OBSIDIAN PROCUREMENT AREA STUDIES: EXCAVATIONS AT BEAR GULCH, IDAHO

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Patrick Martin Raley

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Describing and explaining lithic variability in an obsidian procurement site addresses questions that are of great interest to lithic analysts. These include questions concerning technological shifts, foraging models, mobility patterns, resource availability, resource intensification, and site formation processes, and their effect on assemblage characteristics. In this study, data from Bear Gulch, Idaho is analyzed to determine trends in lithic reduction intensity. These trends are used to explain prehistoric behavior at this site. The Bear Gulch site provides a unique opportunity to study lithic variability as well as site formation processes because the site is located at a high quality obsidian source and a large quantity of artifacts were retrieved from root systems. Data is presented on cortical versus non-cortical obsidian debris in categories of frequency, weight and proportion changes through time. Possible explanations for the

trends observed at Bear Gulch are then posed. The data suggests that more than one factor is directly responsible for the variability in these archaeological deposits.

Las descripciónes y las explicaciónes de la variabilidad lítica encontrada en un yacimiento de la consecución de la obsidiana plantean algunas preguntas que están de gran interés para los analistas de las piedras. Éstas preguntas se centran en cambios tecnológicos, los modelos del forraje, los modelos de la movilidad, la disponibilidad y la intensificación de los recursos naturales, y los procesos de la formación del sitio, y sus efectos sobre las características de la colección. Éste estudio analiza los datos del yacimiento de Bear Gulch, Idaho para determinar las tendencias en la intensidad de la reducción de las piedras. Se utilizan estas tendencias para explicar la conducta prehistórica de los humanos en este lugar. El yacimiento de Bear Gulch presenta una oportunidad única para estudiar la variabilidad lítica así como los procesos de la formación del yacimiento porque está situado en una fuente de la obsidiana de buena calidad. Muchos artefactos de la obsidiana fueron encontrados en las raíces de los árboles. Éste estudio presenta los datos del artifactos de la obsidiana (partes corticales comparados con no-corticales) y analiza los cambios en las frecuencias, los pesos, y las proporciónes con tiempo. El reporte plantea algunas explicaciones posibles para las tendencias observadas en Bear Gulch. Los datos sugieren que muchas variables sean responsables de la variabilidad encontrada en estos yacimientos.

CHAPTER I

INTRODUCTION TO THE RESEARCH PROJECT

Lithic studies are nothing new in the field of archaeology (Andrefsky 1998; Bamforth 1991; Beck et al. 2002; Crabtree 1972; Dibble et al. 2005; Kardulias 2003; Kuhn 1994; Odell 2003; Roth and Dibble 1998), however, focus on excavations within an obsidian procurement area are not as common. My research involves studying the characteristics of an obsidian procurement area known as Bear Gulch, in the Centennial Mountains of eastern Idaho (Figure 1).

Through surface collections and excavations, this study includes lithic reduction stage analysis in order to define the use patterns at the lithic procurement area. This thesis will examine: (1) The nature of work being done at the site, (2) Understanding the special properties of quarried lithics, (3) Illuminating trends in reduction stages through time, (4) Site formation processes, (5) The importance of site location and regional distribution, (6) Problems associated with interpreting this type of assemblage, and (7) Inferring original behavior by the pre-historic peoples utilizing the source.

The Bear Gulch obsidian procurement area offers a special case study in undertaking the research approaches stated above for several reasons. First, the quality of this site is of the highest caliber. The quality and abundance of obsidian in the region has produced hundreds of archaeological sites such as lithic scatters, quarry sites, and

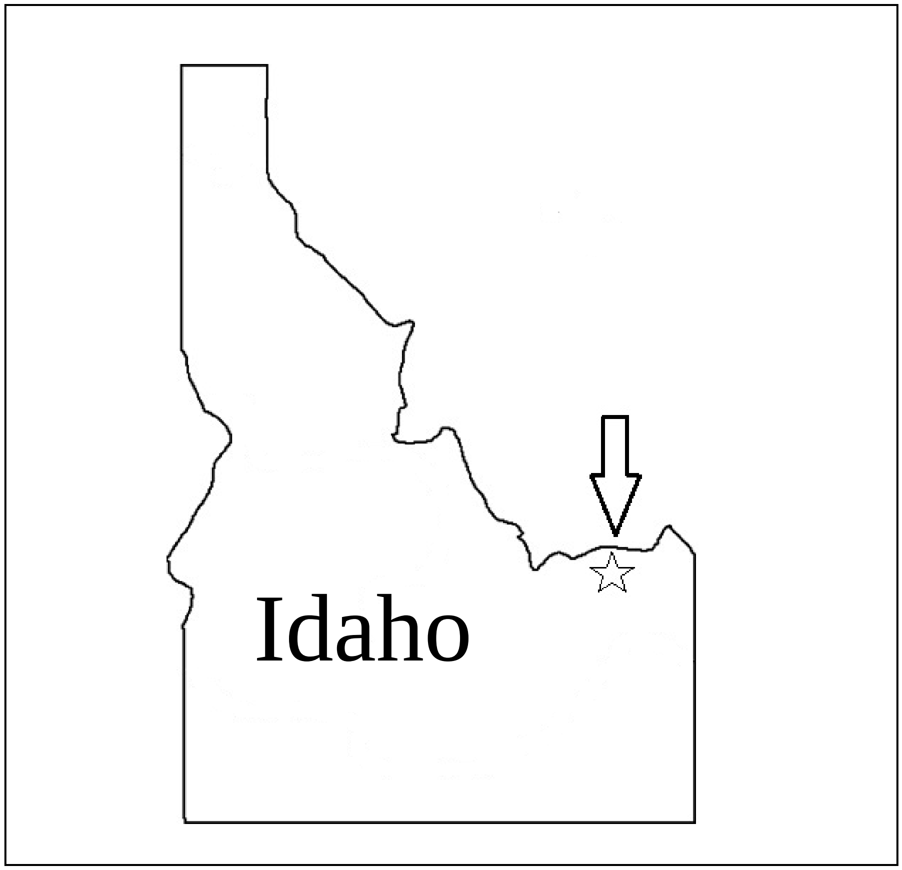

Figure 1. Site location map. (Sketch by the author 2011)

workshops. This demonstrates the desirable nature of this site and its obsidian resources through time.

