limitations Imposed by Intrinsic Water Variability. *Journal of Archaeological Science* 35:2009-2016.

Rogers, Alexander K.
2010 Accuracy of Obsidian Hydration Dating based on Radiocarbon Association and Optical Microscopy. *Journal of Archaeological Science* 37:3239-3246.

Skinner, Craig E.
1995 Obsidian Hydration Studies. *In Archaeological Investigations, PGT-PG&E Pipeline Expansion Project, Idaho, Washington, Oregon, and California, Volume V: Technical Studies*, by Robert U. Bryson, Craig E. Skinner, and Richard M. Pettigrew, pp. 5.1-5.51. Report prepared for Pacific Gas Transmission Company, Portland, Oregon, by INFOTEC Research, Inc., Fresno, California, and Far Western Anthropological Research Group, Davis, California.

Stevenson, Christopher M., Alexander K. Rogers, Michael D. Glascock
2019 Variability in Obsidian Structural Water Content and its Importance in the Hydration Dating of Cultural Artifacts. *Journal of Archaeological Science* 23:231-242.

Appendix

Results of Obsidian Hydration Analysis

Willamette Analytics, LLC

Table A-1. Obsidian Hydration Results and Sample Provenience: Artifacts from Meagher County, Montana

Site	Specimen No.	Catalog No.	Unit	Depth (cm)	Artifact Type [A]	Artifact Source [B]	Hydration Rims: Rim 1	Hydration Rims: Rim 2	Comments [C]
24-ME-163	1	31	EU 3	30-40	DEB	Big Southern Butte *	5.8 ± 0.1	NM ± NM	--
24-ME-163	2	42	EU 4	30-40	DEB	Obsidian Cliff *	5.9 ± 0.1	NM ± NM	--
24-ME-163	3	49a	EU 5	10-20	DEB	Obsidian Cliff?	4.5 ± 0.1	NM ± NM	--
24-ME-163	4	49b	EU 5	10-20	DEB	Obsidian Cliff *	5.3 ± 0.0	NM ± NM	--
24-ME-1109	5	49	EU 16	10-20	DEB	Bear Gulch *	2.8 ± 0.1	NM ± NM	--
24-ME-1109	6	62	EU 19	0-10	DEB	Bear Gulch	3.1 ± 0.1	NM ± NM	--
24-ME-1109	7	80	EU 21	30-40	DEB	Bear Gulch? *	2.2 ± 0.1	NM ± NM	--
24-ME-1109	8	83	EU 22	0-10	DEB	Bear Gulch? *	2.7 ± 0.1	NM ± NM	--
24-ME-1109	9	90	EU 19/EU 20	49-60	DEB	Bear Gulch? *	2.5 ± 0.1	NM ± NM	--
24-ME-1109	10	135	EU 36	0-10	DEB	Unknown obsidian *	2.3 ± 0.1	NM ± NM	--
24-ME-1109	11	193	Surface Find	Surface	DEB	Obsidian Cliff	3.5 ± 0.0	4.3 ± 0.1	Smaller rim on BRE

[A] DEB = Debitage
[B] Obsidian Source Data: Northwest Research Obsidian Studies Laboratory
[C] See text for explanation of comment abbreviations
NA = Not Available; NM = Not Measured

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 opaque 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.

APPENDIX H
Radiocarbon Dating Report

Beta Analytic TESTING LABORATORY

Beta Analytic, Inc.
4985 SW 74th Court
Miami, FL 33155 USA
Tel: 305-667-5167
Fax: 305-663-0964
info@betalabservices.com

ISO/IEC 17025:2017-Accredited Testing Laboratory

November 30, 2020

Ms. Jessica Neal
Garcia and Associates
2616 14TH ST
SACRAMENTO, CA 95818
United States

RE: Radiocarbon Dating Results

Dear Ms. Neal,

Enclosed are the radiocarbon dating results for 17 samples recently sent to us. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable. The Conventional Radiocarbon Ages have all been corrected for total fractionation effects and where applicable, calibration was performed using 2013 calibration databases (cited on the graph pages).

The web directory containing the table of results and PDF download also contains pictures, a cvs spreadsheet download option and a quality assurance report containing expected vs. measured values for 3-5 working standards analyzed simultaneously with your samples.

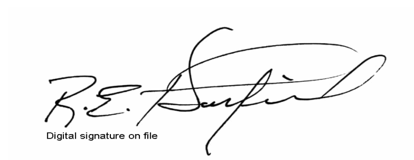
Reported results are accredited to ISO/IEC 17025:2017 Testing Accreditation PJLA #59423 standards and all chemistry was performed here in our laboratory and counted in our own accelerators here. Since Beta is not a teaching laboratory, only graduates trained to strict protocols of the ISO/IEC 17025:2017 Testing Accreditation PJLA #59423 program participated in the analyses.

As always Conventional Radiocarbon Ages and sigmas are rounded to the nearest 10 years per the conventions of the 1977 International Radiocarbon Conference. When counting statistics produce sigmas lower than +/- 30 years, a conservative +/- 30 BP is cited for the result unless otherwise requested. The reported d13C values were measured separately in an IRMS (isotope ratio mass spectrometer). They are NOT the AMS d13C which would include fractionation effects from natural, chemistry and AMS induced sources.

When interpreting the results, please consider any communications you may have had with us regarding the samples.

Thank you for prepaying the analyses. As always, if you have any questions or would like to discuss the results, don’t hesitate to contact us.

Sincerely,



Ronald E. Hatfield President

Beta Analytic, Inc.
4985 SW 74th Court
Miami, FL 33155 USA
Tel: 305-667-5167
Fax: 305-663-0964
info@betalabservices.com

ISO/IEC 17025:2017-Accredited Testing Laboratory

REPORT OF RADIOCARBON DATING ANALYSES

Jessica Neal	Report Date: November 30, 2020
Garcia and Associates	Material Received: November 13, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes	
Beta - 574725	**015**	**2220 +/- 30 BP**	IRMS δ13C: -22.3 o/oo

(95.4%) **375 - 203 cal BC** **(2324 - 2152 cal BP)**

Submitter Material:	Charcoal
Pretreatment:	(charred material) acid/alkali/acid
Analyzed Material:	Charred material
Analysis Service:	AMS-Standard delivery
Percent Modern Carbon:	75.85 +/- 0.28 pMC
Fraction Modern Carbon:	0.7585 +/- 0.0028
D14C:	-241.46 +/- 2.83 o/oo
Δ14C:	-247.86 +/- 2.83 o/oo (1950:2020)
Measured Radiocarbon Age:	(without d13C correction): 2180 +/- 30 BP
Calibration:	BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2017 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

Beta Analytic, Inc.
4985 SW 74th Court
Miami, FL 33155 USA
Tel: 305-667-5167
Fax: 305-663-0964
info@betalabservices.com

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Beta - 574726	**017**	**2280 +/- 30 BP**	IRMS δ13C: -22.0 o/oo

(60.0%)	**403 - 352 cal BC**	**(2352 - 2301 cal BP)**
(33.6%)	**297 - 228 cal BC**	**(2246 - 2177 cal BP)**
(1.8%)	**221 - 211 cal BC**	**(2170 - 2160 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 75.29 +/- 0.28 pMC
Fraction Modern Carbon: 0.7529 +/- 0.0028
D14C: -247.11 +/- 2.81 o/oo
Δ14C: -253.45 +/- 2.81 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 2230 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2017 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Beta - 574727	**027**	**2220 +/- 30 BP**	IRMS δ13C: -21.9 o/oo

(95.4%) **375 - 203 cal BC** **(2324 - 2152 cal BP)**

Submitter Material:	Charcoal
Pretreatment:	(charred material) acid/alkali/acid
Analyzed Material:	Charred material
Analysis Service:	AMS-Standard delivery
Percent Modern Carbon:	75.85 +/- 0.28 pMC
Fraction Modern Carbon:	0.7585 +/- 0.0028
D14C:	-241.46 +/- 2.83 o/oo
Δ14C:	-247.86 +/- 2.83 o/oo (1950:2020)
Measured Radiocarbon Age:	(without d13C correction): 2170 +/- 30 BP
Calibration:	BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2017 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes	
Beta - 574728	**029**	**2190 +/- 30 BP**	IRMS δ13C: -22.0 o/oo

(95.4%) **361 - 177 cal BC** **(2310 - 2126 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 76.14 +/- 0.28 pMC
Fraction Modern Carbon: 0.7614 +/- 0.0028
D14C: -238.62 +/- 2.84 o/oo
Δ14C: -245.04 +/- 2.84 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 2140 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2017 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Beta - 574729	**026**	**2290 +/- 30 BP**	IRMS δ13C: -21.3 o/oo

(70.8%)	**405 - 353 cal BC**	**(2354 - 2302 cal BP)**
(24.6%)	**292 - 231 cal BC**	**(2241 - 2180 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 75.20 +/- 0.28 pMC
Fraction Modern Carbon: 0.7520 +/- 0.0028
D14C: -248.04 +/- 2.81 o/oo
Δ14C: -254.38 +/- 2.81 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 2230 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2017 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes	
Beta - 574730	**033**	**2200 +/- 30 BP**	IRMS δ13C: -24.7 o/oo

(95.4%) **366 - 186 cal BC** **(2315 - 2135 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 76.04 +/- 0.28 pMC
Fraction Modern Carbon: 0.7604 +/- 0.0028
D14C: -239.57 +/- 2.84 o/oo
Δ14C: -245.98 +/- 2.84 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 2190 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2017 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Beta - 574731	**023**	**1320 +/- 30 BP**	IRMS δ13C: -21.2 o/oo

(72.9%)	**652 - 722 cal AD**	**(1298 - 1228 cal BP)**
(22.5%)	**740 - 768 cal AD**	**(1210 - 1182 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 84.85 +/- 0.32 pMC
Fraction Modern Carbon: 0.8485 +/- 0.0032
D14C: -151.53 +/- 3.17 o/oo
Δ14C: -158.69 +/- 3.17 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 1260 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2017 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Beta - 574732	**037**	**2490 +/- 30 BP**	IRMS δ13C: -22.0 o/oo

(95.4%) **781 - 510 cal BC** **(2730 - 2459 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 73.35 +/- 0.27 pMC
Fraction Modern Carbon: 0.7335 +/- 0.0027
D14C: -266.53 +/- 2.74 o/oo
Δ14C: -272.72 +/- 2.74 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 2440 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2017 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Beta - 574733	**039**	**2510 +/- 30 BP**	IRMS δ13C: -22.7 o/oo

(67.7%)	**696 - 540 cal BC**	**(2645 - 2489 cal BP)**
(27.7%)	**791 - 701 cal BC**	**(2740 - 2650 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 73.16 +/- 0.27 pMC
Fraction Modern Carbon: 0.7316 +/- 0.0027
D14C: -268.36 +/- 2.73 o/oo
Δ14C: -274.53 +/- 2.73 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 2470 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

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Beta - 574734	**041**	**3540 +/- 30 BP**	IRMS δ13C: -23.5 o/oo

(95.4%) **1954 - 1767 cal BC** **(3903 - 3716 cal BP)**

Submitter Material:	Charcoal
Pretreatment:	(charred material) acid/alkali/acid
Analyzed Material:	Charred material
Analysis Service:	AMS-Standard delivery
Percent Modern Carbon:	64.36 +/- 0.24 pMC
Fraction Modern Carbon:	0.6436 +/- 0.0024
D14C:	-356.41 +/- 2.40 o/oo
Δ14C:	-361.83 +/- 2.40 o/oo (1950:2020)
Measured Radiocarbon Age:	(without d13C correction): 3520 +/- 30 BP
Calibration:	BetaCal3.21: HPD method: INTCAL13

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Beta - 574735	**043**	**4900 +/- 30 BP**	IRMS δ13C: -21.8 o/oo

(92.4%)	**3715 - 3638 cal BC**	**(5664 - 5587 cal BP)**
(3.0%)	**3761 - 3742 cal BC**	**(5710 - 5691 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 54.34 +/- 0.20 pMC
Fraction Modern Carbon: 0.5434 +/- 0.0020
D14C: -456.64 +/- 2.03 o/oo
Δ14C: -461.22 +/- 2.03 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 4850 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

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Beta - 574736	**044**	**2420 +/- 30 BP**	IRMS δ13C: -24.8 o/oo

(74.9%)	**556 - 402 cal BC**	**(2505 - 2351 cal BP)**
(15.5%)	**748 - 685 cal BC**	**(2697 - 2634 cal BP)**
(4.6%)	**666 - 642 cal BC**	**(2615 - 2591 cal BP)**
(0.4%)	**587 - 581 cal BC**	**(2536 - 2530 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 73.99 +/- 0.28 pMC
Fraction Modern Carbon: 0.7399 +/- 0.0028
D14C: -260.11 +/- 2.76 o/oo
Δ14C: -266.35 +/- 2.76 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 2420 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

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Beta - 574737	**046**	**3210 +/- 30 BP**	IRMS δ13C: -22.5 o/oo

(94.6%)	**1532 - 1418 cal BC**	**(3481 - 3367 cal BP)**
(0.8%)	**1595 - 1589 cal BC**	**(3544 - 3538 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 67.06 +/- 0.25 pMC
Fraction Modern Carbon: 0.6706 +/- 0.0025
D14C: -329.42 +/- 2.50 o/oo
Δ14C: -335.07 +/- 2.50 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 3170 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2017 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

Beta Analytic, Inc.
4985 SW 74th Court
Miami, FL 33155 USA
Tel: 305-667-5167
Fax: 305-663-0964
info@betalabservices.com

ISO/IEC 17025:2017-Accredited Testing Laboratory

REPORT OF RADIOCARBON DATING ANALYSES

Jessica Neal

Garcia and Associates

Report Date: November 30, 2020

Material Received: November 13, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes	
Beta - 574738	**002**	**900 +/- 30 BP**	IRMS δ13C: -26.2 o/oo

(95.4%) **1039 - 1210 cal AD** **(911 - 740 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 89.40 +/- 0.33 pMC
Fraction Modern Carbon: 0.8940 +/- 0.0033
D14C: -105.99 +/- 3.34 o/oo
Δ14C: -113.53 +/- 3.34 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 920 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2017 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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REPORT OF RADIOCARBON DATING ANALYSES

Jessica Neal

Garcia and Associates

Report Date: November 30, 2020

Material Received: November 13, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes	
Beta - 574739	**004**	**930 +/- 30 BP**	IRMS δ13C: -24.3 o/oo

(95.4%) **1025 - 1165 cal AD** **(925 - 785 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 89.07 +/- 0.33 pMC
Fraction Modern Carbon: 0.8907 +/- 0.0033
D14C: -109.32 +/- 3.33 o/oo
Δ14C: -116.83 +/- 3.33 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 920 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2017 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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REPORT OF RADIOCARBON DATING ANALYSES

Jessica Neal		Report Date:	November 30, 2020
Garcia and Associates		Material Received:	November 13, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes	
Beta - 574740	**006**	**950 +/- 30 BP**	IRMS δ13C: -26.1 o/oo

(95.4%) **1024 - 1155 cal AD** **(926 - 795 cal BP)**

Submitter Material:	Charcoal
Pretreatment:	(charred material) acid/alkali/acid
Analyzed Material:	Charred material
Analysis Service:	AMS-Standard delivery
Percent Modern Carbon:	88.85 +/- 0.33 pMC
Fraction Modern Carbon:	0.8885 +/- 0.0033
D14C:	-111.54 +/- 3.32 o/oo
Δ14C:	-119.03 +/- 3.32 o/oo (1950:2020)
Measured Radiocarbon Age:	(without d13C correction): 970 +/- 30 BP
Calibration:	BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2017 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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REPORT OF RADIOCARBON DATING ANALYSES

Jessica Neal	Report Date: November 30, 2020
Garcia and Associates	Material Received: November 13, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes	
Beta - 574741	**008**	**900 +/- 30 BP**	IRMS δ13C: -21.1 o/oo

(95.4%) **1039 - 1210 cal AD** **(911 - 740 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 89.40 +/- 0.33 pMC
Fraction Modern Carbon: 0.8940 +/- 0.0033
D14C: -105.99 +/- 3.34 o/oo
Δ14C: -113.53 +/- 3.34 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 840 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2017 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -22.3 o/oo)

Laboratory number **Beta-574725**

Conventional radiocarbon age **2220 ± 30 BP**

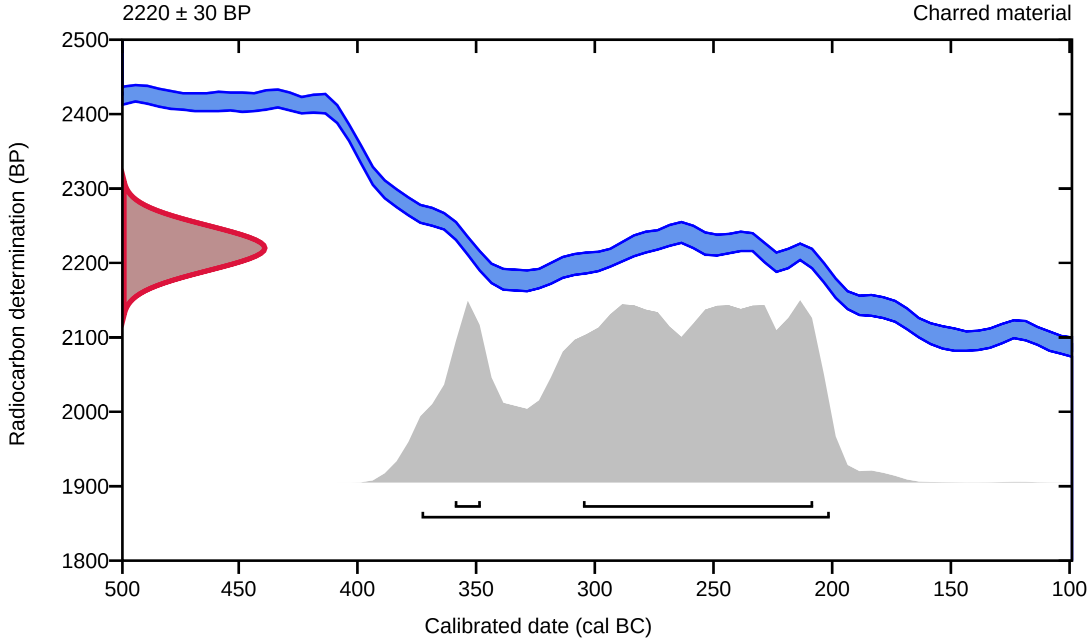
95.4% probability

(95.4%)	375 - 203 cal BC	(2324 - 2152 cal BP)

68.2% probability

(61.6%)	307 - 210 cal BC	(2256 - 2159 cal BP)
(6.6%)	361 - 350 cal BC	(2310 - 2299 cal BP)

015



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -22.0 o/oo)

Laboratory number **Beta-574726**

Conventional radiocarbon age **2280 ± 30 BP**

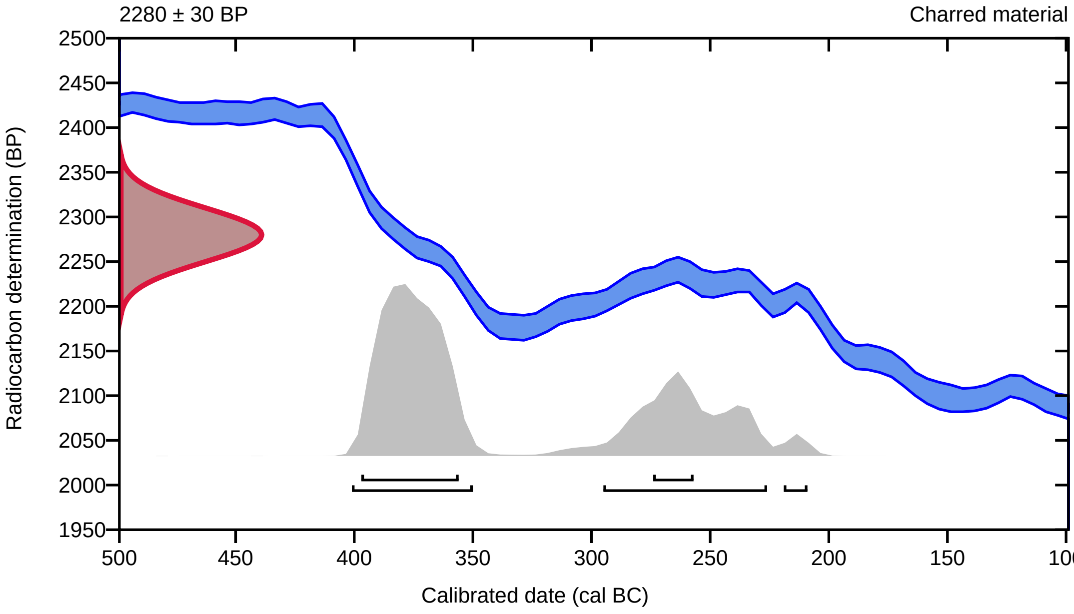
95.4% probability

(60%)	403 - 352 cal BC	(2352 - 2301 cal BP)
(33.6%)	297 - 228 cal BC	(2246 - 2177 cal BP)
(1.8%)	221 - 211 cal BC	(2170 - 2160 cal BP)

68.2% probability

(56%)	399 - 358 cal BC	(2348 - 2307 cal BP)
(12.2%)	276 - 259 cal BC	(2225 - 2208 cal BP)

017



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -21.9 o/oo)

Laboratory number **Beta-574727**

Conventional radiocarbon age **2220 ± 30 BP**

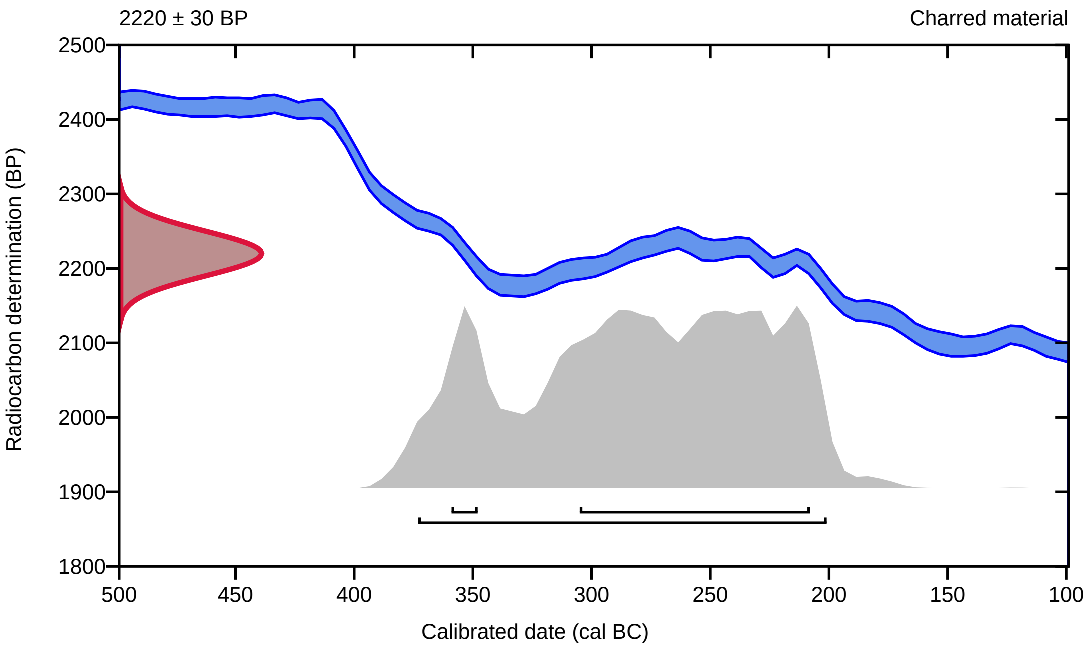
95.4% probability

(95.4%)	375 - 203 cal BC	(2324 - 2152 cal BP)