Bear Gulch also provides for excellent sampling conditions, as well as research in an area that has experienced specific human industrial activity over periods of time extending back to the Paleoindian Period, approximately 11,000, years ago (Willingham 1995:6). The occurrence of Bear Gulch obsidian in contexts far removed from the region is well known (Cannon 1993:8; Griffin 1969:6; Hatch et al. 1990:465; Hughes 1992:516; Hughes and Fortier 2007:144; Willingham 1995:6).

One example of the distance this material has traveled from the source is the occurrence of Bear Gulch obsidian in Hopewell sites in Illinois and Ohio (Griffin et al. 1969:6; Hatch et al. 1990:465; Hughes 1992:516). Through neutron activation analysis, Hatch et al. (1990:465), support the hypothesis that Bear Gulch obsidian, also known as Camas-Dry Creek obsidian, is the source for some of the obsidian being traded into the Midwest. This material has been found specifically in Hopewell burial mounds in Seip, Ohio, and Naples, Illinois, more than 1,500 miles away from the source (Hughes 1992:516). More recently, Hughes and Fortier (2007:155) have identified Bear Gulch obsidian in contexts pre-dating Hopewell sites by several centuries.

The Bear Gulch obsidian source has only recently been identified as the location where many obsidian artifacts discovered in the Midwest have come from (Hughes and Nelson 1987; Wright and Chaya 1985). The importance of this obsidian source having only been recently discovered has provided an environment where limited research has taken place in the past.

The distribution of Bear Gulch obsidian shows the importance of the resource, which demands a closer look at the structure and formation of this procurement site through time. At the same time, the lack of archaeological expeditions at this source area, due mainly to the recent understanding of the sites significance, has provided an archaeological site capable of yielding data to answer a plethora of anthropological questions.

Statement of Problem

The objectives of the thesis are to first, research the archaeological and natural history of the Bear Gulch region. This includes the importance of site location and known distribution of obsidian. This is important for placing the Bear Gulch obsidian procurement area in a cultural and temporal context. This will be accomplished through a literature review.

The second objective is to describe the components of two excavated units in a known obsidian procurement area. This includes reliably retrieving data, identifying lithic reduction stages, and comparing lithic frequencies and volumes. This description is essential in characterizing prehistoric activities at this location. These tasks are accomplished through field recovery methods and laboratory classification methods.

The third objective is to identify site formation processes that have created the site as I have encountered it. A detailed understanding of the specific environment as well as all forces, cultural and environmental, are taken into account to accomplish this goal. This step must be accomplished in order to derive valid interpretations of the data.

The fourth objective is to compare the lithic assemblages from each excavated level to determine patterns through time, as well as to test the integrity of the deposits in regards to their relation to one another. To accomplish this objective, statistical applications designed to elucidate trends in data are utilized. Obsidian hydration band-width analysis is used to determine the antiquity of the deposits as well as stratigraphic integrity of the deposits. This is important for determining reliable temporal sequences as well as measuring change in artifact type and frequency.

The final objective of this project is to infer original behaviors of the aboriginal groups that utilized this lithic source. These inferences are meant to aid in revealing prehistoric use patterns, including trends in lithic reduction intensity, of this lithic procurement site. The strategy employed to reach these inferences are hypotheses testing.

The first hypothesis states: Initial reduction stages in lithic production in the form of cortical debris will increase in frequency, proportion and weight, through time as observed through successive stratigraphic levels, with the null hypothesis stating that there will be no increase in cortical debris through time. Testing this hypothesis may help in answering the problem of recognizing a change in manufacture intensity. Specifically, changes in reduction intensity that may reflect a lesser degree of resource modification from the original state, prior to export from the procurement site.

The second hypothesis states: Later stages of reduction recognized by non-cortical debris will decrease in frequency, proportion, and weight, through time as observed through successive stratigraphic levels, with the null hypothesis stating, there will be no decrease in non-cortical debris through time. Testing this hypothesis will help answer the same question of change in manufacture intensity. Specifically, changes in reduction intensity that may reflect the same lesser degree of resource modification from the original state, prior to transport.

The third and final hypothesis states: The overall weight and frequency of lithic debris increases through time as observed through stratigraphic levels, with the null hypothesis stating that there will be no increase in lithic debris volume and frequency through time. Testing this hypothesis may answer questions of resource intensification at the site.

Testing these hypotheses may help solve the problem of identifying what level of reduction the natural obsidian cobbles found at this site are undergoing prior to export. Reaching these objectives will provide a greater understanding of this specific archaeological site, reveal trends, and provide information on the prehistory of the region. Cortical debris studies such as this can answer questions of site use (Roth and Dibble 1998:47), as well as aid in making behavioral inferences (Dibble et al. 2005:547).

Methodological Approach

The approach taken in this study to collect pertinent data follows the tenets of Behavioral Archaeology (Schiffer 1976), which pays special attention to the forces that create and form archaeological sites. Field work was undertaken utilizing new methods to retrieve archaeological deposits from upturned root systems and the resultant pits that were formed at the time of root exposure. These techniques included improved survey and excavation practices which were informed in part by the work of Tushingham (2010), and Strauss (1978). A surface collection of artifacts were followed by separately excavating 10 cm. levels of soil in stratigraphic sequence.

Chapter Structure

Chapter II describes the geology and geography of the region, as well as the climate, flora, and fauna common to the area. The history of archaeological research conducted in the Eastern Snake River and Intermountain region is discussed along with site specific characteristics of Bear Gulch. Chapter III is devoted to site formation processes. Behavioral archaeology is described as the theoretical framework behind all methodological approaches. Both cultural and non-cultural processes are considered. Chapter IV presents illustrations, processes, parameters, and descriptions of stone tool reduction sequences and classification as it pertains to material culture encountered at Bear Gulch. Chapter V deals with theory guiding the research and methods employed in gathering data. Chapter VI discusses data analysis and interpretation that includes statistical applications as well as results of hypothesis testing. Chapter VII concludes with a summary and suggestions for future research in this area.

This study contributes to the field of archaeology and anthropology in that, first, new methodological approaches are taken in retrieving data that will aid future researchers. Second, it examines a specific type site in a region that has been largely overlooked. Third, behavioral inferences are formed around the specific activity of procuring and processing the lithic resources at the Bear Gulch site through time. The specific focus of determining lithic reduction intensity or level of manufacture of natural resources prior to export from the site could reveal important behaviors of the original groups utilizing this resource. In the next chapter, the background of the thesis project will be addressed.

CHAPTER II

BACKGROUND OF RESEARCH PROJECT

The Bear Gulch obsidian procurement area encompasses a large area within the Centennial Mountains of eastern Idaho. The available literature on the region is limited; however, Willingham (1995) does provide information on the location of the resource, archaeological context, and this area's importance in aboriginal trade. In his article, Willingham (1995) describes the site location in geographic as well as archaeological terms. Obsidian utilization in this region is also described in Cannon's (1993) *Paleoindian Use of Obsidian in the Greater Yellowstone Area,* in which Paleoindian projectile points from Bear Gulch are sourced and dated. Holmer's (1997) *Volcanic Glass utilization in Eastern Idaho*, in which obsidian procurement and transport behaviors are thought to be more easily explained through geochemical analysis, has helped in identifying Bear Gulch's prominence in resource procurement areas of the region. Swanson (1965, 1972) also contributes to a regional description of archaeological sites and geological and geographic information.

The known distance traveled of the Bear Gulch obsidian type is documented in works by Hughes (1992), and Hatch et al. (1990), where the studied source material was discovered in Hopewell sites in the Midwest. Ethnographic information on the region was originally provided by Steward (1938:136, 189). The general history of archaeological research in the Eastern Snake River region is described by E.S. Lohse (1994), Butler (1981), and Swanson (1965).

Bear Gulch, and my specific research area located within the gulch itself, are located in the Centennial Mountains, in the northeastern corner of Clark County, Idaho, along the border of Montana. These mountains contain folded and thrust faulted Mesozoic and Paleozoic sediments, which lie above Paleoproterozoic basement rock. They belong to the Laramide Province, where Mesoproterozoic and Neoproterozoic strata were never deposited beneath the basal Cambrian sandstone (Digital Atlas of Idaho 2010).

Geographically, this area is defined by its steep north to south trending faulted canyons, and ranges in elevation from 7,000 to 8,000 feet above sea level. The specific excavation area lies on a bench, a shelf-like area with steep slopes above and below the location, 20 meters east of a permanent stream (Figure 2).

The area was first chosen because it had a number of trees that were uprooted, of which many revealed obsidian artifacts once buried. This fact allowed for easy identification of sub-surface deposits. Second, the location of the site would have provided relatively easy access to lithic resources for indigenous groups, as compared with other steeper less accessible areas.

This specific area also hosts a variety of wildlife ranging from bear and moose to various bird species and fish. The area has historically experienced full snow cover for seven months out of the year (Western Regional Climate Center 2010).

During the winter months of 2006 and 2007, Bear Gulch experienced a violent storm. This event produced winds capable of blowing down and exposing the root

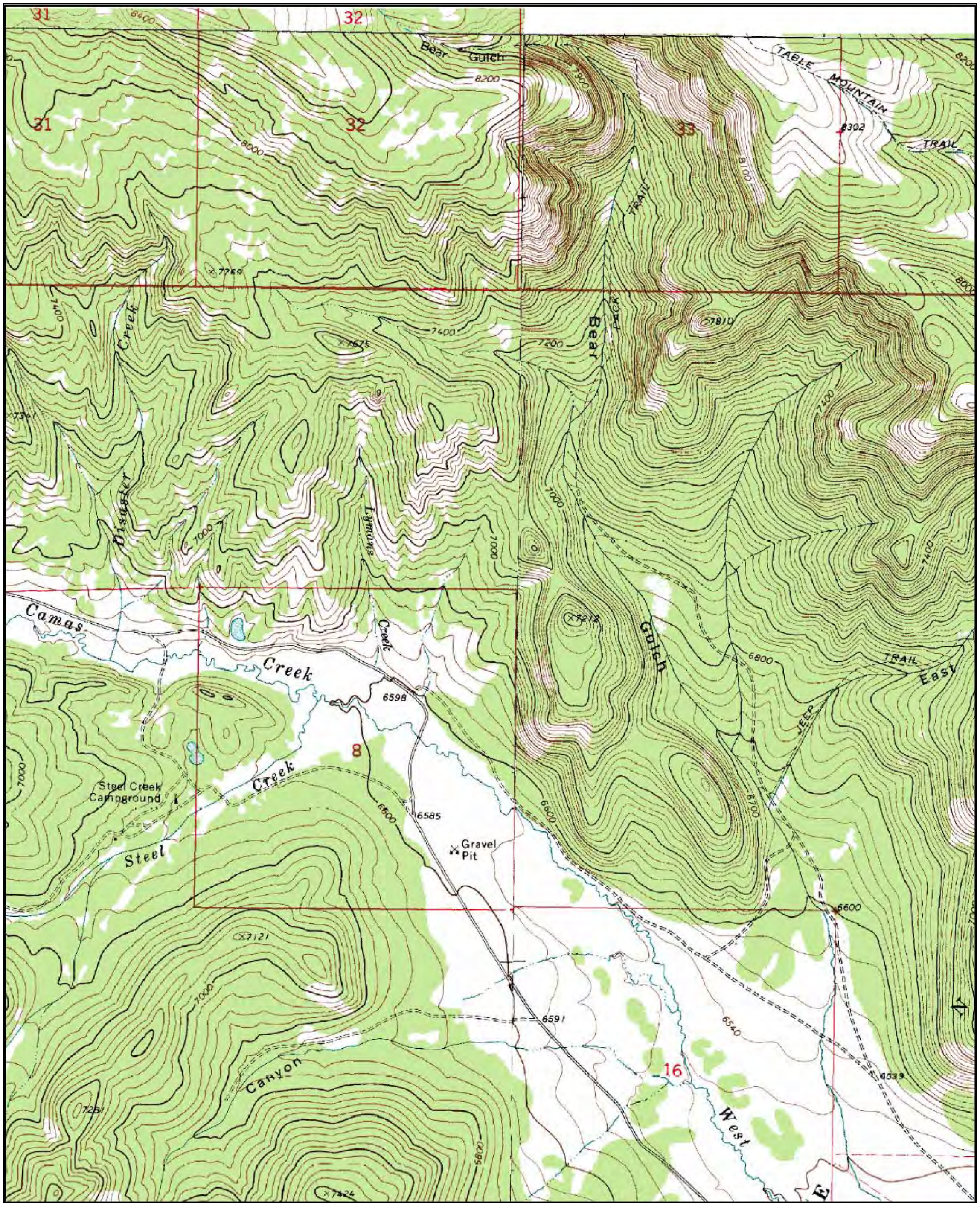

Figure 2. Site location topographic map.