68.2% probability

(61.6%)	307 - 210 cal BC	(2256 - 2159 cal BP)
(6.6%)	361 - 350 cal BC	(2310 - 2299 cal BP)

027



Database used
INTCAL13

References
References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -22.0 o/oo)

Laboratory number **Beta-574728**

Conventional radiocarbon age **2190 ± 30 BP**

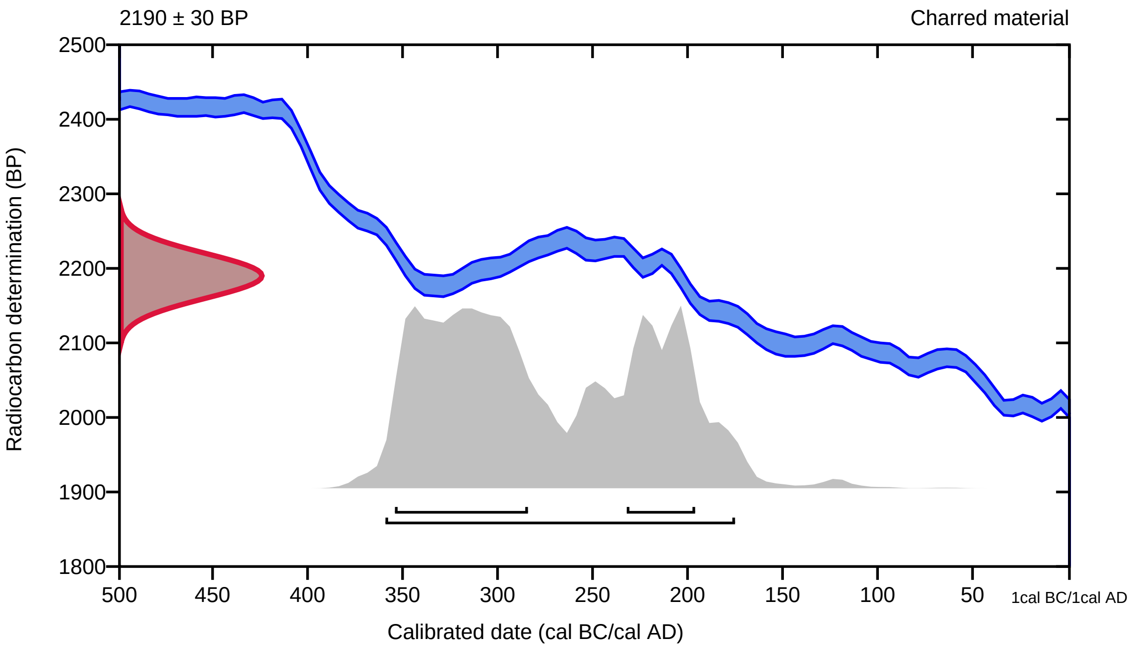
95.4% probability

(95.4%) 361 - 177 cal BC (2310 - 2126 cal BP)

68.2% probability

(46.1%) 356 - 286 cal BC (2305 - 2235 cal BP)
(22.1%) 234 - 198 cal BC (2183 - 2147 cal BP)

029



Database used
INTCAL13

References
References to Probability Method
Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.
References to Database INTCAL13
Reimer, et.al., 2013, Radiocarbon55(4).

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -21.3 o/oo)

Laboratory number **Beta-574729**

Conventional radiocarbon age **2290 ± 30 BP**

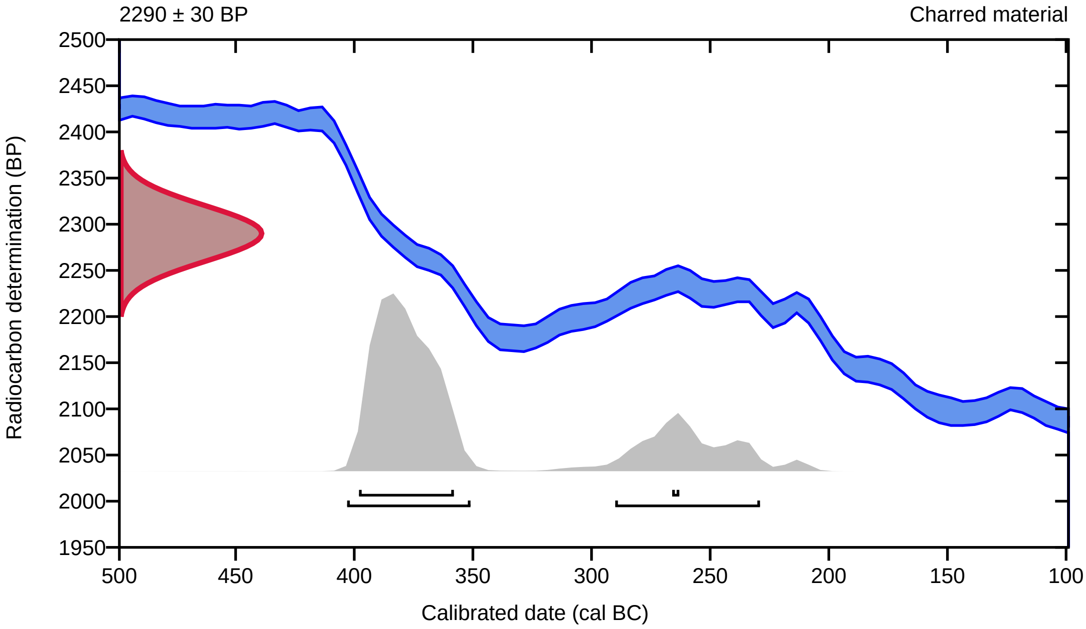
95.4% probability

(70.8%)	405 - 353 cal BC	(2354 - 2302 cal BP)
(24.6%)	292 - 231 cal BC	(2241 - 2180 cal BP)

68.2% probability

(65.7%)	400 - 360 cal BC	(2349 - 2309 cal BP)
(2.5%)	268 - 265 cal BC	(2217 - 2214 cal BP)

026



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -24.7 o/oo)

Laboratory number **Beta-574730**

Conventional radiocarbon age **2200 ± 30 BP**

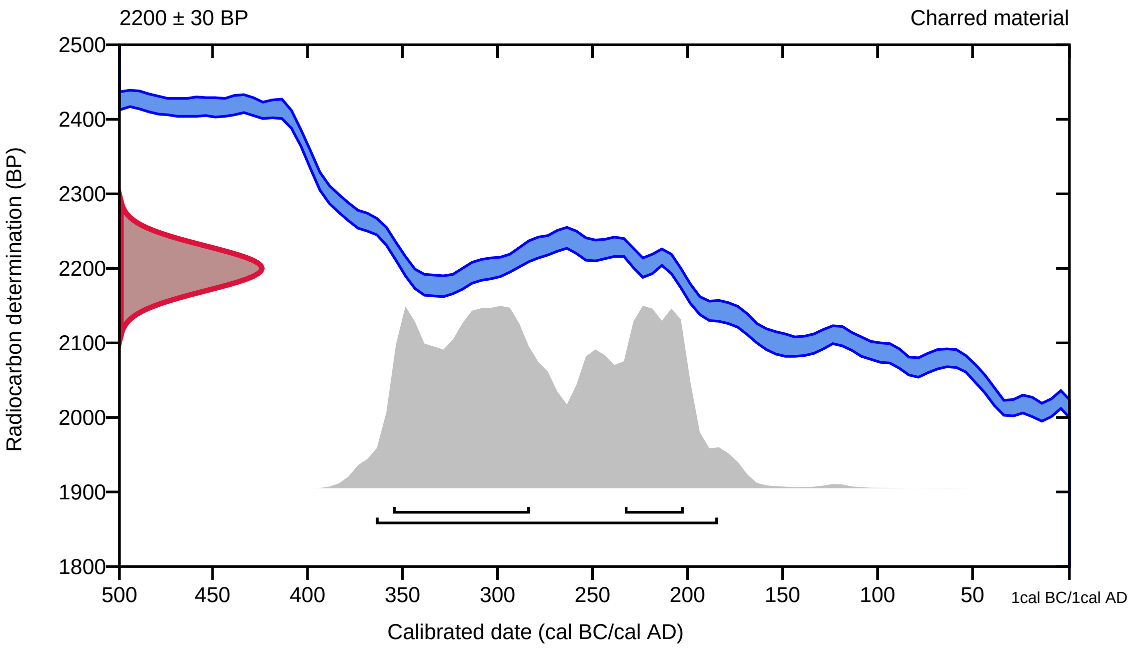
95.4% probability

(95.4%)	366 - 186 cal BC	(2315 - 2135 cal BP)

68.2% probability

(46.9%)	357 - 285 cal BC	(2306 - 2234 cal BP)
(21.3%)	235 - 204 cal BC	(2184 - 2153 cal BP)

033



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -21.2 o/oo)

Laboratory number **Beta-574731**

Conventional radiocarbon age **1320 ± 30 BP**

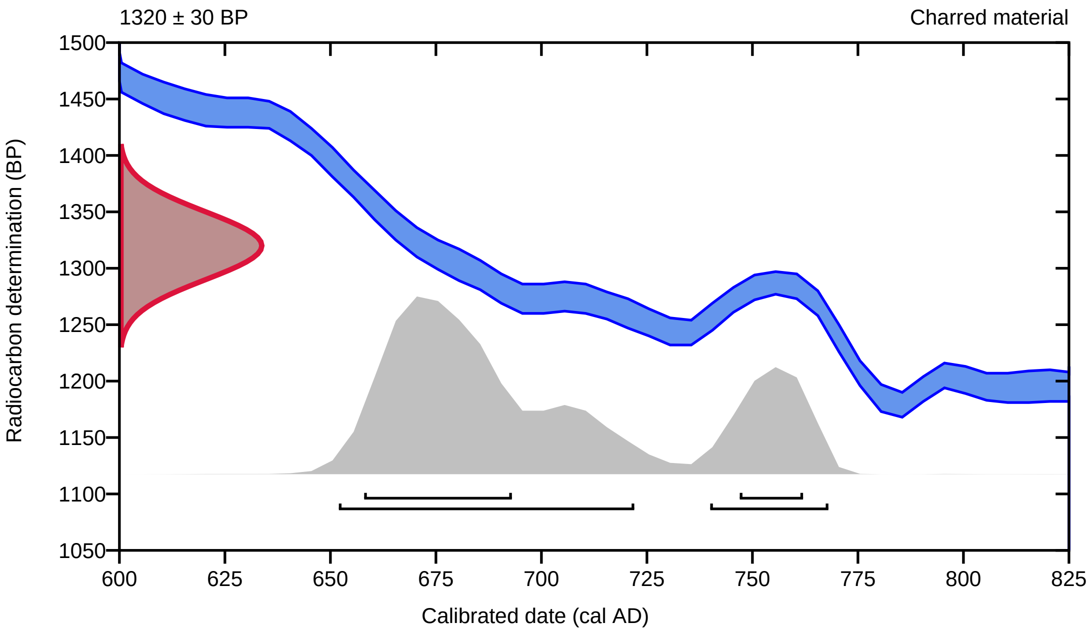
95.4% probability

(72.9%)	652 - 722 cal AD	(1298 - 1228 cal BP)
(22.5%)	740 - 768 cal AD	(1210 - 1182 cal BP)

68.2% probability

(52.3%)	658 - 693 cal AD	(1292 - 1257 cal BP)
(15.9%)	747 - 762 cal AD	(1203 - 1188 cal BP)

023



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -22.0 o/oo)

Laboratory number **Beta-574732**

Conventional radiocarbon age **2490 ± 30 BP**

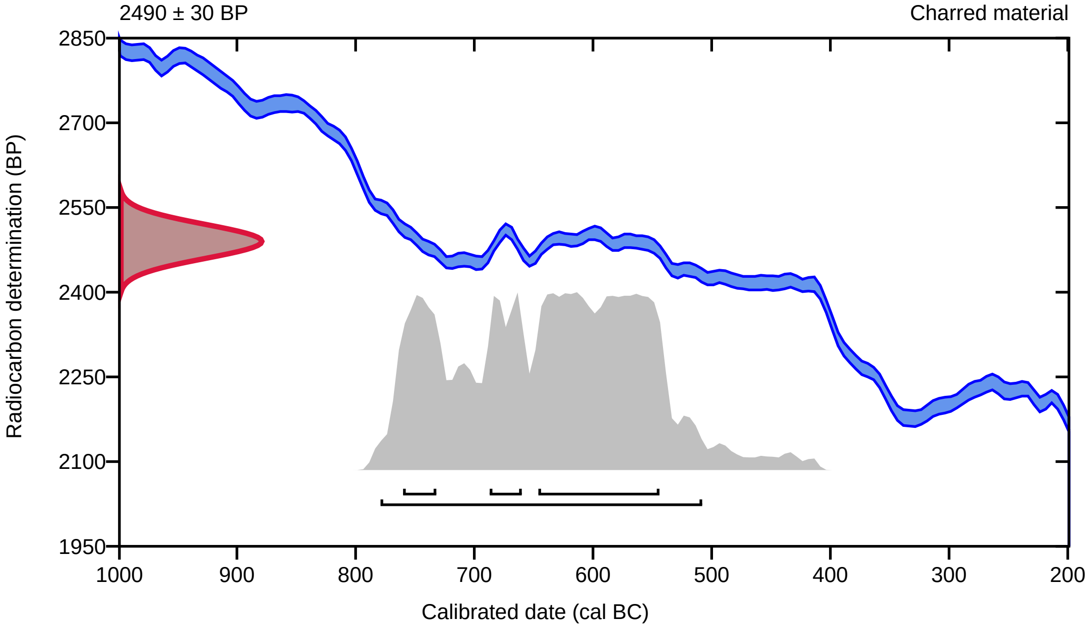
95.4% probability

(95.4%)	781 - 510 cal BC	(2730 - 2459 cal BP)

68.2% probability

(45.6%)	648 - 546 cal BC	(2597 - 2495 cal BP)
(11.6%)	762 - 734 cal BC	(2711 - 2683 cal BP)
(11%)	689 - 662 cal BC	(2638 - 2611 cal BP)

037



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -22.7 o/oo)

Laboratory number **Beta-574733**

Conventional radiocarbon age **2510 ± 30 BP**

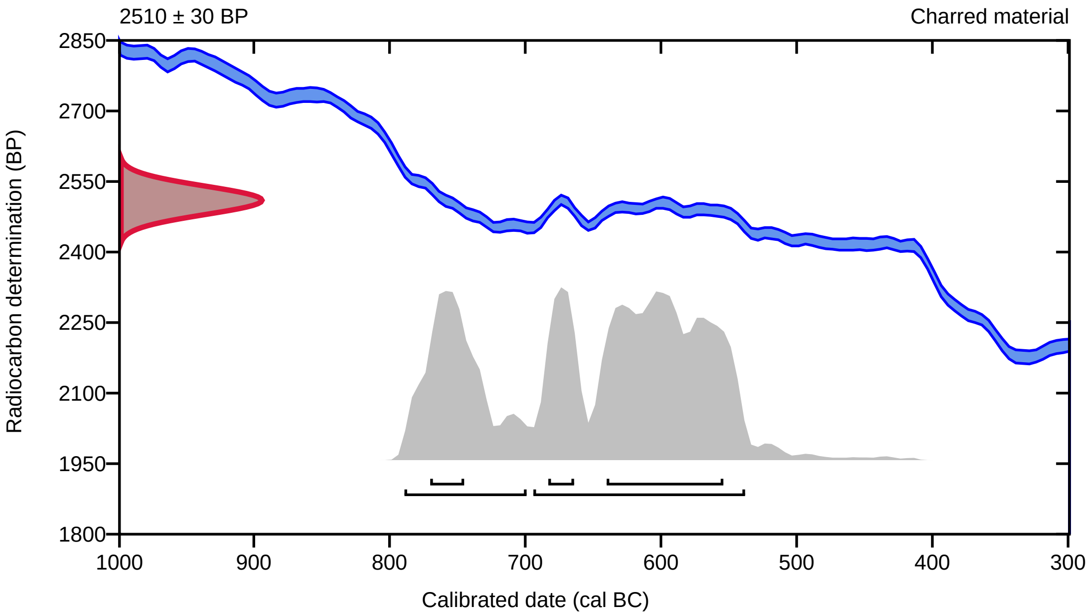
95.4% probability

(67.7%)	696 - 540 cal BC	(2645 - 2489 cal BP)
(27.7%)	791 - 701 cal BC	(2740 - 2650 cal BP)

68.2% probability

(44.3%)	642 - 556 cal BC	(2591 - 2505 cal BP)
(13.4%)	772 - 747 cal BC	(2721 - 2696 cal BP)
(10.5%)	685 - 666 cal BC	(2634 - 2615 cal BP)

039



Database used
INTCAL13

References
References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -23.5 o/oo)

Laboratory number **Beta-574734**

Conventional radiocarbon age **3540 ± 30 BP**

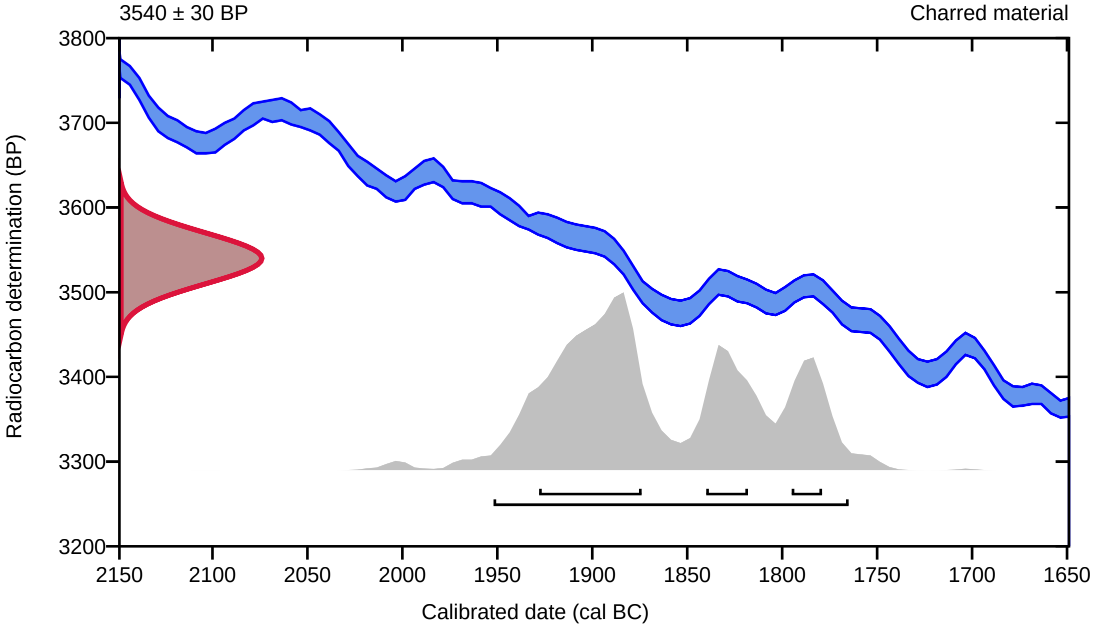
95.4% probability

(95.4%)	1954 - 1767 cal BC	(3903 - 3716 cal BP)

68.2% probability

(44.4%)	1930 - 1876 cal BC	(3879 - 3825 cal BP)
(14.1%)	1842 - 1820 cal BC	(3791 - 3769 cal BP)
(9.7%)	1797 - 1781 cal BC	(3746 - 3730 cal BP)

041



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -21.8 o/oo)

Laboratory number **Beta-574735**

Conventional radiocarbon age **4900 ± 30 BP**

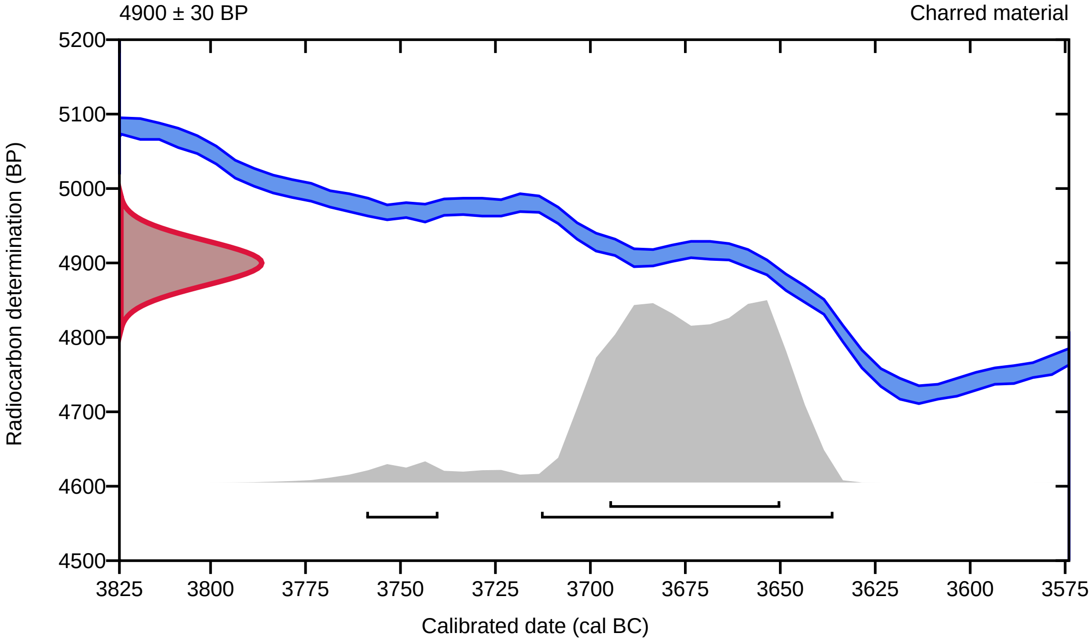
95.4% probability

(92.4%)	3715 - 3638 cal BC	(5664 - 5587 cal BP)
(3%)	3761 - 3742 cal BC	(5710 - 5691 cal BP)