Source: United States Geological Survey, 1990, Kilgore, Idaho 7.5' topographic quadrangle map. United States Geological Survey, Reston, VA.

systems and bound soil of many trees in the area. Hundreds of trees, primarily Douglas Fir and Lodge Pole Pine, were affected. The average age of the trees involved in this study was 135 years old. The ages were determined through a tree ring count. It should be noted that major logging operations in this region did not begin until after A.D. 1900 which means these trees should be considered old growth. The wind event was the catalyst for discovering deposits within this known site (Figure 3).

Figure 3. Blown down trees at site location. (Photograph by the author, 2009)

Site Archaeology

Bear Gulch is an obsidian procurement area known to have been utilized by prehistoric peoples (Cannon 1993:8; Holmer 1997:189; Hughes 1992:516; Willingham 1995:1). This is evidenced through the abundance of archaeological sites consisting of lithic scatters and lithic quarries in the area. The uprooted tree root systems contain large amounts of soil that hold obsidian artifacts ranging from micro flakes to cores and bifaces.

The storm event provides a unique opportunity for archaeologists to identify and excavate exposed soils that are known to contain artifacts. The geographic location of the specific obsidian procurement site also provides an ease of access that is not as available in the surrounding area. This site is located on a relatively flat bench near a permanent source of water, useful for human encampment, and exhibits a large supply of naturally occurring obsidian. These conditions may have drawn the earliest inhabitants of the area to this resource first, as opposed to more difficult, less accessible areas.

After gaining permission from the United States Forest Service (USFS), I conducted a shovel test on one of the root/soil matrices and the soil beneath the tree throw pit, which is the exposed cavity left by the removed root system. A surface survey was then conducted in the area around the fallen tree. Surface artifacts were present, and the root system produced artifacts at all levels. Artifacts were also present beneath the surface of the tree throw pit.

After reporting my finds to the Forest Service and Dr. William Collins, I produced a research design and methodology for three archaeological approaches: surface collections, excavation through exposed root systems, and excavating within a tree throw pit. Surface collections and excavations for Unit 1 took place during the summer of 2009. Surface collections and excavations for Unit 2 took place during the summer of 2010. At this point, I had researched the archaeological and natural history of the area and was primarily interested in describing the components of the lithic assemblages and determining their antiquity. At the same time, I utilized the concepts of site formation processes to guide my methods in collecting and recording data. I then took my plan and tools to the Bear Gulch site and identified several promising areas to excavate. I was able to collect data from two tree throw locations within the same site over the course of the summers of 2009 and 2010. These excavations provided me with a large quantity of cultural and non-cultural obsidian debris.

The artifacts were relocated to California at the completion of the 2009 and 2010 field seasons and are now being housed in the CSU, Chico Archaeology Laboratory. After cleaning the obsidian debris with brushes and water, and noticing the unique character of the assemblage, I decided to focus on the obsidian reduction process encountered at the site. Also, because one-third of the data was retrieved from an uprooted tree root system, this approach could add new dimensions to archaeological field methods.

The literature on archaeological data in this specific type of environment is not abundant, but it does exist. Strauss (1978) describes root action and the effects of this phenomenon on archaeological sites, and Schiffer (1987:210) describes the effects of floralturbation, and specifically root action and the effects on artifacts. I am concerned with the change in use patterns through time at this obsidian resource area. The study of site formation processes, unique artifact assemblages (e.g., reduction stages), method, and inference of aboriginal behavior are elaborated in the thesis hypotheses (see Chapter I).

By conducting an archaeological endeavor that combines surface collection, excavation of exposed root systems, and excavation of the tree throw pit, this thesis will provide a clear presentation of data coupled with a unique methodology that will benefit the field of anthropology. My main goal in this thesis will be to describe use patterns of this obsidian procurement site through analysis of lithic deposition through time with a specific focus on lithic reduction intensity. I will describe the types of problems one encounters during this type of excavation, as well as how these problems might be remedied by this type of approach.

The general history of archaeological research in the Eastern Snake River region is described by Lohse (1994), as taken from the *Manual for Archaeological Analysis: Field and Laboratory Analysis Procedures. Department of Anthropology Miscellaneous Paper No. 92-1 (revised)*. Idaho Museum of Natural History, Pocatello, Idaho 1993. Lohse reported that:

> Systematic archaeological research in southeastern Idaho began in 1958 with the advent of Earl Swanson's archaeological program at Idaho State University. At that time, highly stratified cave and rockshelter sites were selected for examination because they had potential for yielding a broad range of geological and biogeographical data essential for understanding human ecology on the Snake River Plain and in bordering upland regions. Other overriding concerns of this early work involved determining the antiquity of the Northern Shoshone in this area, clarifying the relationships between this region and the surrounding Great Basin, Plains, and Plateau cultural areas, and setting up a regional cultural sequence.
>
> Swanson (1972) defined a series of local cultural phases marked by distinctive projectile point types, associations of faunal remains, and changes in natural deposition in stratified sites. Butler (1986) has grouped these phases into three broad cultural periods labeled Early Big Game Hunting, Archaic, and Late. This cultural sequence spans the last 14,000 years. [1994:1]

The dates acquired from obsidian hydration analysis of artifacts retrieved from the Bear Gulch site extend to 4,148 years before present (BP), which shows the antiquity of this site extending to the Archaic Period. Brief descriptions adapted from Lohse (1994) of all periods are presented below to better understand the cultural history as well as the relation of known occupation time frames in the region, to the time frames represented at the Bear Gulch Site.

Early Big Game Hunting Period
(ca. 14,000-7,800 B.P.)

Cultural adaptations during this period are marked by a focus on hunting large game animals that became extinct during the terminal phase of the Late Pleistocene or in the early Holocene. Butler (1986:128) subdivides this period into three divisions based on the presence of distinctive projectile point types: Clovis, Folsom, and Plano. Associated dates obtained from the Bear Gulch excavations do not extend to this period.

Clovis Subperiod (ca. 12,000-11,000 B.P.)