68.2% probability

(68.2%)	3697 - 3652 cal BC	(5646 - 5601 cal BP)

043



Database used
INTCAL13

References
References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

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BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -24.8 o/oo)

Laboratory number **Beta-574736**

Conventional radiocarbon age **2420 ± 30 BP**

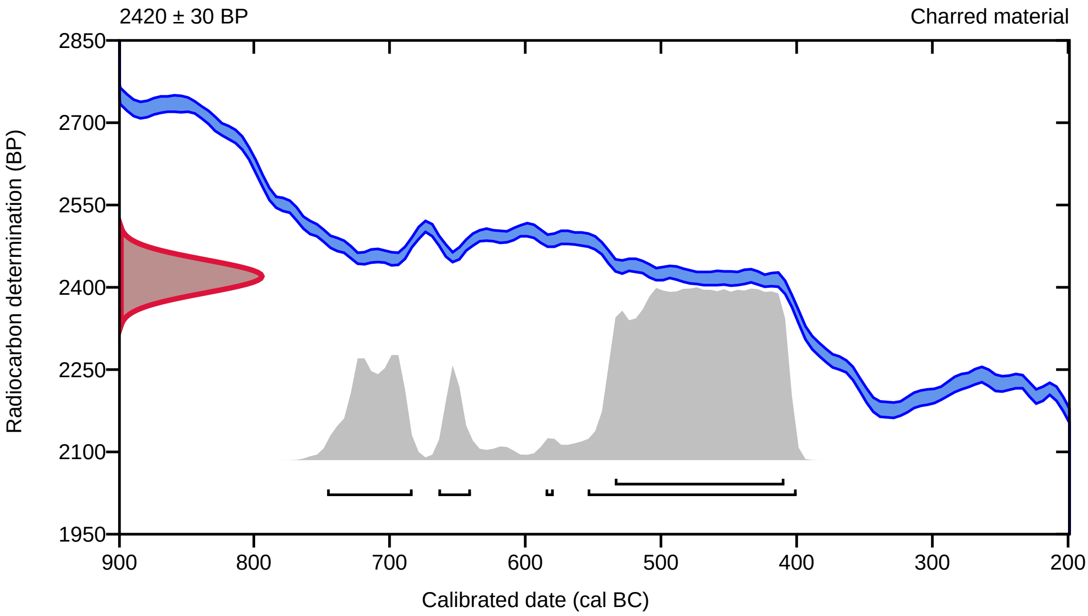
95.4% probability

(74.9%)	556 - 402 cal BC	(2505 - 2351 cal BP)
(15.5%)	748 - 685 cal BC	(2697 - 2634 cal BP)
(4.6%)	666 - 642 cal BC	(2615 - 2591 cal BP)
(0.4%)	587 - 581 cal BC	(2536 - 2530 cal BP)

68.2% probability

(68.2%)	536 - 411 cal BC	(2485 - 2360 cal BP)

044



Database used
INTCAL13

References
References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -22.5 o/oo)

Laboratory number **Beta-574737**

Conventional radiocarbon age **3210 ± 30 BP**

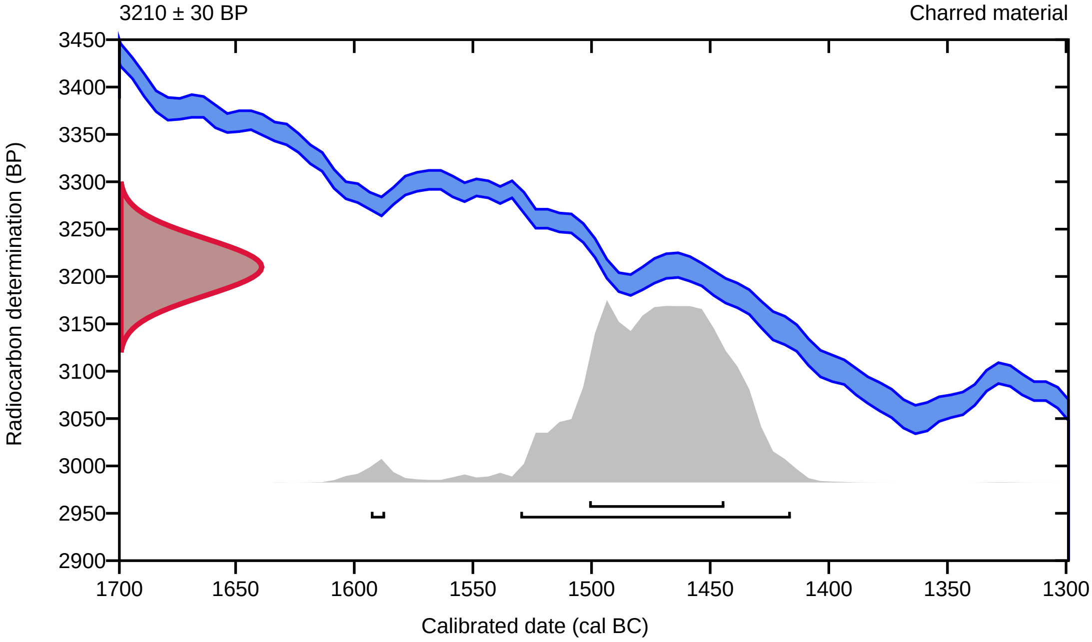
95.4% probability

(94.6%)	1532 - 1418 cal BC	(3481 - 3367 cal BP)
(0.8%)	1595 - 1589 cal BC	(3544 - 3538 cal BP)

68.2% probability

(68.2%)	1503 - 1446 cal BC	(3452 - 3395 cal BP)

046



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

Beta Analytic Radiocarbon Dating Laboratory

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -26.2 o/oo)

Laboratory number **Beta-574738**

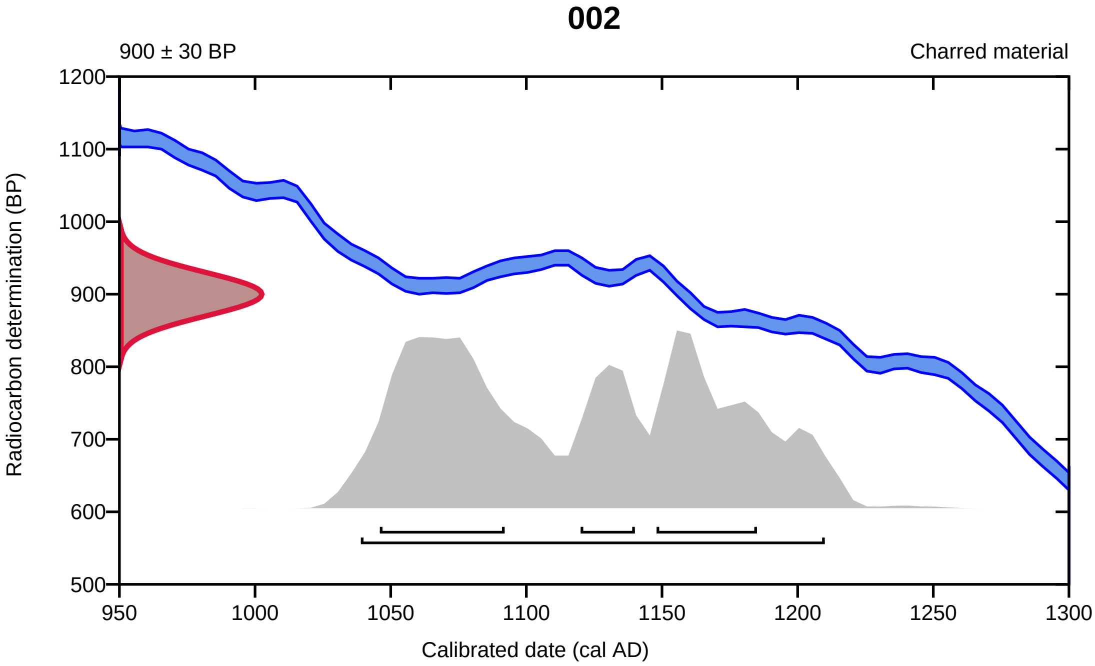
Conventional radiocarbon age **900 ± 30 BP**

95.4% probability

(95.4%)	1039 - 1210 cal AD	(911 - 740 cal BP)

68.2% probability

(33.1%)	1046 - 1092 cal AD	(904 - 858 cal BP)
(23.4%)	1148 - 1185 cal AD	(802 - 765 cal BP)
(11.8%)	1120 - 1140 cal AD	(830 - 810 cal BP)



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -24.3 o/oo)

Laboratory number **Beta-574739**

Conventional radiocarbon age **930 ± 30 BP**

95.4% probability

(95.4%)	1025 - 1165 cal AD	(925 - 785 cal BP)

68.2% probability

(28.5%)	1064 - 1108 cal AD	(886 - 842 cal BP)
(27.2%)	1116 - 1154 cal AD	(834 - 796 cal BP)
(12.6%)	1040 - 1058 cal AD	(910 - 892 cal BP)

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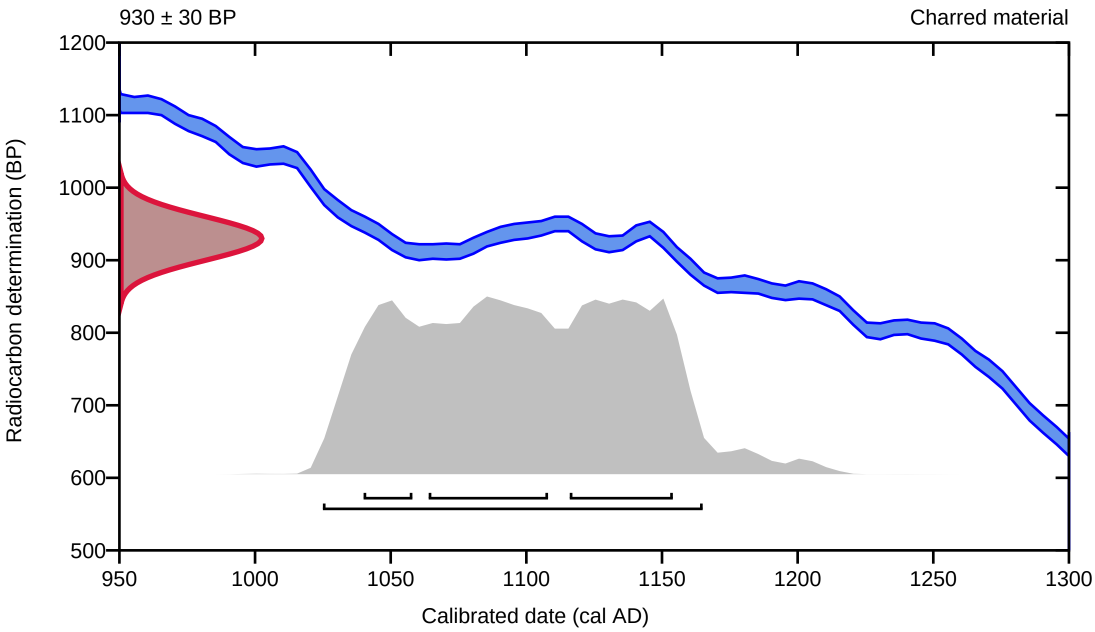

Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -26.1 o/oo)

Laboratory number **Beta-574740**

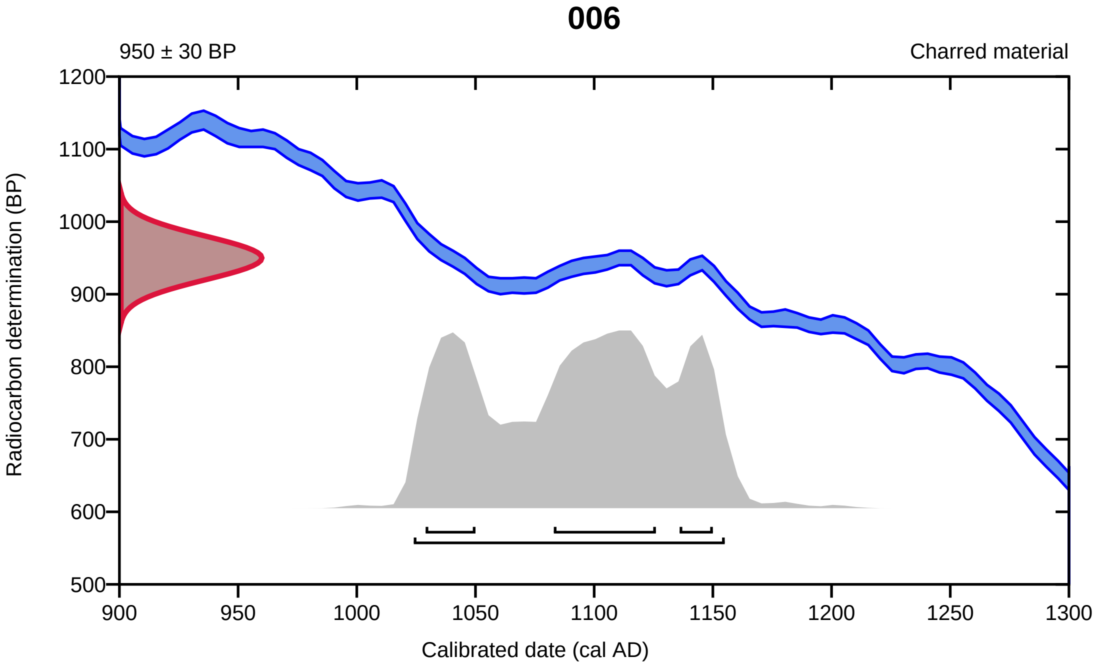
Conventional radiocarbon age **950 ± 30 BP**

95.4% probability

(95.4%)	1024 - 1155 cal AD	(926 - 795 cal BP)

68.2% probability

(37.6%)	1083 - 1126 cal AD	(867 - 824 cal BP)
(18.1%)	1029 - 1050 cal AD	(921 - 900 cal BP)
(12.6%)	1136 - 1150 cal AD	(814 - 800 cal BP)



Database used

INTCAL13

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13

Reimer, et.al., 2013, Radiocarbon55(4).

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BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13)

(Variables: d13C = -21.1 o/oo)

Laboratory number **Beta-574741**

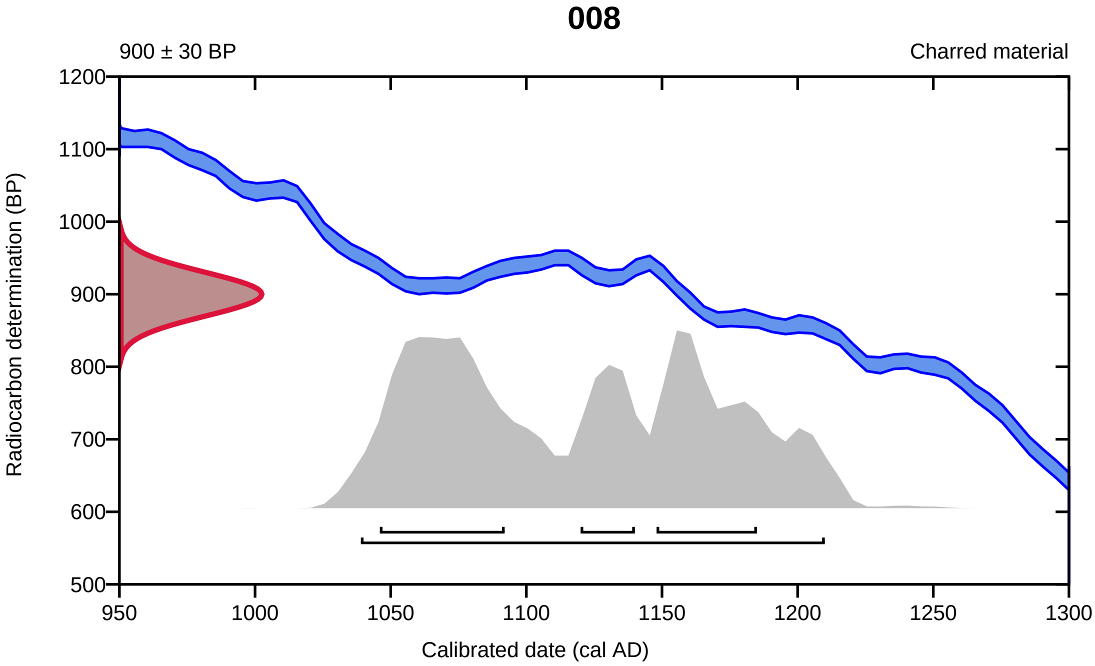
Conventional radiocarbon age **900 ± 30 BP**

95.4% probability

(95.4%)	1039 - 1210 cal AD	(911 - 740 cal BP)

68.2% probability

(33.1%)	1046 - 1092 cal AD	(904 - 858 cal BP)
(23.4%)	1148 - 1185 cal AD	(802 - 765 cal BP)
(11.8%)	1120 - 1140 cal AD	(830 - 810 cal BP)



Database used

INTCAL13

References

References to Probability Method

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APPENDIX I

Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry and Neutron Activation Analysis Report

Archaeometry Laboratory

Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry and Neutron Activation Analysis of Chert from the Sheep Creek Stone Surface Quarry, Meagher County, Montana

ANIDS: SCQ001-030

Report Prepared By:

Whitney A. Goodwin and Brandi L. MacDonald
Archaeometry Laboratory, Research Reactor Center
University of Missouri
Columbia, MO 65211

Report Prepared For:

Jessica Neal, M.A., RPA
Kleinfelder
435 Lincoln Way
Auburn, CA 95603
(618)771-6093
JNeal@kleinfelder.com

January 2021

1. Introduction

This report describes the preparation, analysis, and statistical interpretation of 30 chert samples (ANIDS: SCQ001-030) from the Sheep Creek Stone Surface Quarry District (24ME1111) in Meagher County, Montana (Figure 1). Analyses include laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) and neutron activation analysis (NAA) on all samples.

The Sheep Creek Stone Surface Quarry is an archaeological district that covers approximately 1,048 acres and consists of 13 identified lithic scatters and a thin veneer of isolated flaking debris. It was determined that a large portion of the district will be adversely affected by the Black Butte Copper Project, which will mine the Johnny Lee Copper Deposit. The site has been recommended eligible for the National Register of Historic Places and, accordingly, a cultural resources mitigation plan was developed (Neal and Nixon 2020).

As part of a broader data recovery effort, the current study seeks to chemically characterize the chert sources sampled from within the site to determine if they can be distinguished from other local or regionally important sources (i.e., "fingerprinted") and/or of there is internal variation within the site. The broader aim is to build compositional profiles of local sources that may be used to determine provenance of chert artifacts in the future.

The sample includes materials from 10 of the 13 lithic scatters in the district (Table 1; Figure 2; see also Tetra Tech 2015). The majority (n=27) are debitage, with the remaining samples (n=3) consisting of unworked cobbles. Two samples (SCQ005 and SCQ006) were collected from excavation (at site 24ME1105), while the other samples are all from the surface.

Previous chert sourcing studies in the region (e.g., Roll et al. 2005; Speakman 2003; Speakman and Glascock 2002), were considered promising given demonstrated chemical groupings within the dataset. Despite this success, comparative materials from the region were limited for the current study given that earlier studies employed different procedures for data collection. A summary of this study and its limitations and potential avenues for future comparisons are presented below.

Table 1. Specimen counts by site.

SITE NUMBER	SPECIMENS
24ME160	1
24ME161	3
24ME162	1
24ME163	7
24ME164	2
24ME165	2
24ME1105	2
24ME1107	6
24ME1108	3
24ME1109	3
TOTAL	30

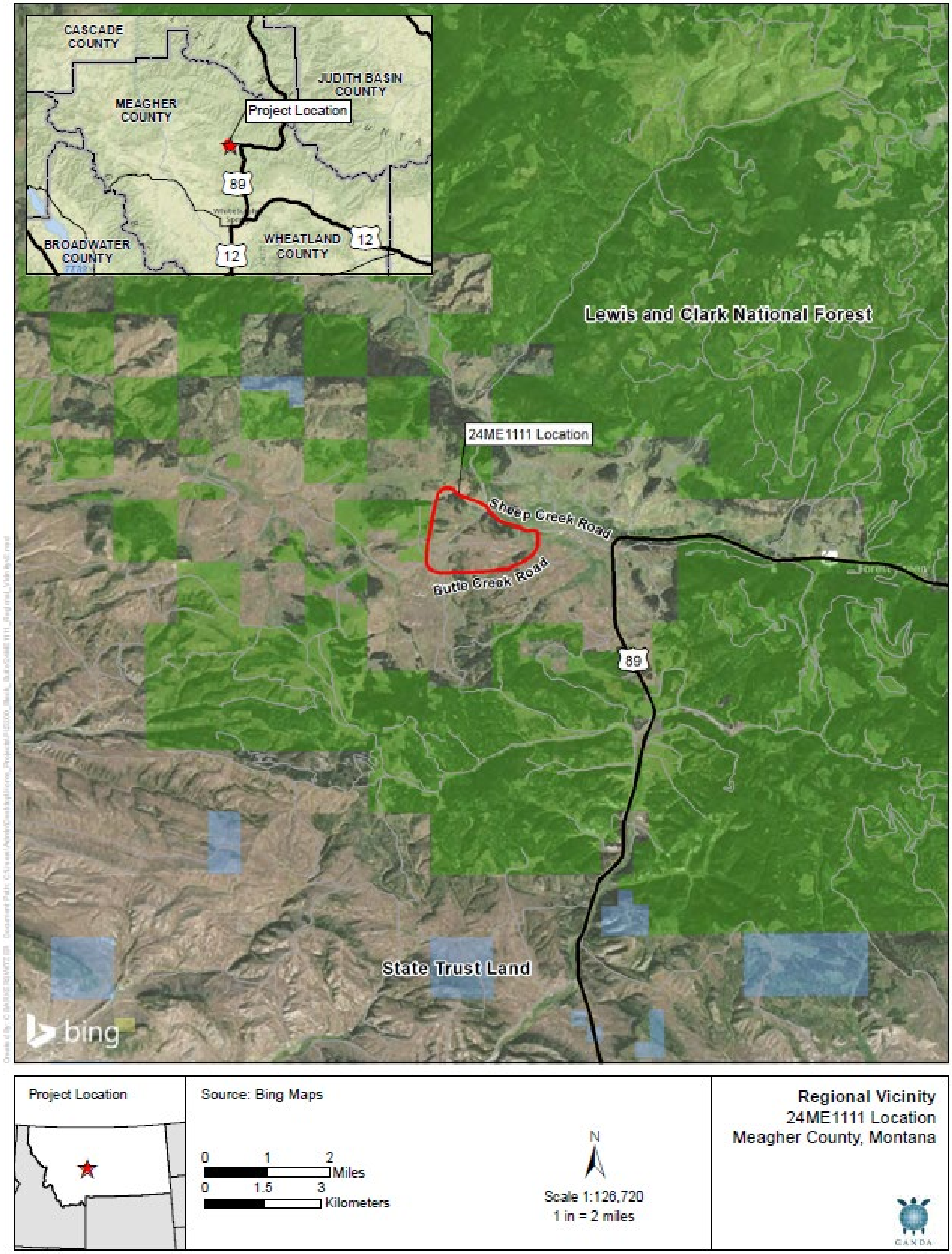

Figure 1. Location of 24ME1111. Map provided by Jessica Neal.

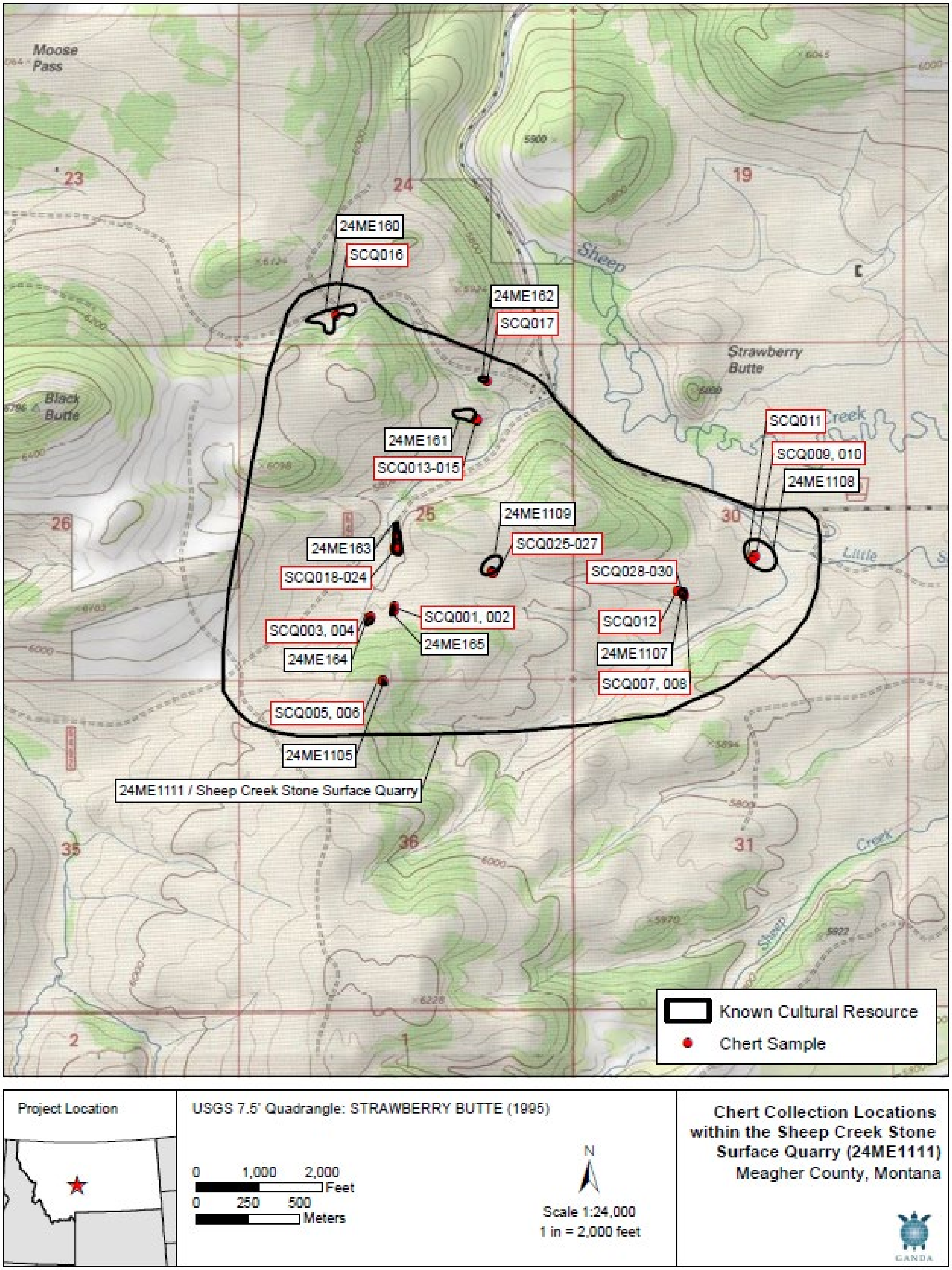

Figure 2. Map of locations sampled within 24ME1111. Map provided by Jessica Neal.

1.1 Background

Chert is difficult to characterize given inherent chemical variability within individual specimens and sources and the generally limited compositional variation that occurs between sources. When compositional studies of chert have been successful, analytical techniques for identifying chert sources have relied heavily on trace elements, as major oxides tend not to provide the necessary level of detail for discrimination between sources (Roll et al. 2005: 60). NAA has emerged as the favored method, given that it provides bulk data on heterogenous samples and that it provides measurements of trace elements at lower levels than other techniques. LA-ICP-MS has been used less frequently in the past, but is gaining popularity given growing examples of successful studies (e.g., Roll et al 2005), the ability to measure a large number of elements, and its practical advantages such as its lower cost (allowing larger sample sizes) and faster turn-around time.

Montana has over 655 prehistoric sites classified as lithic raw material procurement locales, with roughly three times the number of quarries per archaeological sites in southwestern Montana than the rest of the state (Roll et al. 2005:60-61). The Sheep Creek Stone Surface Quarry district is located in this region, within the Little Belt Mountains, a part of the northern Rocky Mountains at around 5600-6100 ft above sea level. The site is situated along Sheep Creek, which empties into the Smith River roughly 11 miles to the west. The area is underlain by Precambrian Belt series, which formed about 1.6 billion years ago and accumulated until about 800 million years ago (Neal and Nixon 2020:2-1). These sedimentary formations contain no trace of animal life, distinguishing them from later Paleozoic formations (Tetra Tech 2015). This area sits at the convergence of several major geological zones (i.e., the North and South Fold-Thrust Belts and the Forelands tectonic province), with prominent chert sources available throughout the region.

The immediate area, known as the Smith River area, is well known for its chert quarries. The deposits in this area are referred to by geologists as 'silicified gossan' (remnants of intensely weathered iron-sulfide mineralization, or iron-rich silicified materials). These deposits cover roughly 100 square miles around the district and fragments of these materials are found in alluvial settings, especially in areas near the exposed weathered portions of these pyrite zones (Peterson and Barnett 2015). Geologist Zieg (in Peterson and Barnett 2015) describes how local cherts are formed and the underlying geological features of the region that allow for these processes:

> "The genesis of this material involves the surficial weathering of the aerially extensive bedded pyrite zones in the host-rock of the Newland shale. The portion of the Newland outcrop belt that contains the greatest abundance of jasperoid extends from about two miles east of US Highway 89 to west of the Smith River – a distance of approximately 20 miles. This exposure belt averages approximately five miles in width. Bedded pyrite zones are scattered across 3,000 feet of Newland stratigraphy. When these zones oxidize near surface, liberation of the sulfur ions from the weathering of pyrite creates sulfuric acid, which carries silica as well as many other ions. This acid is then buffered by the high concentrations of dolomite … in the Newland shale, and as the acid is consumed, silica then precipitates as very fine-grained massive material along with a good deal of the iron-oxide liberated during oxidation of pyrite" (Peterson and Barnett 2015).

Chert of the Smith River quarries have a wide range of physical characteristics. Buff, tan, and brown chert are most prominent but black, white, gray, red, and blue have been reported. Translucence, luster, and texture also vary, while brecciation, resilicification, and dendritic inclusions are common (Roll et al. 2005:63). Although chert is found throughout the Sheep Creek Stone Surface Quarry district, it is generally a poor-quality material for stone tools. In addition to chert, chalcedony, porcellanite, and obsidian have been identified. Cores, some projectile points, worked flakes, and tested nodules are present (Neal and Nixon 2020:3-1). Diagnostic artifacts are lacking, and no carbon-bearing features have been identified, resulting in no clear temporal association for the district, although nearby sites demonstrate Late Paleoindian to Late Prehistoric period activity (Peterson and Barnett 2015).

1.2 Previous Studies

In 2002, Tom Roll at Montana State University submitted 16 samples (ANIDS:CBQ01-16) from the nearby Camp Baker Quarry (24ME467), other sites in Meagher County (24ME69 and 24ME332), and other locales in western Montana (Figure 3) to MURR for analysis by LA-ICP-MS. Analyses and results of this study are presented in Speakman and Glascock (2002). In 2003, Roll submitted an additional 38 samples (SML001-038). The two datasets were combined and reanalyzed (see Speakman 2003) with similar chemical groupings obtained.

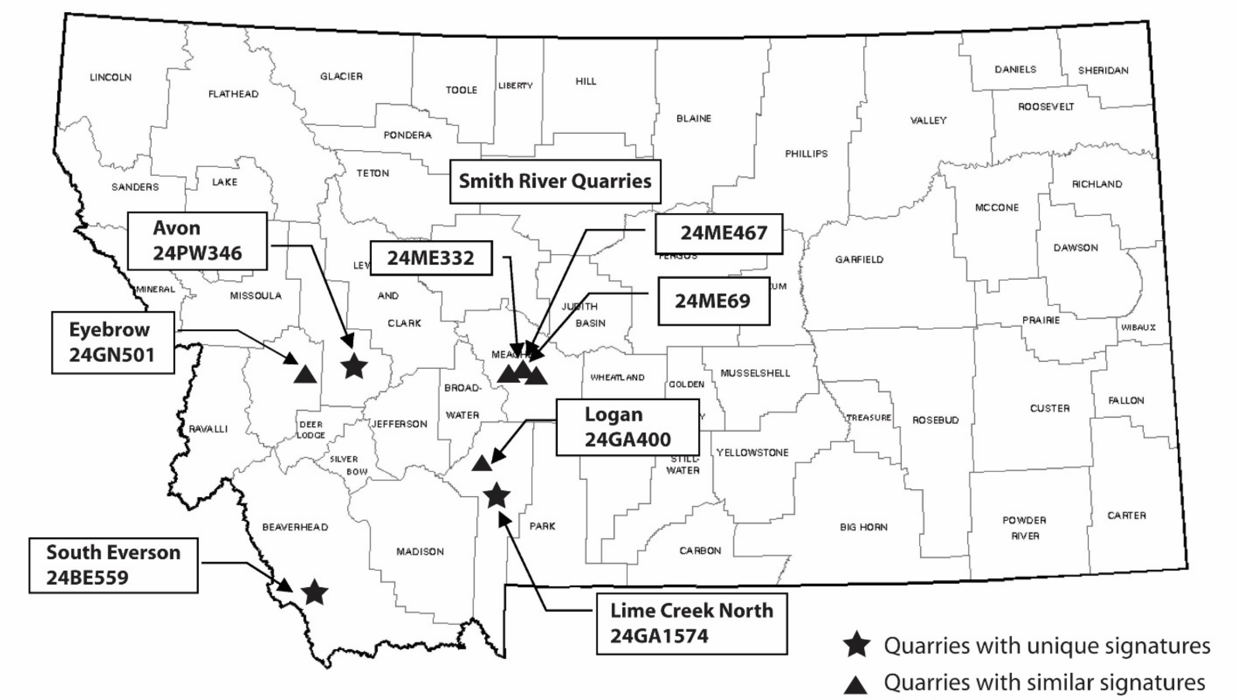

Figure 3. Southwestern Montana quarries sampled by Roll and colleagues (after map provided by Roll to MURR; see also Roll et al. 2005).

This study was considered promising, with success in creating distinct chemical groups among the specimens (Figure 4), which is uncommon for chert studies. However, the results were somewhat ambiguous. There was some indication that Camp Baker materials fell into two distinct groups (Camp Baker-1 and Camp Baker-2), suggesting that there was detectable variation even at the local level. Yet in addition to these groups, some of the Camp Baker and other Smith River quarries materials fell into an "undifferentiated" group that was indistinguishable from materials from the distant Eyebrow and Logan quarries. In other words, the range of variation within a quarry was often so great that it overlapped with the range of variation in other quarries (Roll et al. 2005:59). Additionally, reflecting the heterogeneity in Camp Baker materials, some specimens that were analyzed several times based on different colors present were found to sometimes belong to different compositional groups, although there was no clear pattern between color and composition (Roll et al. 2005:69) Conversely, the Avon, Lime Creek North, and South Emerson quarries were all found to have distinct signatures from the other sampled quarries in the study, with Logan quarry differentiated only among samples of a particular color.

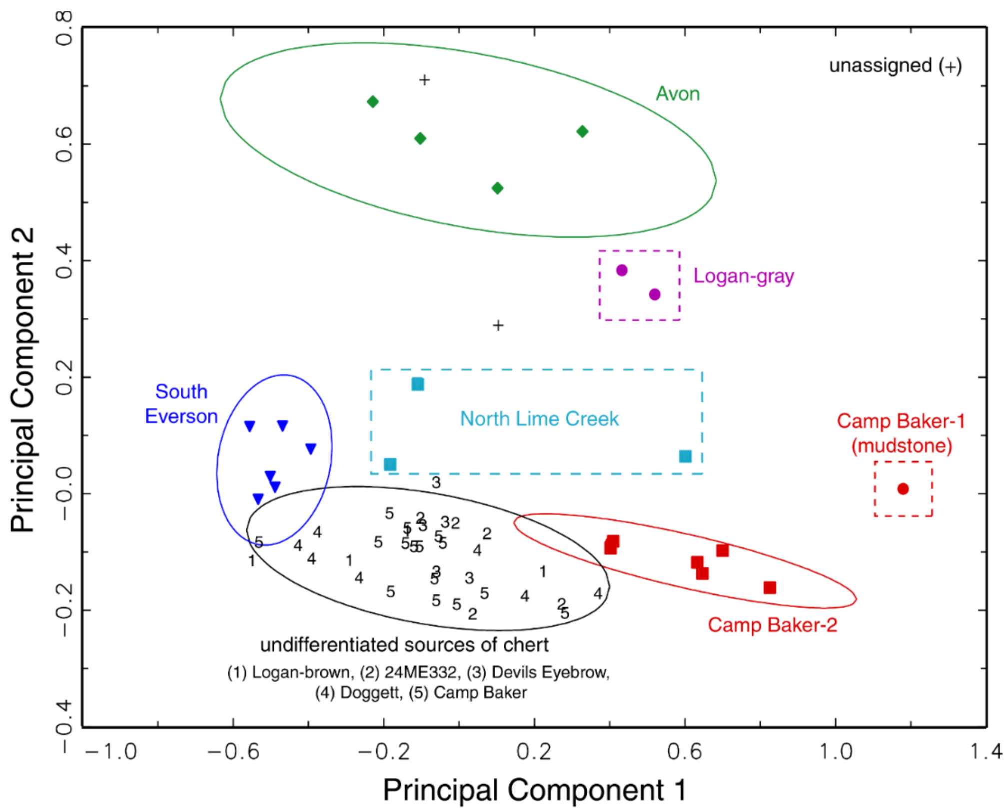

Figure 4. Scatterplot of the first two principal components for the compositional groups from Roll's chert study in southwestern Montana. From Speakman 2003; see Speakman and Glascock 2002.

In the future, the Roll sample could be reanalyzed following the procedures detailed here to produce comparable data. These specimens are archived at the Museum Support Center at the University of Missouri, Columbia. Some limited comparisons for the present study were possible between the current dataset and a distinct sample of materials submitted by Roll from eastern Montana, both collected using NAA (see below) as well as with MURR's broader chert database.

2. Methods and sample preparation

2.1 LA-ICP-MS: sample preparation and instrumentation

Samples were prepared for LA-ICP-MS using procedures standard at the MURR Archaeometry Lab. Pieces of about 1 cm^2 were cut from each sherd using a geological saw. The cut samples were washed in deionized water and allowed to dry in the laboratory. Once dry, the pieces were mounted on a series of standard thin section slides with poster tack. Alongside the unknown samples on each slide, standards and quality control samples were similarly prepared. The standard reference materials used to assess instrument performance and calibrate the LA-ICP-MS data included NIST 610, NIST 612, (glass, issued by National Institute for Standards and Technology), a glass issued by Corning (Brill-D), and USGS BCR-2 (basalt) as a quality control. For NIST glass, consensus values published in Pearce et al (2011) were used. For Corning issued glasses, recommended values from Brill and Rising (1999) were used.

The analysis was performed using a PerkinElmer SCIEX NexION 300 Quadrupole ICP-MS coupled with a Teledyne Instruments Inc. Analyte Excite HelEx 193 nm laser ablation system. We selected five ablation pass lines on each standard reference material, quality control, and unknown sample. Each of the five ablation passes were set to 40 µm wide and 80 µm long. After each ablation, the laser was paused for 25 seconds while the ICP-MS continued to collect data. The laser moved at a rate of 5 µm/s firing laser bursts at a rate of 10/s. Laser power was set to 40% of the maximum output. The routine analytical procedure "brackets" ten unknown samples with a set of standards and quality controls in order to monitor instrument stability and drift over the course of an analytical run. The ablated sample vapor travels through tubing in a helium transport agent. It is mixed with argon gas at the ICP-MS torch, where the sample is ionized and passes through two detectors that measure the intensity of the signal in counts per second.

The method used for this analysis collected data for 61 isotopes listed here in order of atomic mass: ^{7}Li (lithium), ^{9}Be (beryllium), ^{11}B (boron) ^{23}Na (sodium), ^{24}Mg (magnesium), ^{27}Al (aluminum), ^{29}Si (silicon), ^{31}P (phosphorus), ^{35}Cl (chlorine), ^{39}K (potassium), ^{44}Ca (calcium), ^{45}Sc (scandium) ^{47}Ti (titanium), ^{51}V (vanadium), ^{52}Cr (chromium), ^{55}Mn (manganese), ^{57}Fe (iron), ^{59}Co (cobalt), ^{60}Ni (nickel), ^{63}Cu (copper), ^{66}Zn (zinc), ^{69}Ga (gallium), ^{74}Ge (germanium) ^{75}As (arsenic), ^{80}Se (selenium) ^{85}Rb (rubidium), ^{88}Sr (strontium), ^{89}Y (yttrium), ^{90}Zr (zirconium), ^{93}Nb (niobium), ^{98}Mo (molybdenum), ^{107}Ag (silver), ^{115}In (indium), ^{118}Sn (tin), ^{121}Sb (antimony), ^{133}Cs (cesium), ^{138}Ba (barium), ^{139}La (lanthanum), ^{140}Ce (cerium), ^{141}Pr (praseodymium), ^{146}Nd (neodymium), ^{147}Sm (samarium), ^{153}Eu (europium), ^{157}Gd (gadolinium), ^{159}Tb (terbium), ^{163}Dy (dysprosium), ^{165}Ho (holmium), ^{166}Er (erbium), ^{169}Tm (thulium), ^{172}Yb (ytterbium), ^{175}Lu (lutetium), ^{178}Hf (hafnium), ^{181}Ta (tantalum), ^{182}W (tungsten), ^{197}Au (gold), ^{205}Tl (thallium), ^{208}Pb (lead), ^{209}Bi (bismuth), ^{232}Th (thorium), and ^{238}U (uranium).

Switching the laser on and off for a pause of 25 seconds between scans forms a series of curves for each isotope. Each peak represents a single ablated spot, whereas the baseline between peaks serves as the sample blank. An Excel-based macro script subtracts the sample blank (the average of 5 baseline replicates both before and after the sample signal peak) from each replicate. The blank-subtracted replicates within each peak are summed and averaged over however many individual spots were ablated on the specimen. At this stage, anomalous peaks are identified and eliminated to avoid a single peak from skewing the average signal intensity counts.

The average data for element isotopes in counts per second are then corrected to a total elemental signal by comparing the signal intensity measured for each element in the sample for the same element measured in the standard reference materials. The isotope Si^{29} is used as the internal standard. The standard signals are then referenced to published values for standard reference materials to arrive at the *Ky:*

$$Ky = \frac{Standardized\ signal\ for\ Y}{[Y] in\ the\ reference\ material} * [internal\ standard] in\ the\ reference\ material$$

Where *K* is the conversion factor for element *y.* The standard signal is then divided by the *Ky* and the sum of all elements is normalized to 100 percent oxide, as proposed by Gratuze et al (1999, 2001).

2.2 Neutron Activation Analysis: sample preparation and spectrometry

Samples were prepared for NAA using procedures standard at MURR. Two analytical samples were prepared from each ceramic specimen. Portions of approximately 150 mg of powder were weighed into clean high-density polyethylene vials used for short irradiations at MURR. At the same time, 200 mg of each sample was weighed into clean high-purity quartz vials used for long irradiations. Individual sample weights were recorded to the nearest 0.01 mg using an analytical balance. Both vials were sealed prior to irradiation. Along with the unknown samples, Standards made from National Institute of Standards and Technology (NIST) certified standard reference materials of SRM-1633b (coal fly ash) and SRM-688 (basalt rock) were similarly prepared, as were quality control samples (e.g., standards treated as unknowns) of SRM-278 (obsidian rock) and New Ohio Red Clay (a standard developed for in-house applications).

2.3 Irradiation and Gamma-Ray Spectroscopy

Neutron activation analysis of ceramics at MURR, which consists of two irradiations and a total of three gamma counts, constitutes a superset of the procedures used at most other NAA laboratories (Glascock 1992; Neff 1992, 2000). As discussed in detail by Glascock (1992), a short irradiation is carried out through the pneumatic tube irradiation system. Samples in the polyvials are sequentially irradiated, two at a time, for five seconds by a neutron flux of 8×10^{13} n cm^{-2} s^{-1} The 720-second count yields gamma spectra containing peaks for nine short-lived elements aluminum (Al), barium (Ba), calcium (Ca), dysprosium (Dy), potassium (K), manganese (Mn), sodium (Na), titanium (Ti), and vanadium (V). The samples are encapsulated in quartz vials and are subjected to a 24–hour irradiation at a neutron flux of 5×10^{13} n cm^{-2} s^{-1}. This long irradiation is analogous to the single irradiation utilized at most other laboratories. After the long irradiation, samples decay for seven days, and then are counted for 1,800 seconds (the "middle count") on a high-resolution germanium detector coupled to an automatic sample changer. The middle count yields determinations of seven medium half-life elements, namely arsenic (As), lanthanum (La), lutetium (Lu), neodymium (Nd), samarium (Sm), uranium (U), and ytterbium (Yb). After an additional three- or four-week decay, a final count of 8,500 seconds is carried out on each sample. The latter measurement yields the following 17 long half-life elements: cerium (Ce), cobalt (Co), chromium (Cr), cesium (Cs), europium (Eu), iron (Fe), hafnium (Hf), nickel (Ni), rubidium (Rb), antimony (Sb), scandium (Sc), strontium (Sr), tantalum (Ta), terbium (Tb), thorium (Th), zinc (Zn), and zirconium (Zr). The element concentration data from the three measurements are tabulated in parts per million.