Evidence of this period in the Upper Snake and Salmon River country is largely confined to surface sites lacking good stratified deposits. Some stratified sites like Jaguar Cave in south central Idaho have deposits radiocarbon dated to this period but lack diagnostic artifacts (Sadek-Kooros 1972:370). In general, surface finds have been without any associated patterning in cultural remains. Associated dates obtained from the Bear Gulch excavations do not extend to this period.

Folsom Subperiod (ca. 11,000-10,600 B.P.)

This period is found in one excavated stratified site and a variety of surface finds. Owl Cave is a deeply stratified lava tube on the Snake River Plain (Butler 1978:37). Radiocarbon dates on bone from a Folsom component ranged from about 12,850-10,920 B.P. Parts of four Folsom points were found in association with elephant, bison, and camel remains. Isolated surface finds of Folsom points are common in this region. Associated dates obtained from the Bear Gulch excavations do not extend to this period either.

Plano Subperiod (ca. 10,600-7,800 B.P.)

This period is the most abundantly represented in the region, and is found in excavated contexts as well as surface finds. There is a fairly wide diversity of generalized lanceolate projectile point forms. Prehistoric economy seems to have been geared toward hunting bison at lower elevations, and mountain sheep in higher zones (Swanson 1972: Table 18). Although this period is well represented, associated dates obtained from the Bear Gulch excavations do not extend to this period.

Archaic Period (ca. 7800-1300 B.P.)

After about 8000 B.P., the lanceolate point type's characteristic of the preceding Plano Period were replaced by Bitterroot or Northern Side-notched points and stemmed-indented base points. As defined by Willey and Phillips (1958), the Archaic Period is the stage in North American prehistory characterized by generalized hunting-and-gathering economies in physical environments basically similar to those of today. It is assumed that the atlatl and dart weapon system enters the archaeological record during the Archaic Period, and that this is reflected in the smaller and more variable types of projectile point types.

Reed et al. (1986) have divided the Archaic Period into three sub periods: 1) Early Archaic (7500-5000 B.P.), marked by use of Northern Side-notched type projectile points and the large bifurcate or stemmed-indented base projectile points also labeled Pinto series; 2) Middle Archaic period (5000-3500 B.P.), which is marked by a proliferation of projectile point types rather than any one point type, but including lanceolate and stemmed points, Elko series points, and Humboldt series points; and 3) the

Late Archaic (3500-1300 B.P.), marked by a number of projectile point types including Pelican Lake points, Besant points, and Elko series points.

The Archaic is characterized by a climatic shift toward warmer and drier conditions, which Reed et al. (1986:110) suggest prompted bison hunting populations of the Plains to enter the upper Snake River Basin and begin hunting mountain sheep as well as bison. Willey and Phillips (1958) note that the Archaic in this region documents a highly diversified subsistence. Butler (1978) argues that as the Altithermal reached its maximum about 3800 B.P., grasses essential to large bison herds began to fail, and bison hunting populations must have experienced some dietary stress than could be expected to prompt changes in subsistence strategy. Associated dates obtained from the Bear Gulch excavations begin with the oldest acquired date of 4148 BP, which fits into the Archaic Period.

Late Period (ca. 1300-150 B.P.)

The Late Prehistoric Period is better known than any of the preceding periods in regional prehistory, and most likely represents prehistoric and protohistoric Shoshoneans occupying the Upper Snake and Salmon River country. Two cultural identifiers are indicative of this period: the Shoshonean Intermountain Ware pottery tradition and use of the bow and arrow.

The Late Prehistoric Period is marked by a range of small triangular projectile point types. Corner-notched Rosegate series points extend throughout the period, as do Desert Side-notched series, and Cottonwood triangular points. Cultural diagnostics include Desert Side-notched and Rosegate series projectile points and grey-ware pottery.

Associated dates obtained from the Bear Gulch excavations end during this period at 393 BP.

Protohistoric and Historic Shoshone Period

The transition from protohistoric to historic Shoshonean groups, which hinges on finding European trade goods in association with aboriginal materials, are not well documented in the archaeological record of this region. Sometime after about 300 B.P. horses came to the Shoshone and other Plateau tribes. At about the same time, trade goods of metal and glass were passing north in trade from the Spanish Southwest. To date, no professionally excavated stratified site with early European trade goods in definitive association with aboriginal Shoshonean assemblages has been recorded. Defined by Reed et al. (1986:114), the boundary between protohistoric and historic periods for Shoshone has been arbitrarily set at the year 1805, when the first written records of the Upper Snake River Basin were produced by Lewis and Clark. The dates associated with the Bear Gulch excavations all occur prior to this time period.

The following chapter discusses the study of site formation processes and geoarchaeology at the Bear Gulch site, as well as the effects of these phenomena on the archaeological site and the artifact assemblage.

CHAPTER III

SITE FORMATION PROCESSES

Studying the Bear Gulch archaeological site requires not only knowledge of the region's ethnohistory, regional technologies and resources, migration and settlement patterns, and culture contact history, but just as importantly the natural and cultural forces that physically shape the archaeological site as encountered and studied. The focus of this chapter is the importance of understanding site formation processes that affect the physical structure of the site and the contributing artifact assemblage.

Site formation processes and geoarchaeology comprise a significant portion of this thesis. The approach is crucial in understanding how archaeological sites are formed and interpreted by archaeologists. Prime sources for these sub-fields are the works of Schiffer (1972, 1983, 1987), Strauss (1978), Reid (1985) and Hull (1987) in the field of site formation processes. Goldberg and Macphail (2006), Rapp and Hill (2006), and Waters (1992) provide information on the field of geoarchaeology. A more in depth look at the unique effects of root systems on archaeological sites are described by Strauss (1978), Waters (1992:306), and Tushingham (2010: Personal Communication). The aspects of these works that relate to my study are cultural and environmental processes that together, shape the way archaeologists see and interpret archaeological sites.

I will begin by outlining the methodological study of behavioral archaeology as defined by Michael B. Schiffer (1976). Next, a definition of what site formation processes are, as well as the two distinct types will be discussed. Climate, weather and the role of geoarchaeology in the region will also be investigated. A specific regional approach will then be taken to understand these forces as we turn our gaze on eastern Idaho and its archaeological resources. Finally, the specific archaeological characteristics of Bear Gulch will be explored to elucidate the effects of site formation processes and the results of these actions on inference and interpretation. This is a study of the impact of human and natural processes on the archaeological record.