3. Identifying Compositional Groups in Archaeological Materials

The interpretation of compositional data obtained from the analysis of archaeological materials is discussed in detail elsewhere (e.g., Baxter and Buck 2000; Bieber et al. 1976; Bishop and Neff 1989; Glascock 1992; Harbottle 1976; Neff 2000) and will only be summarized here. These concepts can be applied to datasets generated by both NAA and LA-ICP-MS. The main goal of data analysis is to identify distinct homogeneous groups within the sample set. Based on the provenance postulate of Weigand *et al*. (1977), different chemical groups may be assumed to represent geographically restricted sources. For lithic materials such as obsidian, basalt, and cryptocrystalline silicates (e.g., chert, flint, or jasper), raw material samples are frequently collected from known outcrops or secondary deposits and the compositional data obtained on the samples is used to define the source localities or boundaries. The locations of sources can also be inferred by comparing unknown specimens (i.e., ceramic artifacts) to knowns (i.e., source samples) or by indirect methods such as the "criterion of abundance" (Bishop *et al*. 1992) or by arguments based on geological and sedimentological characteristics (e.g., Steponaitis *et al*. 1996). The ubiquity of ceramic raw materials usually makes it impossible to sample all potential "sources" intensively enough to create groups of knowns to which unknowns can be compared. Lithic sources tend to be more localized and compositionally homogeneous in the case of obsidian or compositionally heterogeneous as is the case for most cherts.

Compositional groups can be viewed as "centers of mass" in the compositional hyperspace described by the measured elemental data. Groups are characterized by the locations of their centroids and the unique relationships (i.e., correlations) between the elements. Decisions about whether to assign a specimen to a particular compositional group are based on the overall probability that the measured concentrations for the specimen could have been obtained from that group.

Initial hypotheses about source-related subgroups in the compositional data can be derived from non-compositional information (e.g., archaeological context, decorative attributes, etc.) or from application of various pattern-recognition techniques to the multivariate chemical data. Some of the pattern recognition techniques that have been used to investigate archaeological data sets are cluster analysis (CA), principal components analysis (PCA), and discriminant analysis (DA). Each of the techniques has its own advantages and disadvantages which may depend upon the types and quantity of data available for interpretation.

3.1 Principal Component Analysis

The variables (measured elements) in archaeological and geological data sets are often correlated and frequently large in number. This makes handling and interpreting patterns within the data difficult. Therefore, it is often useful to transform the original variables into a smaller set of uncorrelated variables in order to make data interpretation easier. Of the above-mentioned pattern recognition techniques, PCA is a technique that transforms from the data from the original correlated variables into uncorrelated variables most easily.

PCA creates a new set of reference axes arranged in decreasing order of variance subsumed. The individual PCs are linear combinations of the original variables. The data can be displayed on combinations of the new axes, just as they can be displayed on the original elemental concentration axes. PCA can be used in a pure pattern-recognition mode, i.e., to search for subgroups in an undifferentiated data set, or in a more evaluative mode, i.e., to assess the coherence of hypothetical groups suggested by other criteria. Generally, compositional differences between specimens can be expected to be larger for specimens in different groups than for specimens in the same group, and this implies that groups should be detectable as distinct areas of high point density on plots of the first few components. It is well known that PCA of chemical data is scale dependent (Mardia *et al*. 1979), and analyses tend to be dominated by those elements or isotopes for which the concentrations are relatively large. This is yet another reason for the log transformation of the data.

One frequently exploited strength of PCA, discussed by Baxter (1992), Baxter and Buck (2000), and Neff (1994, 2002), is that it can be applied as a simultaneous R- and Q-mode technique, with both variables (elements) and objects (individual analyzed samples) displayed on the same set of principal component reference axes. A plot using the first two principal components as axes is usually the best possible two-dimensional representation of the correlation or variance-covariance structure within the data set. Small angles between the vectors from the origin to variable coordinates indicate strong positive correlation; angles at 90 degrees indicate no correlation; and angles close to 180 degrees indicate strong negative correlation. Likewise, a plot of sample coordinates on these same axes will be the best two-dimensional representation of Euclidean relations among the samples in log-concentration space (if the PCA was based on the variance-covariance matrix) or standardized log-concentration space (if the PCA was based on the correlation matrix). Displaying both objects and variables on the same plot makes it possible to observe the contributions of specific elements to group separation and to the distinctive shapes of the various groups. Such a plot is commonly referred to as a "biplot" in reference to the simultaneous plotting of objects and variables. The variable inter-relationships inferred from a biplot can be verified directly by inspecting elemental concentration scatterplots.

3.2 Canonical Discriminant Analysis

Canonical discriminant analysis (CDA) is another dimension-reducing method that transforms multiple independent variables into a linear combination of those variables (one fewer than the total number of groups), which describe decreasing amounts of separation between compositional groups. These are referred to as the canonical discriminant function (i.e. CDA-1, CDA-2, etc.), and are expressed as a percentage of the magnitude of separation. Additionally, each independent variable (i.e. element) is calculated a score relative to its influence on the separation of groups. Bivariate plots of discriminant functions are a typical visual output showing group separation. CDA differs from PCA in that it extracts a new set of variables that maximize the differences between two or more groups rather than maximizing the variance of the total data set, and is more advantageous in circumstances when known sources can be treated as groups.

3.3 Mahalanobis Distance and Group Membership Probabilities

Whether a group can be discriminated easily from other groups can be evaluated visually in two dimensions or statistically in multiple dimensions. A metric known as the Mahalanobis distance (or generalized distance) makes it possible to describe the separation between groups or between individual samples and groups on multiple dimensions. The Mahalanobis distance of a specimen from a group centroid (Bieber *et al*. 1976, Bishop and Neff 1989) is defined by:

$$D^2_{y,X} = [y - \overline{X}]^t I_x [y - \overline{X}]$$

where y is the 1 x m array of logged elemental concentrations for the specimen of interest, X is the n x m data matrix of logged concentrations for the group to which the point is being compared with $\overline{X}$ being it 1 x m centroid, and I_x is the inverse of the m x m variance-covariance matrix of group *X*. Because Mahalanobis distance takes into account variances and covariances in the multivariate group it is analogous to expressing distance from a univariate mean in standard deviation units. Like standard deviation units, Mahalanobis distances can be converted into probabilities of group membership for individual specimens. For relatively small sample sizes, it is appropriate to base probabilities on Hotelling's T^2, which is the multivariate extension of the univariate Student's t.

When group sizes are small, Mahalanobis distance-based probabilities can fluctuate dramatically depending upon whether or not each specimen is assumed to be a member of the group to which it is being compared. Harbottle (1976) calls this phenomenon "stretchability" in reference to the tendency of an included specimen to stretch the group in the direction of its own location in elemental concentration space. This problem can be circumvented by cross-validation, that is, by removing each specimen from its presumed group before calculating its own probability of membership (Baxter 1994; Leese and Main 1994). This is a conservative approach to group evaluation that may sometimes exclude true group members.

Small sample and group sizes place further constraints on the use of Mahalanobis distance: with more elements than samples, the group variance-covariance matrix is singular thus rendering calculation of I_x (and D^2 itself) impossible. Therefore, the dimensionality of the groups must somehow be reduced. One approach would be to eliminate elements considered irrelevant or redundant. The problem with this approach is that the investigator's preconceptions about which elements should be discriminate may not be valid. It also squanders the main advantage of multielement analysis, namely the capability to measure a large number of elements. An alternative approach is to calculate Mahalanobis distances with the scores on principal components extracted from the variance-covariance or correlation matrix for the complete data set. This approach entails only the assumption, entirely reasonable in light of the above discussion of PCA, that most group-separating differences should be visible on the first several PCs. Unless a data set is extremely complex, containing numerous distinct groups, using enough components to subsume at least 90% of the total variance in the data can be generally assumed to yield Mahalanobis distances that approximate Mahalanobis distances in full elemental concentration space.

Lastly, Mahalanobis distance calculations are also quite useful for handling missing data (Sayre 1975). When many specimens are analyzed for a large number of elements, it is almost certain that a few element concentrations will be missed for some of the specimens. This occurs most frequently when the concentration for an element is near the detection limit. Rather than eliminate the specimen or the element from consideration, it is possible to substitute a missing value by replacing it with a value that minimizes the Mahalanobis distance for the specimen from the group centroid. Thus, those few specimens which are missing a single concentration value can still be used in group calculations.

4. LA-ICP-MS Dataset

4.1 Dataset Structure

The general structure of the dataset was assessed first by examining the elemental concentration data. Elements with values below the limit of detection (<LOD) were present in high numbers for gold (n=12) and beryllium (n=4) and some samples had higher reported <LOD than others (e.g., SCQ018 with nine elements and SCQ004 with five elements <LOD). None of the elements were immediately excluded from subsequent analyses.

A series of PCAs were performed, with unreliable elements and those with missing values or outliers excluded. SCQ025 was identified as an outlier, with very high concentrations of most elements relative to other specimens, but its inclusion or exclusion from analyses did not appear to have a significant effect on the spread of the data in multivariate space. Overall, very little change was noted across different combinations, suggesting that the structure of the dataset is fairly stable and not heavily reliant on any specific element or set of elements.

PCA was used to understand the most significant elements driving variation within the sample (Figure 5; Table 2). A total of 27 elements were selected for inclusion in the PCA below based on their relative significance within the dataset. On PC1, some transition metals (Ti, Co, Cr) and most rare earth elements (REEs: Ce, Nb, Zr, Nb, La, Nd, Ta, Sm, La, Yb, Tb, Hf, Lu, U) are all positively loaded, while arsenic, rubidium, and vanadium are negatively loaded. On PC2, silver is positively loaded, while some transition metals (Zn, Mn) and alkali and alkaline earth metals (Ba, Rb, Cs, Sr) are negatively loaded.

Some tentative patterning is visible when the specimens are plotted by site (Figure 6). Sites 24ME1105, 24ME1109, 24ME161, 24ME162, 24ME163, 24ME164, and 24ME165, tend to have specimens that are positively loaded on PC1 while sites 24ME1107, 24ME1108, and 24ME161do not. These patterns are not consistent, however, and the relationships between sites and compositional groups tend to be equivocal within the LA-ICP-MS dataset, as discussed below.

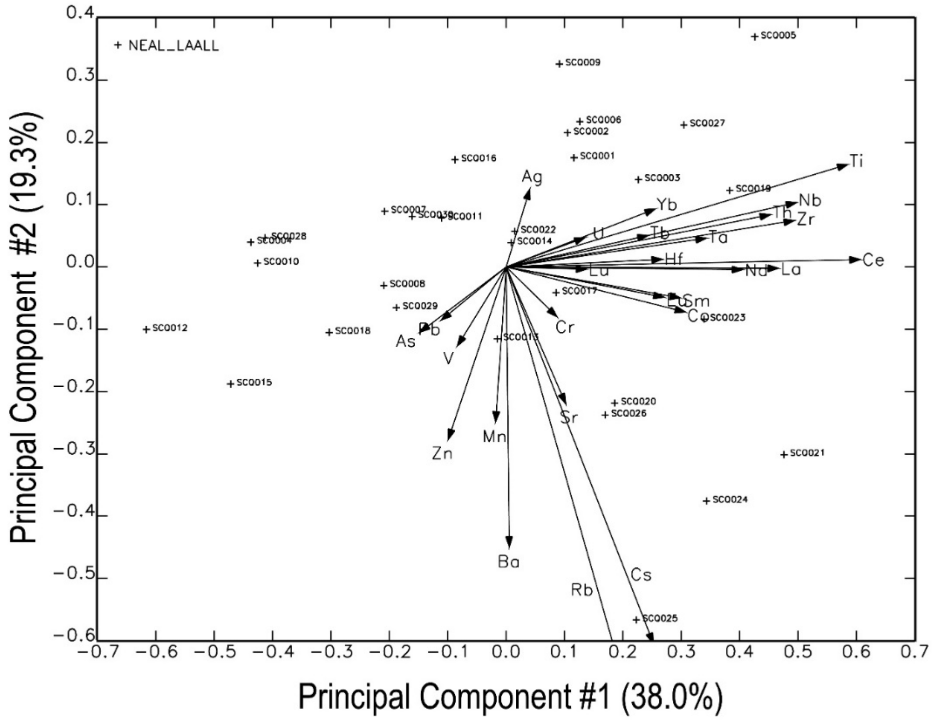

Figure 5. Biplot of the first two principal components calculated for the current LA-ICP-MS dataset with labeled vectors demonstrating the loading of individual elements. 57.3% of the variation in the dataset is captured by the first two PCs.

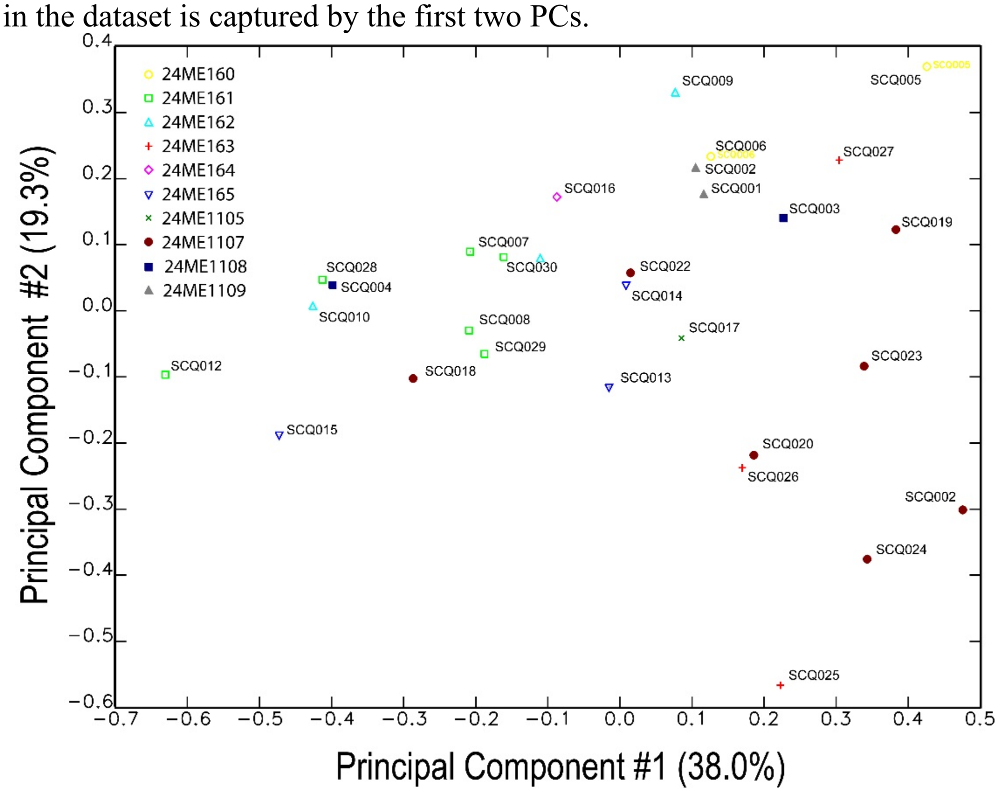

Figure 6. Scatterplot of the first two principal components calculated for the current dataset with specimens labeled according to their provenience.

Table 2. Elemental loadings for principal component axes 1-8 based on the variance-covariance matrix. Values in bold explain the greatest amount of variation within each component. Over 90% of the cumulative variance in the dataset is explained by the first 8 principal components.

VARIABLE	AVERAGE	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
Ti	3912.87	**0.365**	**0.144**	0.051	0.044	**-0.238**	-0.045	-0.223	**0.211**
V	82.33	**-0.052**	-0.111	**0.487**	**-0.289**	-0.013	**-0.617**	-0.182	-0.248
Cr	71.12	0.054	-0.070	-0.048	**0.445**	0.046	-0.114	0.056	0.056
Mn	96.05	-0.011	-0.218	0.078	0.027	-0.054	-0.131	0.039	**0.358**
Co	4.73	0.192	-0.063	0.167	0.131	0.268	-0.039	**0.386**	**0.253**
Zn	176.81	**-0.062**	-0.242	0.210	0.110	0.117	-0.162	**0.340**	**0.204**
As	83	**-0.092**	-0.092	**0.438**	0.157	0.213	-0.070	-0.168	-0.077
Zr	99.43	**0.308**	0.065	0.118	0.046	**-0.270**	-0.075	0.187	-0.105
Cs	0.37	0.157	**-0.529**	**-0.251**	0.100	0.109	-0.103	-0.264	0.121
Ba	83.14	0.003	-0.393	0.086	-0.042	**-0.271**	**0.305**	0.047	**-0.373**
La	10.18	0.291	-0.002	0.120	**-0.287**	0.248	**0.264**	-0.239	0.107
Ce	15.41	**0.378**	0.011	0.071	**-0.309**	0.187	0.152	0.001	0.241
Nd	6.24	0.253	-0.004	-0.054	-0.184	**0.438**	-0.041	0.094	-0.219
Sm	3.63	0.186	-0.044	-0.085	0.154	0.156	0.007	0.083	**-0.284**
Eu	0.85	0.169	-0.042	-0.080	0.139	0.261	0.035	-0.075	**-0.373**
Tb	0.76	0.152	0.044	-0.059	0.114	0.167	-0.075	0.013	-0.263
Yb	3.85	0.159	0.082	0.014	0.194	-0.042	-0.034	0.071	-0.141
Lu	0.75	0.086	-0.003	0.011	0.154	-0.035	-0.072	0.254	-0.079
Hf	6.05	0.167	0.011	0.023	0.113	0.016	-0.112	0.198	0.067
Ta	1.98	0.214	0.040	-0.053	0.111	-0.126	-0.065	0.088	-0.013
Th	8.54	0.283	0.074	0.146	-0.059	-0.238	-0.062	-0.090	-0.033
U	10.29	0.084	0.041	0.136	0.106	-0.130	0.010	0.056	-0.022
Sr	11.87	0.064	-0.192	0.202	-0.018	-0.223	**0.316**	0.156	-0.179
Rb	2.94	0.122	**-0.567**	**-0.184**	-0.052	-0.140	-0.078	-0.105	0.058
Pb	561.38	**-0.070**	-0.075	**0.492**	0.261	0.106	**0.454**	-0.129	0.102
Ag	11.79	0.025	**0.109**	-0.004	**0.450**	0.072	-0.053	**-0.495**	0.027
Nb	22.46	**0.311**	**0.091**	0.065	0.078	**-0.248**	-0.061	-0.105	0.045
% VARIATION		37.962	19.308	12.327	6.501	5.627	4.462	3.022	2.604
% VARIATION CUMULATIVE		37.962	57.270	69.596	76.097	81.724	86.187	89.209	91.813
EIGENVALUES:		2.566	1.305	0.833	0.439	0.380	0.302	0.204	0.176

4.2 Group Descriptions

PCA plots were used to form preliminary compositional groups within the dataset. These were refined using biplots of individual elements. Three groups were defined (Figures 7-8). Summary statistics of the groups relative to the overall LA-ICP-MS dataset demonstrate that the relative percentage of standard deviation is lower within groups than it is within the entire combined dataset (Table 3). Group 1 (n=6) is enriched in alkali and alkaline earth metals, particularly cesium and rubidium, relative to the rest of the dataset. Group 2 (n=11) is depleted in REEs while Group 3 (n=10) is enriched in REEs, as well as titanium. Unassigned samples (n=3) generally fell in between these groups and could not be confidently assigned to any single group. This reflects the fact that the groups are weakly structured, with some overlap present on most plots. Group membership probabilities were further explored using Mahalanobis distance calculations (Table 4). The results suggest there is some coherency to the groups as defined. However, because of the small number of specimens per group these calculations are not considered very reliable.

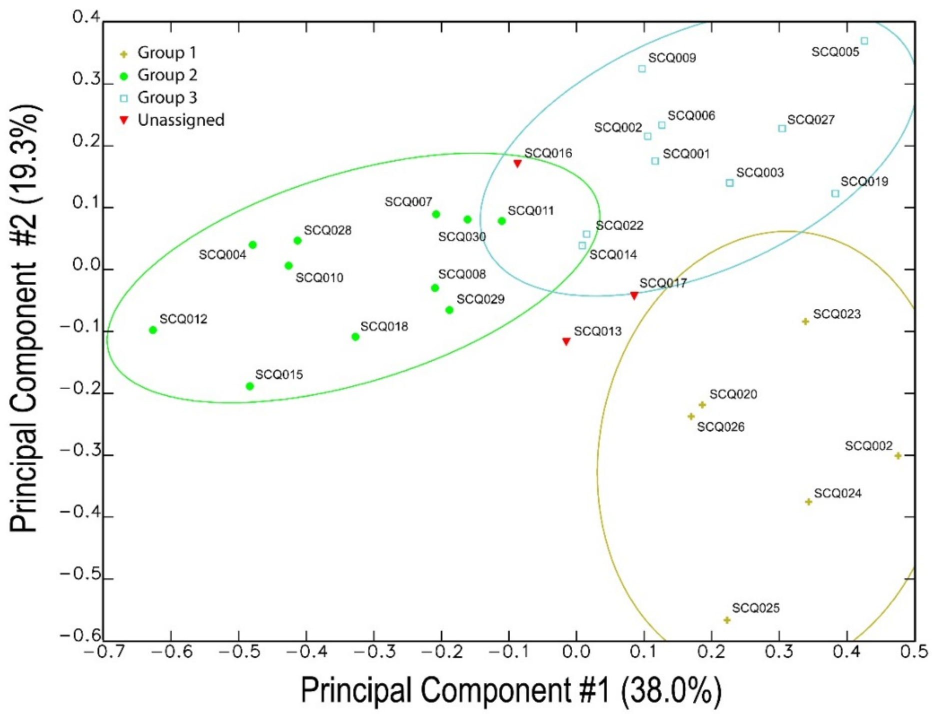

Figure 7. Scatterplot of the first two principal components calculated for the current sample with compositional groups plotted. Ellipses represent 90% confidence interval of group membership.

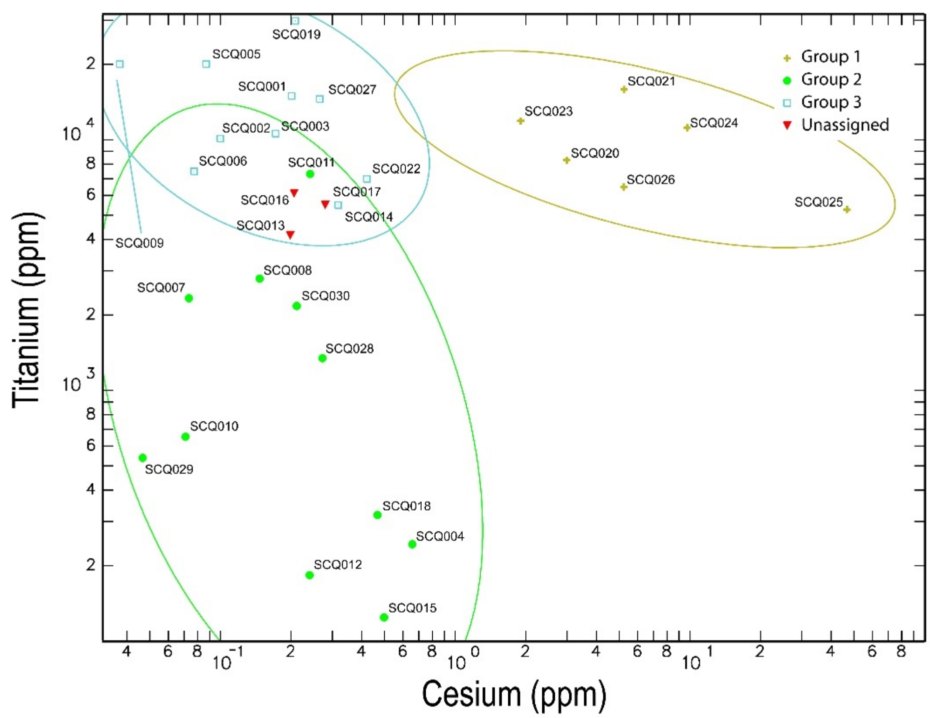

Figure 8. Bivariate plot of cesium and titanium concentrations with compositional groups plotted. Ellipses represent 90% confidence interval of group membership.

Table 3. Summary statistics by group compared to the overall LA-ICP-MS dataset.

	GROUP 1			GROUP 2			GROUP 3			OVERALL		
	Mean	SD	%SD	Mean	SD	%SD	Mean	SD	%SD	Mean	SD	%SD
Ti	9831.72	3935.76	40.03	1637.18	2111.83	128.99	14013.60	7579.94	54.09	7769.17	7163.94	92.21
V	89.81	35.62	39.66	479.22	648.61	135.35	46.51	39.54	85.00	250.17	466.06	186.30
Cr	240.37	315.14	131.10	66.27	75.96	114.62	71.15	33.45	47.01	108.88	156.51	143.75
Mn	238.13	145.96	61.29	126.96	76.94	60.60	92.47	127.65	138.05	134.64	117.69	87.41
Co	15.70	14.15	90.14	2.53	1.65	65.46	13.49	14.24	105.56	9.17	11.52	125.68
Ni	48.83	48.73	99.78	13.73	7.04	51.25	40.20	38.08	94.73	29.98	33.52	111.83
Zn	319.30	148.69	46.57	338.57	261.37	77.20	124.51	95.66	76.83	274.97	260.85	94.87
As	128.66	153.89	119.61	186.28	175.75	94.35	70.17	65.81	93.78	147.15	153.56	104.36
Rb	91.66	119.86	130.78	2.26	1.74	76.98	1.31	0.98	74.88	19.91	61.73	310.10
Sr	30.10	20.05	66.60	15.18	18.40	121.19	14.33	18.80	131.17	19.29	20.32	105.33
Zr	251.35	88.05	35.03	57.68	67.77	117.49	250.42	116.13	46.37	170.61	130.93	76.75
Sb	9.80	12.55	128.06	3.23	2.11	65.33	4.91	1.70	34.69	5.79	6.71	115.84
Cs	11.97	17.24	144.03	0.27	0.20	74.21	0.19	0.12	63.90	2.58	8.61	334.01
Ba	427.88	246.41	57.59	160.54	198.23	123.48	33.96	21.95	64.62	183.18	236.48	129.10
La	33.72	39.68	117.67	5.63	5.50	97.76	36.17	39.26	108.52	22.29	31.09	139.47
Ce	72.19	87.00	120.52	4.65	3.78	81.37	74.29	77.23	103.96	42.63	65.59	153.87
Nd	18.84	17.48	92.79	2.82	3.29	116.82	17.84	18.31	102.67	11.21	14.84	132.31
Sm	11.07	8.51	76.89	1.96	1.42	72.48	6.32	4.41	69.81	5.31	5.61	105.64
Eu	2.21	1.37	62.15	0.39	0.30	76.34	1.54	1.42	92.63	1.18	1.23	103.86
Tb	1.17	0.61	52.25	0.31	0.23	74.45	1.42	0.93	65.29	0.89	0.78	86.99
Yb	8.05	7.88	97.82	2.27	1.15	50.73	6.97	4.29	61.44	5.27	4.85	91.99
Lu	1.20	0.61	51.29	0.50	0.32	64.63	1.00	0.54	54.67	0.85	0.54	63.31
Hf	12.55	7.90	62.96	2.59	2.38	91.91	9.31	4.62	49.63	7.31	5.94	81.20
Ta	4.11	1.15	28.07	1.22	0.99	81.05	3.70	1.75	47.19	2.70	1.79	66.24
Pb	596.99	580.78	97.28	1402.17	1509.95	107.69	567.55	411.74	72.55	1170.30	1440.38	123.08
Th	20.21	9.82	48.60	5.07	4.54	89.53	18.34	11.04	60.18	13.34	10.34	77.49
U	14.15	7.99	56.47	9.39	5.63	60.00	13.56	7.91	58.29	12.09	6.81	56.32

Table 4. Group classification using Mahalanobis distance for the compositional groups within the LA-ICP-MS dataset. Calculated using the first 3 PCs (69.6% of the variation within the dataset) of the PCA described above. Best group is based on highest membership probability over .001%.

Group 1:

ANID	GROUP 1	GROUP 2	GROUP 3	BEST FIT
SCQ020	62.308	0.239	1.173	Group 1
SCQ021	73.739	0.028	0.265	Group 1
SCQ023	73.85	0.628	8.586	Group 1
SCQ024	95.131	0.032	0.217	Group 1
SCQ025	68.566	0.014	0.076	Group 1
SCQ026	79.005	0.523	3.015	Group 1

Group 2:

ANID	GROUP 1	GROUP 2	GROUP 3	BEST FIT
SCQ004	4.505	47.317	2.67	Group 2
SCQ007	10.407	67.159	8.967	Group 2
SCQ008	9.005	64.533	6.74	Group 2
SCQ010	6.316	66.821	3.909	Group 2
SCQ011	18.686	61.101	45.511	Group 2
SCQ012	3.99	51.144	1.573	Group 2
SCQ015	6.388	43.036	2.468	Group 2
SCQ018	10.6	65.738	8.269	Group 2
SCQ028	6.897	79.213	5.923	Group 2
SCQ029	10.54	60.232	9.224	Group 2
SCQ030	14.992	57.915	35.02	Group 2

Group 3:

ANID	GROUP 1	GROUP 2	GROUP 3	BEST FIT
SCQ001	27.842	8.898	97.648	Group 3
SCQ002	25.376	14.591	63.297	Group 3
SCQ003	39.523	6.62	85.581	Group 3
SCQ005	16.402	0.623	48.336	Group 3
SCQ006	25.568	9.202	87.264	Group 3
SCQ009	14.446	3.625	53.459	Group 3
SCQ014	29.441	31.38	61.545	Group 3
SCQ019	40.087	1.866	43.558	Group 3
SCQ022	23.473	9.806	38.988	Group 3
SCQ027	21.638	1.239	59.278	Group 3

Unassigned

ANID	GROUP 1	GROUP 2	GROUP 3	BEST FIT
SCQ013	28.704	13.112	20.432	Group 1
SCQ016	16.567	34.233	45.455	Group 3
SCQ017	19.154	15.16	16.984	Group 1

4.3 Group Assignments

Group assignments are summarized in Table 5 and detailed by specimen in Appendix A as well as in the digital file provided with this report. There were some weak associations between sites and groups. Sites 24ME163 and 24ME1109 comprised all of Group 1, however specimens from these sites were also included in other groups. All of 24ME1107 specimens were included in Group 2, but this group also included some portion of the sample from sites 24ME1108, 24ME161, 24ME163, and 24ME164. Similarly, Group 3 includes both of the specimens from 24ME1105 and 24ME165, but also some portion of the sample from 24ME1108, 24ME1109, 24ME161, 24ME163, and 24ME164. Samples from sites with only one specimen – sites 24ME160 and 24ME162 – were unassigned, as was one sample from 24ME161.

Group 1 is loosely associated with the central portion of the district, while Group 2 is most prevalent among sources in the eastern portion of the district. The composition of Group 3 is more varied, although the majority of the samples come from the western side of the district. The inability to assign samples from sites 24ME160 or 24ME162 to any group could be suggestive of distinct compositions, but within this dataset seems to be a result of these samples falling within the ranges of all three groups.

Overall, the variation within the dataset suggests there are some differences between local sources but that these are not distinct enough to be reliably distinguished at this level of analysis using this technique. This does not preclude the possibility that the district as a whole could be reliably fingerprinted and distinguished from other source zones using this method, only that internal variability is not reliability consistent to distinguish between sources within the district. As stated above, a reanalysis of Roll's specimens from other sources in southwestern Montana would help evaluate this possibility.

Table 5. Group assignments by site for LA-ICP-MS dataset.

	GROUP 1	**GROUP 2**	**GROUP 3**	**UNASSIGNED**	**SITE TOTAL**
24ME160				1	1
24ME161		1	1	1	3
24ME162				1	1
24ME163	4	1	2		7
24ME164		1	1		2
24ME165			2		2
24ME1105			2		2
24ME1107		6			6
24ME1108		2	1		3
24ME1109	2		1		3
GROUP TOTAL	6	11	10	3	30

5. NAA Dataset

5.1 Sample Structure

As with LA-ICP-MS, the general structure of the sample was assessed first by examining the elemental concentration data. Of the 33 elements returned by NAA, five elements – strontium (n=26), nickel (n=20), rubidium (n=19), calcium (n=13), and potassium (n=9) – had a high number of specimens (at least 30%) with levels below detection limits. These elements were eliminated from analyses due to these excessive missing values. This was expected as low concentrations of numerous elements is a common problem among compositional studies of chert using NAA.

Following these steps, a principal component analysis (PCA) was used to understand the most significant elements driving variation within the sample (Figure 9; Table 6). Rare earth elements (REEs; Th, Yb, Lu, Tb, Ce, La, Eu, Nd, Dy, Sm, Sc, and U), some transition metals (Co, Hf, Ta, Ti, Zr, and Cr), and antimony, aluminum, and barium are positively loaded on PC1. Cesium is negatively loaded on PC1. On PC2, most of the other transition metals (Fe, Mn, V, As, Zn, and Co, Sb, and Cr) are positively loaded, while barium is negatively loaded.

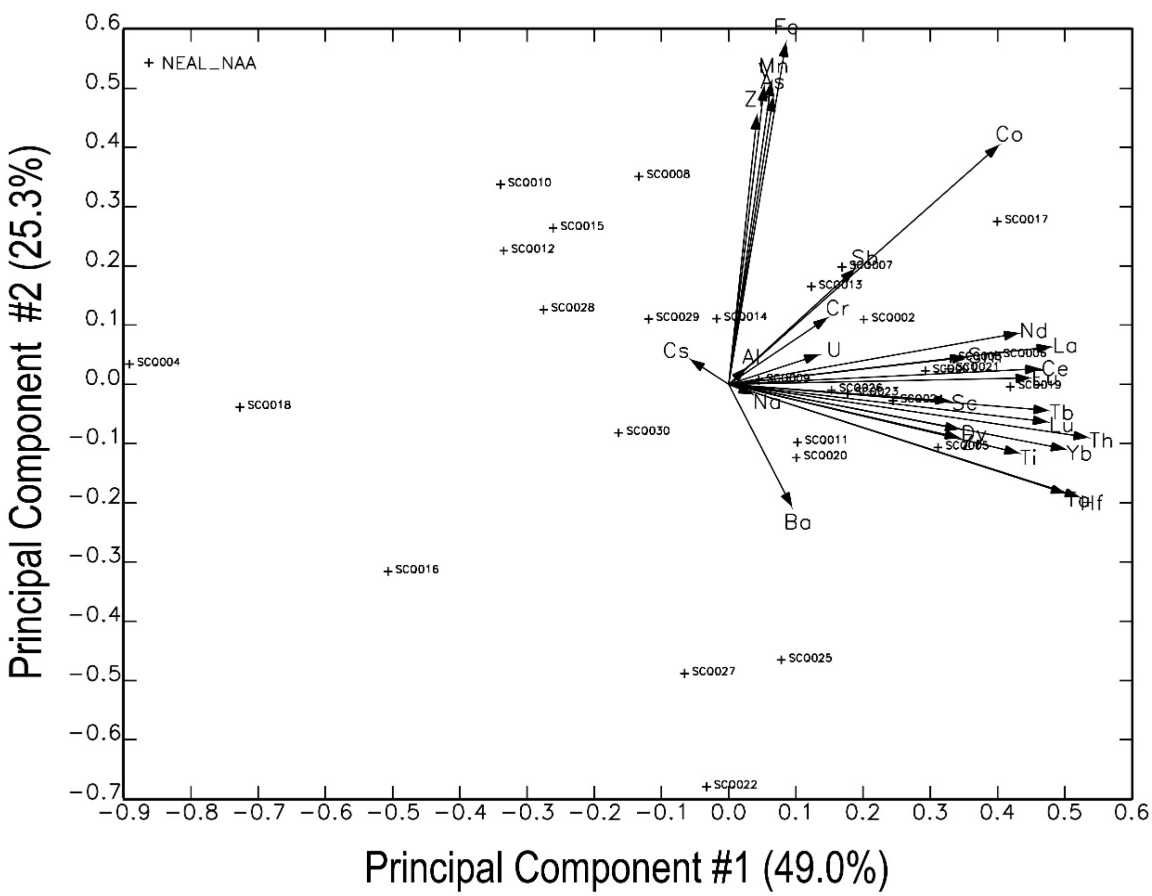

Figure 9. Biplot of the first two principal components calculated for the current dataset with labeled vectors demonstrating the loading of individual elements. 74.3% of the variation in the dataset is captured by the first two PCs.

Table 6. Elemental loadings for principal component axes 1-6 based on the variance-covariance matrix. Values in bold explain the greatest amount of variation within each component. Over 90% of the cumulative variance in the dataset is explained by the first 6 principal components.

VARIABLE	AVERAGE	PC1	PC2	PC3	PC4	PC5	PC6
Na	**76.258**	**0.019**	**-0.012**	**-0.084**	**-0.110**	**-0.060**	**0.021**
Al %	**0.239**	0.014	0.020	0.000	-0.099	-0.047	0.010
Sc	**0.712**	0.182	-0.021	-0.096	-0.183	0.117	-0.044
Ti %	**0.104**	**0.239**	-0.089	-0.017	0.014	0.052	0.167
V	**29.563**	0.029	**0.387**	**-0.356**	-0.067	**0.463**	0.010
Cr	**3.578**	0.081	0.086	-0.245	0.064	**0.278**	-0.105
Mn	**29.512**	0.035	**0.394**	0.147	**-0.502**	-0.055	0.258
Fe %	**2.353**	0.047	**0.444**	**-0.368**	**0.299**	-0.295	-0.275
Co	**0.923**	**0.222**	**0.311**	**0.484**	0.119	-0.162	0.128
Zn	**21.071**	0.023	**0.350**	0.138	-0.239	-0.273	0.060
As	**20.676**	0.037	**0.373**	-0.237	0.163	-0.124	0.162
Zr	**68.951**	0.190	-0.069	-0.056	0.026	0.023	0.195
Sb	**1.201**	0.104	0.149	0.057	0.027	**0.366**	**0.338**
Cs	**0.061**	**-0.031**	0.031	-0.003	-0.271	0.076	-0.218
Ba	**98.421**	0.052	**-0.158**	**-0.326**	**-0.376**	**-0.433**	0.034
La	**6.982**	**0.266**	0.049	0.167	0.128	0.057	-0.206
Ce	**10.723**	**0.256**	0.020	0.245	0.097	-0.015	-0.103
Nd	**5.079**	**0.238**	0.067	0.183	0.097	0.036	-0.195
Sm	**1.222**	0.195	0.035	0.081	0.047	-0.007	-0.170
Eu	**0.191**	**0.248**	0.008	0.029	-0.040	0.044	-0.266
Tb	**0.141**	**0.263**	-0.034	-0.094	-0.111	0.033	**-0.358**
Dy	**1.173**	0.190	-0.058	0.022	**-0.342**	**0.302**	-0.009
Yb	**0.841**	**0.277**	-0.084	-0.091	-0.194	-0.061	-0.035
Lu	**0.129**	**0.263**	-0.049	-0.083	-0.136	-0.174	-0.107
Hf	**1.789**	**0.289**	**-0.146**	-0.139	0.177	-0.129	**0.331**
Ta	**0.340**	**0.277**	**-0.142**	-0.147	0.120	-0.045	**0.308**
Th	**2.545**	**0.296**	-0.069	-0.109	0.083	-0.015	0.108
U	**3.709**	0.073	0.038	-0.106	0.059	-0.026	0.147
% VARIATION		48.977	25.330	8.655	4.247	2.551	2.329
% VARIATION CUMULATIVE		48.977	74.307	82.962	87.209	89.760	92.089
EIGENVALUES		3.243	1.677	0.573	0.281	0.169	0.154

Again, some spatial patterning is evident when the specimens are plotted according to site (Figures 10-11). It is more consistent within the NAA dataset than the LA-ICP-MS dataset. Generally, specimens from site 24ME1107 cluster together. Specimens from site 24ME161 plot with or near site 24ME1107, as do specimens from site 24ME1108. Site 24ME1109 specimens tend to cluster together and are mostly distinct from others. Sites with single specimens, 24ME160 and 24ME162, are also distinct, although this may be due to small sample size. Site 24ME162 is somewhat of an outlier.

Site 24ME163 also generally clusters together, with the exception of one outlier (SCQ018). These cluster with the samples from site 24ME1105 and from site 24ME165. Samples from each of these sites are tightly clustered with each other, suggesting they are similar and that these sources may be fairly homogenous, although again a larger sample size would help clarify their compositional profiles. The two samples from site 24ME164 appear to be relatively dissimilar, with one clustering among sites 24ME163, 24ME1105, 24ME165 and the other (SCQ004) appearing as somewhat of an outlier.

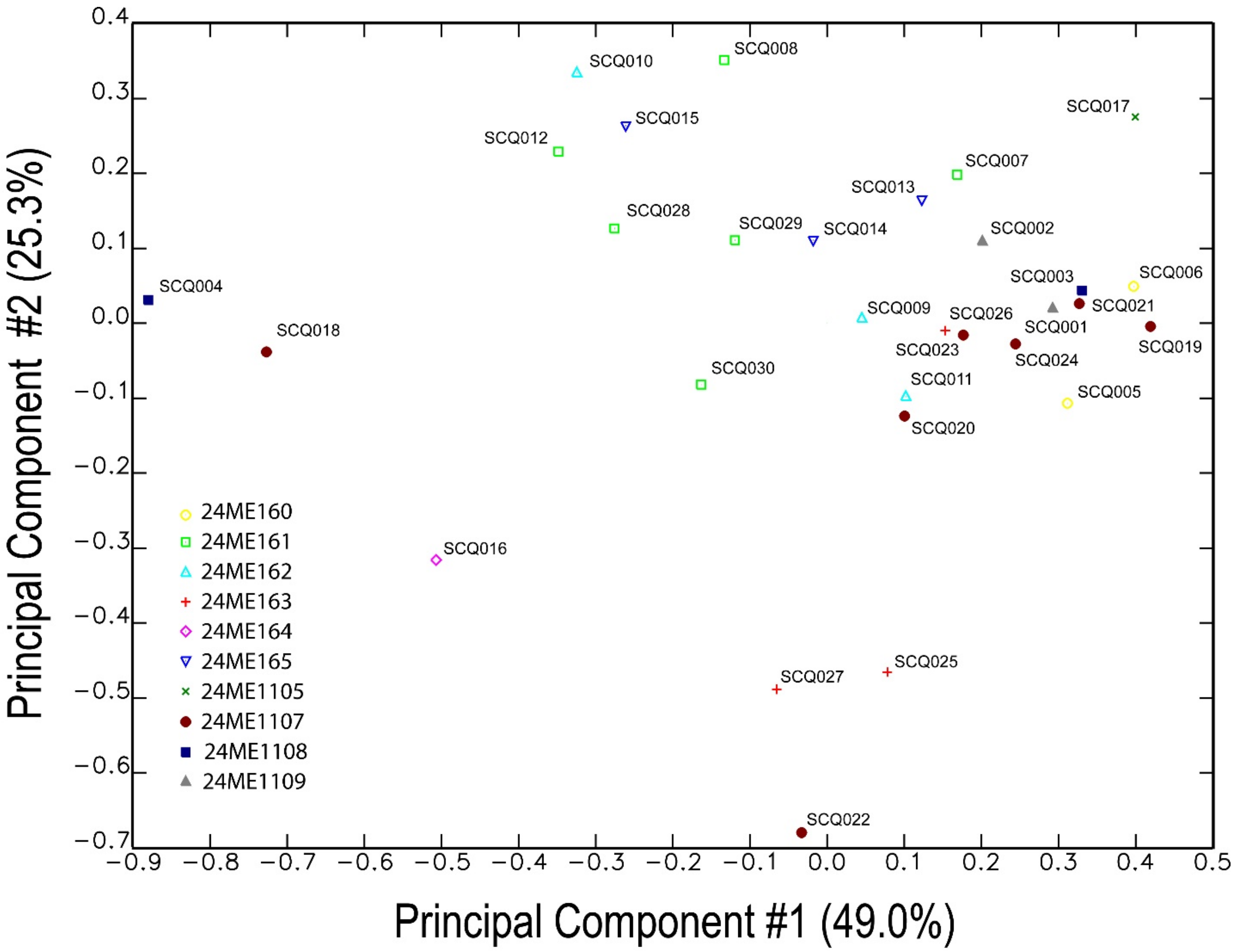

Figure 10. Scatterplot of the first two principal components calculated for the current dataset with specimens labeled according to their provenience.