Site Formation Processes

Archaeological site formation processes are defined by two types, cultural and non-cultural. Michael Schiffer (1976:14-16) describes these laws as *C-Transforms* and *N-Transforms*. C-Transforms, or cultural formation processes are defined by those variables in an existing cultural system that creates the material assemblages archaeologists encounter. Examples of these activities are disposal of exhausted tools, food and fuel waste production, and the discard of obsolete items. Another example of this phenomenon is when discarded items are reused, also known as the adaptive re-use of materials. Reuse processes, defined by Schiffer (1987:28) as “a change in the user or use or form of an artifact, following its initial use” are not considered for the Bear Gulch procurement area due to the assumption that the ubiquitous nature of the resource would preclude any need for reusing the lithic debris created by previous users. In simpler terms, a user would more likely spend time gathering and processing a better quality material over a poorer quality one if the amount of energy expended was the same for both. This would be the case at Bear Gulch, where the access to obsidian cobbles is nearly infinite.

This notion is expanded upon in the concept of Optimal Foraging Theory (MacArthur and Pianka 1966:603). Briefly, this concept, originally applied to acquisition of food resources, states that organisms will maximize their energy intake using the least amount of time possible. This applies to resource gathering at Bear Gulch in that re-use of waste materials at this site would not return the quantity or quality of the desired product as would using the raw, natural material already readily available throughout the area.

When exploring the factors that create an archaeological assemblage, cultural variability must also be accounted for. This includes inter-system and intra-system variation. In other words, what types of activities are unique to specific human populations that leave a correlating behavioral trait in the archaeological record? This can reveal itself in burial practices, discard processes, refuse locations, lithic reduction debris, volume of refuse, and abandonment processes. Of these examples, studying lithic reduction debris and volume of lithic debris can be one of the most useful research strategies in the arena of site formation processes (Hull 1987:772). The information inferred from these activities can help answer questions of technological or strategic shifts in lithic resource utilization, effects of migration or diffusion, increase or decrease in populations, use patterns through time, or episodes of independent invention.

Cultural site formation processes, or *C-Transforms*, do not end with the departure of the original social groups. Reclamation processes as well as disturbance processes can affect site structure. Examples of reclamation processes include human reoccupation of an existing site, salvage and scavenging activities, and collecting and looting. Disturbance processes can include small-scale activities such as human and livestock trampling to construction projects and large-scale earthmoving endeavors (Schiffer 1987:121).

The sheer number and variability of cultural site formation processes can consume much of the archaeologist's time and resources in accounting for their effects on a studied site. Regardless of the efforts required, these processes must be taken into account to arrive at acceptable conclusions regarding inference and explanation of past human behaviors.

Examples of cultural site formation processes in the Bear Gulch region mainly consist of reports describing the occurrence of indigenous obsidian extraction activities (Cannon 1993:8; Hughes 1992:516; Willingham 1995:3). Post Euro-American contact in the region has also left its mark on the landscape in timber harvesting, mining operations, and recreational trails.

Laws governing correlations between these actions and the resultant material objects or assemblages are followed to better understand their effect on the archaeological site. Put simply, ideally every action has an observable consequence. It is these consequences that inform what type of activity took place at the studied site. For example, logging operations produce tree stumps as well as a population of second-growth trees. More in line with the current study, obsidian extraction and processing activities leave broken cobbles and waste flake material. These correlations can be identified for large scale activities like the examples provided above, as well as smaller scale specific activities such as production of large tool blanks as opposed to smaller projectile points. Both of these activities leave different signatures in the archaeological record.

Non-cultural site formation processes or environmental processes (*N-Transforms*) have another serious impact on how archaeological sites develop. These processes can be considered different from cultural processes in that they involve natural mechanisms that affect archaeological deposition. Human cultural systems do have, and exercise their capacity to modify their own actions in the archaeological record; however, those actions are identifiable and distinct from those of nature. So what are these forces that act on the land? These phenomena broadly include chemical, biological, and physical stresses, all or some, which alter or destroy archaeological artifacts, sites, and can even transform whole regions.

The general effects on archaeological sites from a physical transformation of the environment vary from soil churning from plant and animal activity, to complete annihilation of a region due to catastrophic weather or tectonic events. These phenomena can rearrange stratigraphic deposits or remove all evidence of human activity.

Initially, the archaeologist must be capable of detecting primary versus secondary areas of deposition. These two areas are first, the primary location of cultural deposition. That is, the original and final resting place of cultural artifacts as the user left it, archaeologically termed an *in situ* artifact. Second is the location of cultural artifacts that have been transported by some force of nature away from its original drop or deposition point. This can occur through the forces of wind, water, gravity, floralturbation, faunalturbation, tectonic events or mass wasting.

Among the list of processes for affecting the archaeological record are: pedoturbation or the natural mixing of soils; faunalturbation, an animal-induced mixing of soils; floralturbation, the physical effects of plant life activity; cryoturbation, or freeze-thaw forces; graviturbation, or down slope movement of soils; argilliturbation, a swelling and shrinking of soils; and aeroturbation, which are the effects of wind on soils (Schiffer1987:147-150). These are forces that can affect archaeological sites, their artifacts, features, or distribution, on any scale, site specific or at the regional level. Environmental formation processes on the regional scale can include volcanism; the large scale effects of wind, or eolian forces; hydrological processes; vegetation; and effects of large scale populations of fauna.

Geoarchaeology

Geoarchaeology is the study of the environmental context of archaeological data (Waters 1992:7). This ranges from microscopic soil samples to regional study areas. In the earth science approach to better understanding the archaeological record, soil characteristics, sediment dynamics, stratigraphy, hydrological systems, aeolian and overall geoarchaeological environments are studied to understand their effects on small-scale sites to large regional areas. The understanding of this subfield's importance when making inferences in human behavior can mean the difference between a credible study and one rife with mischaracterization. Many basic archaeological principles such as uniformitarianism and superposition come from geology. This field is a cornerstone in knowing the environmental processes that form the archaeological record.

An example of the useful nature of this approach is in understanding properties of artifact materials such as obsidian. During and after the artifact, feature, or site ceases to become part of the systemic context, or part of a human behavioral system, it is susceptible to actions ranging from weathering to hydration. Rapp and Hill (2006:26) explain that disintegration or decomposition of parent materials has an important effect on sites, features, and artifacts.