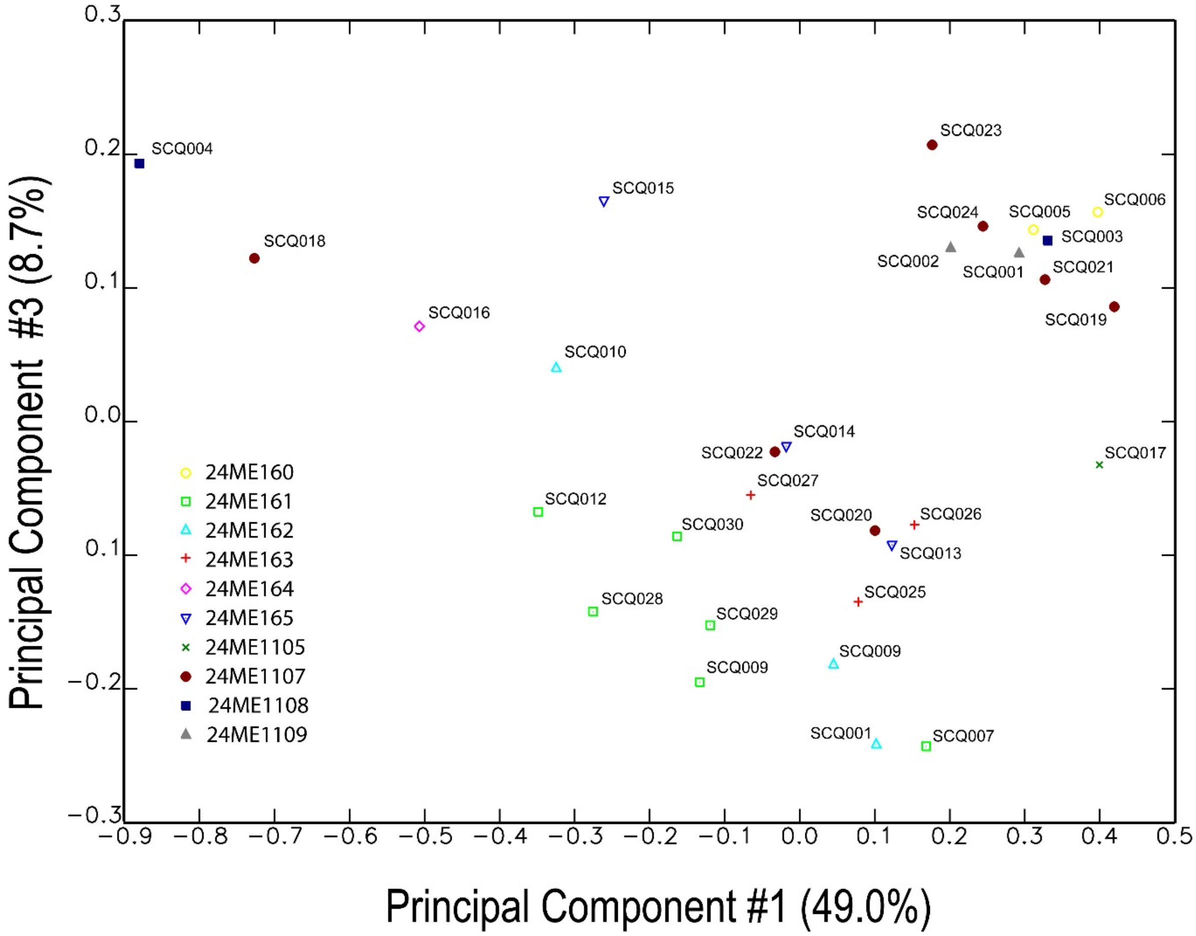

Figure 11. Scatterplot of the first and third principal components calculated for the current dataset with specimens labeled according to their provenience.

Supporting the apparent variation in composition by site, the percent standard deviation (%SD) tended to be greater for the dataset as a whole than it was when split by site (Table 7), suggesting that internal variation by source was generally less than that of the overall sample for the district (see for example values for Cr, Zn, Mn).

Table 7. Summary statistics by site for the NAA dataset.

	WHOLE DATASET		A		B		C		D		E	F		G	H		I		J	
	Mean	%SD	Mean	%SD	Mean	%SD	Mean	%SD	Mean	%SD		Mean	%SD		Mean	%SD	Mean	%SD	Mean	%SD
As	41.84	135.15	17.13	25.85	86.66	113.34	35.91	40.83	33.14	152.98	2.99	76.04	95.98	79.96	13.93	54.70	25.17	71.33	17.53	103.32
La	12.18	97.39	32.64	4.66	4.52	29.78	3.58	39.35	6.88	50.57	1.76	6.94	44.02	23.36	17.98	83.94	14.33	137.64	20.55	40.81
Lu	0.19	70.59	0.29	9.52	0.11	123.96	0.18	89.80	0.24	26.65	0.03	0.14	33.05	0.57	0.20	51.66	0.14	138.72	0.26	17.99
Nd	8.37	97.91	23.12	8.48	3.53	49.85	2.87	26.48	4.50	57.82	0.81	5.35	18.40	10.55	12.14	89.40	10.68	135.67	13.92	35.03
Sm	1.66	76.41	3.94	6.25	0.94	52.00	0.88	12.75	1.25	33.62	0.23	1.38	21.33	1.88	2.13	78.71	1.89	130.73	2.45	33.15
U	4.15	46.43	4.46	19.51	4.37	67.94	5.47	31.84	3.37	26.14	1.97	3.79	65.45	7.96	4.10	25.58	3.10	77.07	3.35	0.22
Yb	1.33	70.95	2.03	10.37	0.70	120.85	1.27	85.02	1.70	28.75	0.20	0.92	29.87	4.10	1.42	51.70	1.03	138.20	1.87	12.12
Ce	19.51	104.23	55.11	5.28	4.31	20.38	6.43	31.04	11.55	46.80	2.60	10.10	41.82	37.34	29.91	85.01	25.17	135.91	32.64	39.67
Co	2.37	126.27	8.48	75.96	0.49	60.51	0.69	79.71	0.38	135.12	0.15	1.56	44.21	4.11	3.39	87.14	3.37	132.36	4.29	17.35
Cr	4.43	66.97	3.57	27.13	8.14	51.58	4.44	12.91	3.38	26.06	0.58	3.19	54.54	7.73	3.39	54.34	2.77	51.79	3.14	35.94
Cs	0.06	111.72	0.03	43.67	0.01	244.95	0.04	100.88	0.07	27.90	0.03	0.14	124.36	0.08	0.08	81.33	0.10	83.08	0.06	17.99
Eu	0.28	69.35	0.60	5.53	0.15	50.75	0.14	45.69	0.24	27.62	0.03	0.28	19.64	0.38	0.37	67.24	0.26	135.87	0.37	21.01
Fe %	5.91	139.19	2.26	81.41	16.70	73.02	8.81	90.54	2.31	149.26	0.3	5.74	44.79	6.6	1.39	61.98	1.11	122.99	1.63	31.48
Hf	3.00	69.40	5.91	24.69	1.49	89.30	2.65	81.01	4.41	29.85	0.53	1.17	89.93	5.83	3.76	50.58	2.45	139.80	3.49	16.76
Sb	1.65	89.99	2.01	9.49	1.76	66.68	1.00	12.30	0.73	101.95	0.75	0.92	58.54	7.60	1.61	86.87	1.71	44.38	1.99	47.06
Sc	0.96	71.18	1.52	33.90	0.63	70.83	1.21	91.12	0.73	42.17	0.32	0.78	10.90	3.01	1.08	57.43	0.63	110.29	0.78	1.03
Ta	0.55	64.40	0.87	12.87	0.31	82.57	0.53	82.49	0.78	35.48	0.08	0.26	87.65	1.04	0.71	46.95	0.38	137.97	0.66	18.97
Tb	0.20	64.86	0.36	12.36	0.11	110.73	0.18	82.61	0.28	19.62	0.02	0.17	22.94	0.42	0.22	60.82	0.16	137.78	0.27	9.50
Th	4.21	75.50	9.09	13.39	2.35	91.72	3.25	90.81	3.62	42.33	0.55	2.90	108.21	7.38	5.71	63.75	3.77	138.68	4.73	36.28
Zn	39.28	118.11	19.07	50.29	24.12	69.68	64.95	76.59	2.75	63.10	2.46	105.83	72.80	175.32	25.43	46.57	32.50	40.64	27.10	13.95
Zr	89.05	64.29	167.60	18.99	44.81	84.72	85.57	77.82	103.76	31.43	21.06	48.64	72.80	200.12	109.33	42.61	78.84	126.00	104.66	14.48
Al %	0.25	29.80	0.26	1.02	0.23	21.35	0.24	6.07	0.20	7.96	0.2	0.29	4.20	0.3	0.26	54.11	0.26	5.26	0.28	28.64
Ba	181.51	137.19	38.27	56.88	93.40	42.14	214.94	93.75	516.73	98.25	123.80	179.76	99.90	85.73	128.27	128.21	41.88	67.52	441.48	130.34
Dy	1.58	65.26	2.38	8.23	0.81	96.03	1.26	80.37	2.14	24.46	0.2	1.20	17.35	3.8	1.69	51.25	1.22	141.42	2.90	23.93
Mn	86.56	212.44	18.52	71.29	48.81	55.40	36.15	104.24	10.16	120.89	5.4	115.57	71.80	396.5	19.32	100.25	47.56	32.89	574.53	95.08
Na	81.68	42.22	62.12	0.34	68.28	27.72	110.08	42.33	72.23	10.95	102.3	94.14	18.43	176.9	82.19	51.67	59.66	13.14	56.63	8.74
Ti %	0.16	69.56	0.28	10.13	0.06	57.47	0.16	79.18	0.17	33.70	0.0	0.06	59.90	0.3	0.21	49.44	0.14	131.19	0.25	12.51
V	82.43	213.84	15.33	25.91	281.24	120.08	85.02	41.25	8.20	106.41	3.5	41.28	12.52	159.9	17.55	66.90	19.27	40.42	13.32	141.42

5.2 Group Descriptions

Spatial patterning by site and the associations outlined above split the sample into two larger groups – one that is enriched in REEs and other elements that are positively loaded on PC1 and one that is depleted in REEs and most other elements but particularly Co and Ba. The former is labeled Group 1, with 10 specimens, and the latter Group 2, with 12 specimens (Figures 12-13. Group 3, with only two specimens, is enriched in barium and depleted in Fe, V, Mn, As, and Zn (Figures 12-15).

Although not included in the analyses, some of the excluded elements differed across the groups. Group 1 had a higher mean for nickel (at 13.91 ppm) than any of the other groups and the dataset as a whole (at 4.83 ppm). Group 2, unlike other groups, was missing all strontium values, and also had higher rubidium (1.49 ppm), calcium (567.70 ppm), and potassium (576.44 ppm) means than the other two groups and the dataset as a whole (Rb =.97 ppm, Ca =273.03 ppm, K=433.02 ppm). Group 3 had nickel and calcium values below detection limits for both specimens in the group, but Sr (7.84 ppm) was higher than other groups and the dataset as a whole (1.90 ppm).

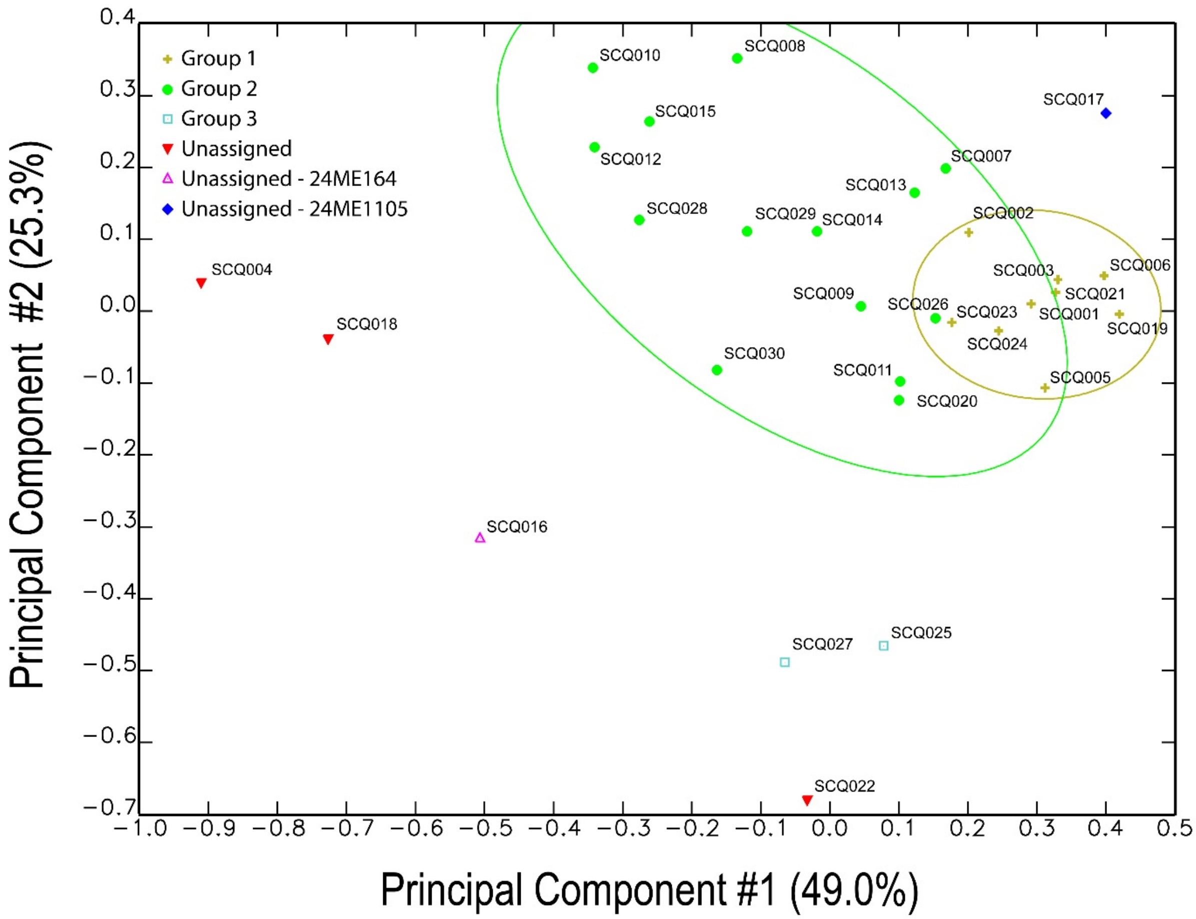

Figure 12. Scatterplot of the first two principal components calculated for the current sample with compositional groups plotted. Ellipses represent 90% confidence interval of group membership. Group 3 has too few members to plot ellipses.

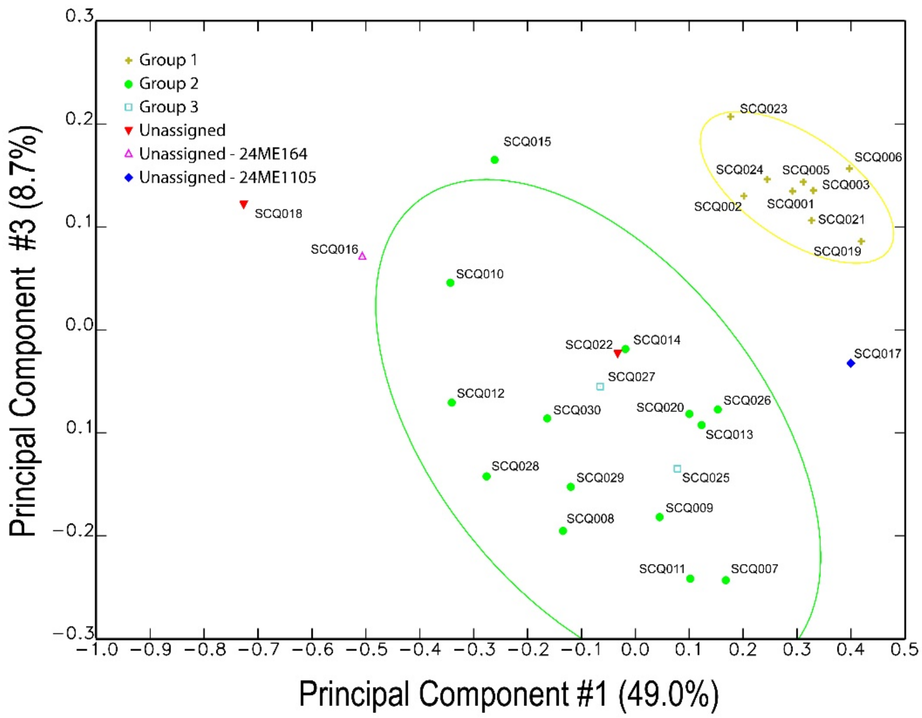

Figure 13. Scatterplot of the first and third principal components calculated for the current sample with compositional groups plotted. Ellipses represent 90% confidence interval of group membership. Group 3 has too few members to plot ellipses.

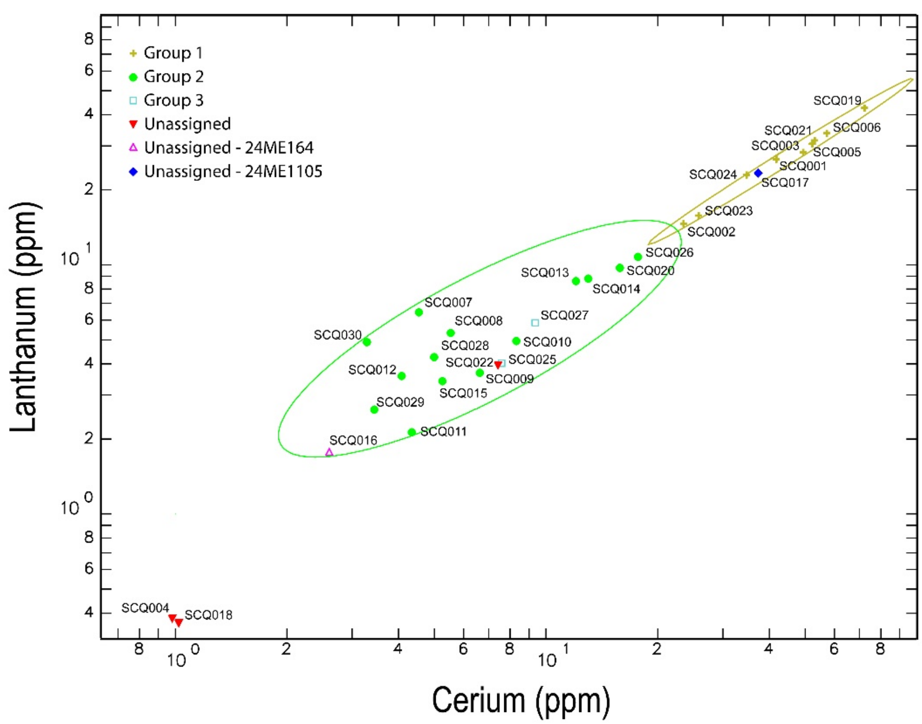

Figure 14. Bivariate plot of cerium and lanthanum concentrations with compositional groups plotted. Ellipses represent 90% confidence interval of group membership.

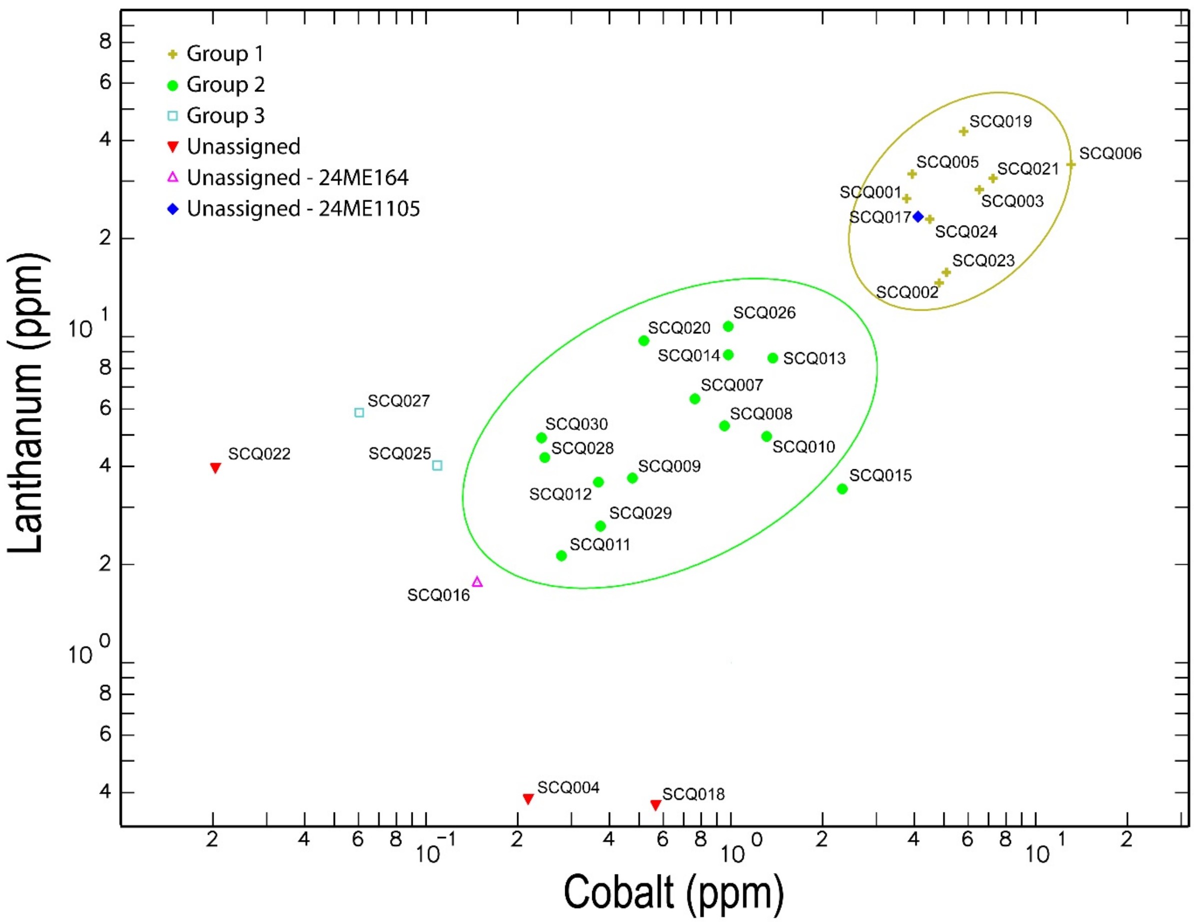

Figure 15. Bivariate plot of cobalt and lanthanum concentrations with compositional groups plotted. Ellipses represent 90% confidence interval of group membership.

5.3 Group Assignments

Group assignments are summarized in Table 8 and presented in detail in Appendix A in the digital file provided with this report. Summary statistics by compositional group are provided in Table 9 and can be compared relative to summary statistics by site (see above Table 7).

Group 1 is made up of most site 24ME163 specimens, all specimens from site 24ME1105 and 24ME165, and one specimen from site 24ME164. Group 2 is made up of all specimens from site 24ME1107, as well as specimens from site 24ME1108 and 24ME161, and one specimen each from sites 24ME1109 and 24ME163. This might be best described as similar in nature to the "undifferentiated group" in Roll et al. (2005). The remaining 24ME1109 specimens fall into their own group, Group 3. As noted above, there are several unassigned samples, including the single specimens from sites 24ME160 and 24ME162.

The trends in these larger groups have some broader spatial relationships as well (see Figure 2), with Group 1 associated with sources in the southwestern portion of the district, and Group 2 mostly with northeastern sources within the district. While preliminary, this suggests there may be some detectable chemical variation by source area within the district itself that may lend itself to artifact sourcing at a surprisingly detailed scale of analysis. There is a strong chance, however, that increased sample sizes will further expand the range of variation within each group, increasing overlap amongst them.

Table 8. Group assignments by site.

	GROUP 1	**GROUP 2**	**GROUP 3**	**UNASSIGNED**	**SITE TOTAL**
24ME160				1	1
24ME161		3			3
24ME162				1	1
24ME163	4	1		2	7
24ME164	1			1	2
24ME165	2				2
24ME1105	2				2
24ME1107		6			6
24ME1108		3			3
24ME1109		1	2		3
GROUP TOTAL	**9**	**14**	**2**	**5**	**30**

Table 9. Summary statistics by compositional group for the NAA dataset.

	GROUP 1				GROUP 2			GROUP 3		
	Mean	StDev	%SD		Mean	StDev	%SD	Mean	StDev	%SD
As	19.01	10.50	55.27	68.77	72.33	105.18	19.01	3.87	0.86	22.28
La	27.38	8.79	32.10	5.65	2.77	48.97	27.38	4.94	1.29	26.10
Lu	0.26	0.06	22.39	0.14	0.11	78.09	0.26	0.24	0.09	37.27
Nd	18.99	6.85	36.06	4.22	1.83	43.42	18.99	3.01	0.40	13.29
Sm	3.21	1.14	35.56	1.10	0.42	38.41	3.21	1.01	0.17	16.63
U	4.21	0.85	20.28	4.46	2.29	51.49	4.21	3.37	1.24	36.87
Yb	1.86	0.40	21.69	0.98	0.75	76.46	1.86	1.75	0.68	38.67
Ce	45.55	15.72	34.51	7.78	4.84	62.16	45.55	8.47	1.24	14.68
Co	6.08	2.85	46.96	0.80	0.58	73.19	6.08	0.08	0.03	40.53
Cr	3.55	1.18	33.31	5.81	3.47	59.67	3.55	2.91	0.47	16.01
Cs	0.05	0.01	26.34	0.06	0.10	151.31	0.05	0.06	0.02	35.63
Eu	0.51	0.13	26.45	0.19	0.09	45.04	0.51	0.21	0.06	27.71
Fe %	1.86	0.89	47.72	10.83	9.95	91.87	1.86	0.32	0.10	30.52
Hf	4.66	1.28	27.43	1.94	1.51	78.01	4.66	4.60	1.81	39.25
Sb	2.25	0.85	37.56	1.32	0.88	66.19	2.25	0.30	0.06	20.63
Sc	1.14	0.39	33.82	0.89	0.65	72.48	1.14	0.72	0.43	60.60
Ta	0.82	0.14	17.33	0.39	0.29	74.38	0.82	0.81	0.39	47.62
Tb	0.30	0.08	26.48	0.15	0.11	70.45	0.30	0.27	0.07	27.82
Th	7.36	2.56	34.74	2.90	2.26	78.07	7.36	3.86	2.08	54.01
Zn	27.71	8.15	29.42	49.01	51.86	105.82	27.71	1.75	0.26	14.80
Zr	136.06	31.39	23.07	61.57	43.65	70.90	136.06	107.22	45.34	42.28
Al	2453.08	463.72	18.90	2650.81	951.72	35.90	2453.08	1908.95	12.37	0.65
Ba	137.11	267.63	195.20	168.38	151.88	90.20	137.11	713.89	531.33	74.43
Dy	2.35	0.60	25.44	1.15	0.75	64.98	2.35	2.13	0.74	34.81
Mn	147.74	310.00	209.84	55.91	52.24	93.44	147.74	3.10	1.65	53.28
Na	63.07	9.53	15.10	90.94	37.31	41.03	63.07	70.05	9.83	14.03
Ti	2664.69	437.78	16.43	996.40	803.32	80.62	2664.69	1734.70	792.10	45.66
V	18.55	10.19	54.93	150.36	241.52	160.63	18.55	3.19	1.30	40.66

5.4 Comparison to MURR NAA Database

NAA data for the current sample was compared with MURR's NAA chert database (n=7040). Comparisons focused on materials from Plains states where MURR has collected chert data (Figure 16) with a total of 1,294 comparative samples. Particular attention was given to an additional sample of porcellanite and nonvolcanic glass from far eastern Montana (n=54), submitted by Roll in 2003 (ANIDS: PNV101-511; see Speakman 2003). Comparisons were made using two forms of analysis. The first was the examination of biplots using PCA and individual elemental concentrations. This was complemented by Euclidean distance searches for each specimen against the entirety of the existing database to find the closest compositional matches by specimen.

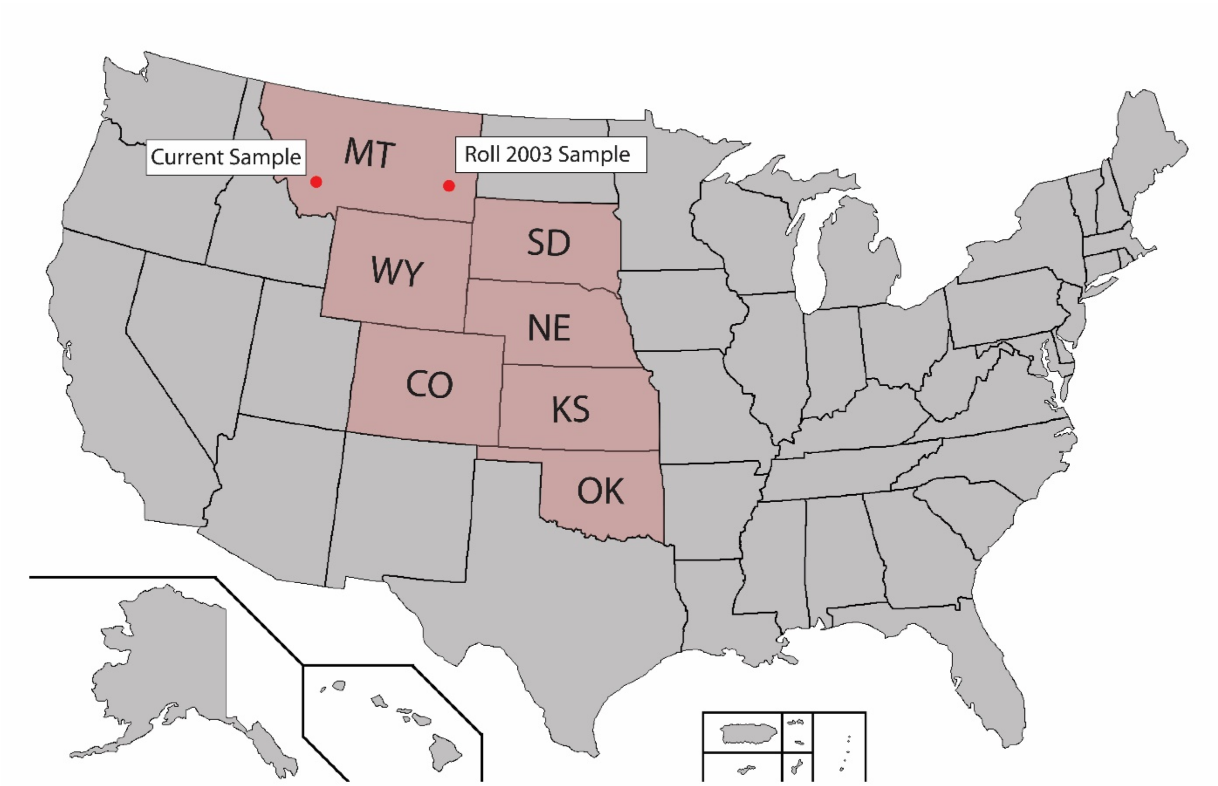

Figure 16. Plains states represented in MURR's NAA chert database, with the current study and Roll's 2003 sample locations indicated.

As Figures 17-18 demonstrate, the current sample is distinct from most of the chert samples within MURR's chert database for the Plains region. It is also easily distinguishable from the nearest comparative dataset (although of dissimilar materials) from eastern Montana (i.e., Roll's 2003 sample). The Euclidean distance search also demonstrated that the closest matches for the current dataset, although distant, tend to be from outcrops in central Colorado. This is certainly due to coincidental geological similarities that resulted in similar chemical composition, rather than any actual association between the samples. Overall, these comparative results are promising as they suggest that chert sources from southwestern Montana may be distinguished from other chert producing areas on the Plains.

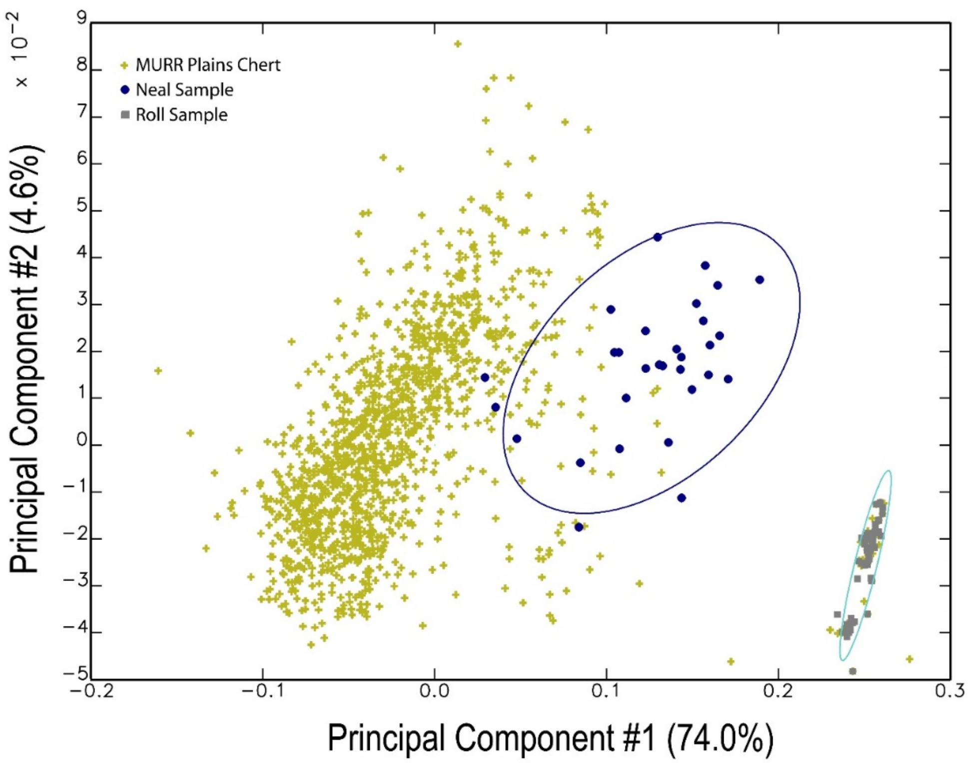

Figure 17. Scatterplot of the first two principal components calculated for the MURR chert database for the northern Plains. The current sample and Neal 2003 sample are indicated.

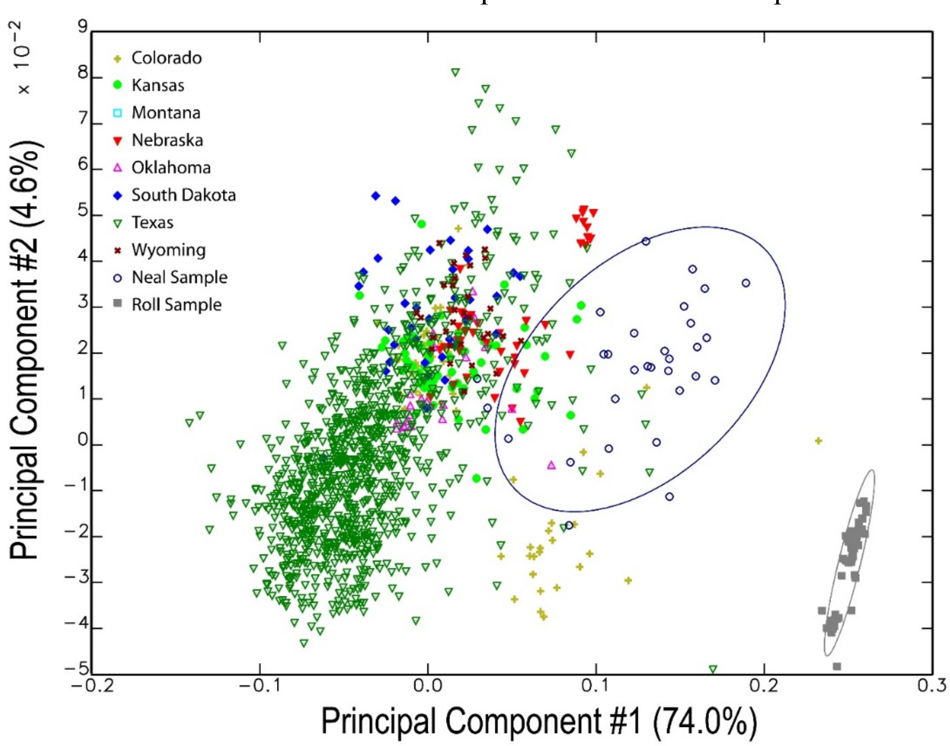

Figure 18. Scatterplot of the first two principal components calculated for the MURR chert database for the northern Plains, plotted by state.

6. Summary

The analyses detailed here suggest there is some potential for the Sheep Creek Stone Surface Quarry district to be chemically fingerprinted using archaeometric techniques. The scale at which this can be accomplished remains to be determined pending increased and more spatially representative sampling of chert sources in the region. Additionally, results of both NAA and LA-ICP-MS analyses were suggestive of spatial patterning within the current dataset, with the NAA dataset more clearly demonstrating some level of possible differentiation between sources within the district itself.

Future studies should focus on expanding coverage of chert sources within western Montana, particularly reanalysis of previous samples submitted by Roll (Roll et al. 2005; Speakman 2003; Speakman and Glascock 2002). It is advisable that both NAA and LA-ICP-MS techniques be employed until the relationships between these types of datasets is further clarified for chert materials.

7. Acknowledgments

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8. References Cited

Baxter, Michael J.

1992 Archaeological uses of the biplot—a neglected technique? In *Computer Applications and Quantitative Methods in Archaeology, 1991*, edited by G. Lock and J. Moffett. BAR International Series S577, 141–148. Tempvs Reparatvm, Archaeological and Historical Associates, Oxford.

1994 *Exploratory Multivariate Analysis in Archaeology*. Edinburgh University Press, Edinburgh.

Baxter, M.J. and C.E. Buck

2000 Data Handling and Statistical Analysis. In *Modern Analytical Methods in Art and Archaeology*, edited by E. Ciliberto and G. Spoto, pp. 681-746. John Wiley and Sons,

Bieber, Alan M. Jr., Dorothea W. Brooks, Garman Harbottle, and Edward V. Sayre

1976 Application of multivariate techniques to analytical data on Aegean ceramics. *Archaeometry* 18:59–74.

Bishop, Ronald L. and Hector Neff

1989 Compositional data analysis in archaeology. In *Archaeological Chemistry IV*, edited by R. O. Allen, pp. 576–586. Advances in Chemistry Series 220, American Chemical Society, Washington, D.C.

Bishop, Ronald L., Robert L. Rands, and George R. Holley

1982 Ceramic compositional analysis in archaeological perspective. In *Advances in Archaeological Method and Theory*, vol. 5, pp. 275–330. Academic Press, New York.

Brill, R.H., & B.A. Rising

1999 Chemical Analyses of Early Glasses, Vol. 2. Corning Museum of Class, Corning, New York.

Glascock, Michael D.

1992 Characterization of archaeological ceramics at MURR by neutron activation analysis and multivariate statistics. In *Chemical Characterization of Ceramic Pastes in Archaeology*, edited by H. Neff, pp. 11–26. Prehistory Press, Madison, WI.

Gratuze, B.

1999 Obsidian Characterization by Laser Ablation ICP-MS and its Application to Prehistoric Trade in the Mediterranean and the Near East: Sources and Distribution of Obsidian within the Aegean and Anatolia. *Journal of Archaeological Science* 26: 869-881.

Gratuze, B., Blet-Lemarquand, M. and Barrandon, J-N.

2001 Mass spectrometry with laser sampling: a new tool to characterize archaeological materials. *Journal of Radioanalytical and Nuclear Chemistry* 247: 645-656.

Harbottle, Garman
1976 Activation analysis in archaeology. *Radiochemistry* 3:33–72. The Chemical Society, London.

Leese, Morven N. and Peter L. Main
1994 The efficient computation of unbiased Mahalanobis distances and their interpretation in archaeometry. *Archaeometry* 36:307–316.

Mardia, Kantilal, John T. Kent, and John Bibby
1979 *Multivariate Analysis*. Academic Press, London, UK.

Neal, Jessica and Rachael Nixon
2020 Cultural Resources Mitigation Plan for Site 24ME1111 Black Butte Copper Project Meagher County, Montana.

Neff, Hector
1992 Introduction. In *Chemical Characterization of Ceramic Pastes in Archaeology*, edited by H. Neff, pp. 1–10. Prehistory Press, Madison.

1994 RQ-mode principal components analysis of ceramic compositional data. *Archaeometry* 36:115–130.

2000 Neutron activation analysis for provenance determination in archaeology. In *Modern Analytical Methods in Art and Archaeology*, edited by E. Ciliberto and G. Spoto, pp. 81–134. John Wiley and Sons, New York.

2002 Quantitative techniques for analyzing ceramic compositional data. In Ceramic *Source Determination in the Greater Southwest*, edited by D. M. Glowacki and H. Neff. *Cotsen Institute of Archaeology, UCLA,* Los Angeles.

Pearce, N.J.G., W.T. Perkins, J.A. Westgate, M.T. Gorton, S.E. Jackson, C.R. Neal, and S.P. Chenery
1997 A compilation of new and published major and trace element data for NIST SRM 610 and SRM 612 glass reference materials, *Geostandards Newsletter*, XXI: 114-115.

Peterson, Lynn and Kyle Barnett
2015 Site form 24ME1111 on file at the Montana State Historic Preservation Office, Helena, MT.

Roll, Thomas E., M. P. Neely, R. J. Speakman, and M. D. Glascock.
2005 Characterization of Montana Chert by LA-ICP-MS. In Laser Ablation ICP-MS in Archaeological Research edited by Robert J. Speakman and Michael D. Glascock, pp. 58-74, University of New Mexico Press, Albuquerque.

Sayre, Edward V.
1975 Brookhaven Procedures for Statistical Analyses of Multivariate Archaeometric Data. Brookhaven National Laboratory Report BNL-23128. New York.

Speakman, Robert J.
2003 LA-ICP-MS Analysis of Chert from Southwestern Montana. *Correspondence with*: Tom Roll. Archaeometry Laboratory, University of Missouri Research Reactor. [See also Appendix B. in Roll 2003 "The Camp Baker Quarry (24ME467):200"].

Speakman, Robert J. and Michael D. Glascock
2002 Laser Ablation ICP-MS Analysis of Chert from the Camp Baker Quarry Site (24ME467), Montana. Report prepared for: Tom Roll. Archaeometry Laboratory, University of Missouri Research Reactor.

Steponaitis, Vincas, M. James Blackman, and Hector Neff
1996 Large-scale compositional patterns in the chemical composition of Mississippian pottery. *American Antiquity* 61:555–572.

Tetra Tech
2015 Cultural Resource Inventory of Proposed Mine Facilities and Access Roads within the Black Butte Copper Project Area, Meagher County, Montana.

Weigand, Phil C., Garman Harbottle, and Edward V. Sayre
1977 Turquoise sources and source analysis: Mesoamerica and the southwestern U.S.A. In *Exchange Systems in Prehistory*, edited by T. K. Earle and J. E. Ericson, pp. 15–34. Academic Press, New York.

9. Appendix A

Specimen assignments to NAA and LA-ICP-MS compositional groups with limited descriptive data.

ANID	Site Number	Description	Provenance	Period	NAA Group	LA-ICP-MS Group
SCQ001	24ME165	Debitage	Surface	Prehistoric	Group_1	Group_3
SCQ002	24ME165	Debitage	Surface	Prehistoric	Group_1	Group_3
SCQ003	24ME164	Debitage	Surface	Prehistoric	Group_1	Group_3
SCQ004	24ME164	Debitage	Surface	Prehistoric	Unas	Group_2
SCQ005	24ME1105	Debitage	Excavation	Prehistoric	Group_1	Group_3
SCQ006	24ME1105	Debitage	Excavation	Prehistoric	Group_1	Group_3
SCQ007	24ME1107	Debitage	Surface	Prehistoric	Group_2	Group_2
SCQ008	24ME1107	Debitage	Surface	Prehistoric	Group_2	Group_2
SCQ009	24ME1108	Debitage	Surface	Prehistoric	Group_2	Group_3
SCQ010	24ME1108	Debitage	Surface	Prehistoric	Group_2	Group_2
SCQ011	24ME1108	Debitage	Surface	Prehistoric	Group_2	Group_2
SCQ012	24ME1107	Debitage	Surface	Prehistoric	Group_2	Group_2
SCQ013	24ME161	Debitage	Surface	Prehistoric	Group_2	Unas
SCQ014	24ME161	Debitage	Surface	Prehistoric	Group_2	Group_3
SCQ015	24ME161	Debitage	Surface	Prehistoric	Group_2	Group_2
SCQ016	24ME160	Debitage	Surface	Prehistoric	Unas_E	Unas
SCQ017	24ME162	Debitage	Surface	Prehistoric	Unas_G	Unas
SCQ018	24ME163	Debitage	Surface	Prehistoric	Unas	Group_2
SCQ019	24ME163	Debitage	Surface	Prehistoric	Group_1	Group_3
SCQ020	24ME163	Debitage	Surface	Prehistoric	Group_2	Group_1
SCQ021	24ME163	Debitage	Surface	Prehistoric	Group_1	Group_1
SCQ022	24ME163	Debitage	Surface	Prehistoric	Unas	Group_3
SCQ023	24ME163	Debitage	Surface	Prehistoric	Group_1	Group_1
SCQ024	24ME163	Debitage	Surface	Prehistoric	Group_1	Group_1
SCQ025	24ME1109	Debitage	Surface	Prehistoric	Group_3	Group_1
SCQ026	24ME1109	Debitage	Surface	Prehistoric	Group_2	Group_1
SCQ027	24ME1109	Debitage	Surface	Prehistoric	Group_3	Group_3
SCQ028	24ME1107	Unworked Cobble	Surface	N/A	Group_2	Group_2
SCQ029	24ME1107	Unworked Cobble	Surface	N/A	Group_2	Group_2
SCQ030	24ME1107	Unworked Cobble	Surface	N/A	Group_2	Group_2