Geoarchaeology informs the researcher of what types of weathering to expect from specific materials in specific environments. Geologic maps can aid in these endeavors in that knowledge of where and what types of materials are available can also inform researchers of procurement sites or habitation areas. This study utilizes geoarchaeological technique in a variety of approaches, including understanding soil creation, properties of lithic materials, and the effects of root activity on archaeological deposits.

Climate

In addition to cultural and naturally induced factors affecting archaeological sites, climate is also a factor. Climate has characteristics of temperature, precipitation and wind that have an effect on the archaeological sites of a region. The climate of the mountainous area of this study is defined as a Highland Climate. Highland climates range from cool to cold, and are found in mountains and high plateaus. Climates change rapidly on mountains, becoming colder with higher elevation. Climate information for this site is taken from the town of Kilgore, Idaho, approximately 15 miles to the southeast of the Bear Gulch site. Average temperatures in this region range from a high of 49.8 degrees

Fahrenheit to a low of 21.6 degrees Fahrenheit, with an average precipitation of 21.13 inches, average snowfall of 131.6 inches, and an average snow depth of 10 inches (Western Regional Climate Center 2010). Important climate facts for this study include number of months with no snow on the ground, average temperatures that may affect cryoturbation, and frequency of winds that cause damage to local forests.

Climactic anomalies such as the Younger Dryas (~11Kya), Holocene Climatic Optimum (~7-3Kya), climate changes of 535-536 (A.D. 535-536), Medieval Warm Period (A.D. 900-1300), and the Little Ice Age (A.D. 1300-1800), will be taken into consideration and compared with dates obtained from obsidian hydration analysis to see if any change in procurement patterns are noticeable during these events. Specifically, looking for increases or decreases in lithic debris frequencies or volumes during these events.

Site Formation Processes at Bear Gulch

The Bear Gulch site occurs within the Centennial Mountains, which are the southernmost sub-range of the Bitterroot Range in U.S. states of Idaho and Montana. The excavation units occur at an elevation of 7,060 feet above mean sea level. The Centennial Mountains include the Western and Eastern Centennial Mountains, extending east from Monida Pass along the Continental Divide to Henrys Fork, 30 miles North-North-West of Ashton, Idaho; bounded on the west by Beaver Creek, on the north by Centennial Valley and Henrys Lake Mountains, on the east by Henrys Lake Flat, and on the south by Shotgun Valley and the Snake River Plain (USGS Geographical Names Information System 2011).

The highest peak in the range is Mount Jefferson at 10,216 feet above mean sea level. The Centennials are one of a only a few ranges within the Rocky Mountains that trend west to east, and the Continental Divide runs along their ridge line. The Western Centennial Mountains extend west from the Eastern Centennial Mountains along the Continental Divide to Monida Pass, 25 mi North East of Dubois, Idaho; Snake River Plain, on the north by Centennial Valley, and the east by a line connecting Odell Creek and an unnamed tributary, in Montana, to Ching Creek in Idaho (USGS Geographical Names Information System 2011; see Figure 4).

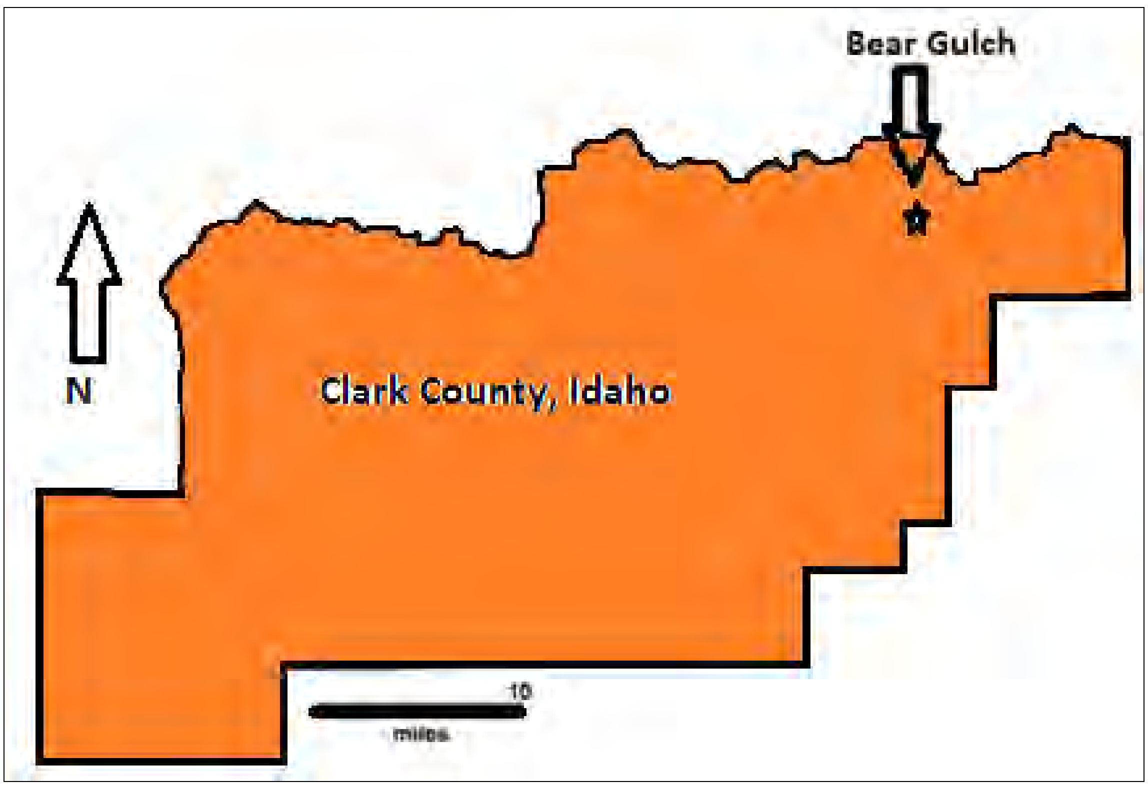

Figure 4. Clark County, Idaho and Bear Gulch. (Sketch by the author 2011)

Human Habitation

As Discussed in Chapter II the cultural history of this region can be divided into seven stages as described by Lohse (1994:1) in Chapter II.

The archaeological record at Bear Gulch may reflect these stages in changing artifact concentrations, type or frequency. It is of great importance to understand these changes and how they are reflected in the artifacts recovered from archaeological sites in the region. These changes affect the structure and hence the interpretation of archaeological sites and the behavior attributed to them. Any correlation between change in artifact assemblages at the Bear Gulch site and these periods will be discussed in the interpretation section of Chapter VI.

The Bear Gulch site has its own unique set of formation processes. Cultural site formation processes in this region can affect a site in several ways. This area has experienced several periods when new cultures were introduced to the area. These new culture systems sometimes occupied older settlements. In this case, destruction or co-mingling of two different systems can occur. Another force can be changes in technology or overall life-way strategies. This can be seen in the region in several time periods including events associated with the advent of atlatl dart technology (Archaic Period), to contact with Euro-American populations (Historic Shoshone Period). These changes are discussed in the following section on *C-Transforms*.

The Bear Gulch site is considered to be a primary site under the definition provided by Schiffer (1987:200) as “a place that could have experienced many environmental disturbances but where overall artifact movements are small *on a regional scale*” (emphasis in the original). It is also my intent to defend this site’s integrity at the stratigraphic level by describing observed effects from noncultural site formation processes.

C-Transforms at Bear Gulch

Cultural deposition is the human social group's contribution of recognizable materials to the natural environment. Examples of this are manufactured and discarded material, lost, or abandoned materials, and cached materials. At the Bear Gulch procurement area, the type of cultural deposition that dominates the site is discarded lithic material, with obsidian being the dominant material. As an obsidian procurement area, the overwhelmingly predominant artifacts are flakes removed from obsidian cobbles for the creation of stone tools.

The artifact assemblage suggests that the site was utilized mainly for decortication of natural cobbles as well as a considerable amount of reduction associated with creating portable tool blanks. The data points to an industry concerned with exporting usable raw material instead of completed tools such as projectile points.

The artifact locations are considered to be primary refuse sites. This is described as the place where artifacts are discarded at their location of use, or in this case, location of removal (Schiffer 1987:58). The natural distribution of raw material at this site does not occur at point specific locations like large natural outcrops of material, but in a dispersed pattern of individual cobbles over the landscape. This distribution relieves the individual working the material from maintaining a workable space free of built up debris. After the cobble is reduced to the desired size, the individual would in all likelihood search out the next cobble and perform the next task at that location.

Abandonment processes apply to the Bear Gulch site in that this area and its resources are inaccessible for the majority of the year due to deep snow. The window of opportunity for resource procurement occurs only during the summer months, after which the site must be abandoned until access becomes possible the following summer. These conditions allow for a culturally undisturbed periods of time between procurement phases. Peaks in artifact frequencies and weights at Bear Gulch, and their accompanying troughs, show periods of time with limited to no activity, that extend in some instances, to hundreds of years.

Reclamation processes, or “transformations of artifacts from archaeological context back into systemic context” (Schiffer 1987:99), are not considered to be a major factor in determining the physical characteristics of this site because of the artifacts comprising this site. The same reason applies for dismissing adaptive re-use of waste flakes, since obsidian was, and remains plentiful.

This conclusion does not include later artifact collecting activities that may have occurred at this site in recent years. Looting activity, although not reported in this area, may have affected components of the surface assemblage. Reclamation of this source area is however a factor. Defined as a recurrent occupation area (Schiffer 1987:101), the Bear Gulch site was used repeatedly by brief visitations. This pattern of use has the capability of introducing additional cultural formation processes. Examples of this phenomenon may include change in lithic reduction strategies with the introduction of disparate groups to the area, change in technologies, or complete abandonment due to population movement or change in preferred material type. These scenarios are considered to be part of the archaeological record as opposed to distorting it. Further data analysis and interpretation may help define episodes such as these.

Disturbance processes at this site include the activities of the original peoples extracting the obsidian cobbles from the earth. The continuous re-visitation of this site for obsidian procurement and processing may have impacted the site's formation in that the extraction of sub-surface or semi-subterranean cobbles would have required a measure of earth moving activities. Although the need for extensive quarrying into the soil is not required for this area due to the nature and distribution of the obsidian, some of the cobbles have been found to be partially buried by soil. These cobbles may have been extracted from the soil leaving a small pit in its place that would then have been re-filled by soil and possibly other artifacts.

According to Schiffer (1987:218), in areas that have cold winters and abundant precipitation, such as Bear Gulch, a two-stage process defines the infilling of human created pits, which are then acted on by successive natural processes. First, rapid infilling from the weathering of the sides of the pit could occur, and second, the slower process of wind-borne sediments being trapped in the pit could also impact the site. This process likely occurred at the Bear Gulch site, however the majority of usable cobbles in this area are found on the ground surface. These cobble pits would also have been relatively small in size as well as in number, reducing the effect of soil mixing at the site.

More contemporary cultural disturbances to this site are forest management practices used by land management agencies, in this case, the United States Forest Service. Trail construction near the site, timber harvesting, road construction, public access, and the introduction of cattle grazing all have had an effect on this particular site.

These activities have been recent and appear to have only affected surface assemblages near trails or roads.

In this regard, the overall effects from recent cultural formation processes at the Bear Gulch site are considered to be negligible. The site type and location, coupled with prehistoric temporal use patterns, have left the area in a largely culturally undisturbed state. The nature and distribution of surface as well as subsurface artifact assemblages in this area maintain a homogenous signature that allows for a realistic interpretation of indigenous peoples utilization of this area.

N-Transforms

Faunalturbation is a possible natural disturbance, but was not observed at the excavated units. Signatures such as rodent backfill piles at the ground surface as well as the presence of rodent burrows filled in with sediments, known as *krotovinas*, within the excavated units were absent. During the course of excavations, one earthworm was found. According to Stein (1983:279), “excessive clay restricts burrowing because of increased soil hardness.” Clay/sandy clay is the soil type found at this site which may explain the limited amount of earthworm activity. Given this scenario, the effects of faunalturbation on this site are considered negligible.

Floralturbation has been the greatest concern to the integrity of the site as almost half of the soils were found disturbed by root systems. The effects of root systems on individual artifacts are described by Schiffer (1987:210) as “small,” and as noted by Strauss (1978:60), have their greatest influence on archaeological sites after the death of the tree. Strauss (1978:60) notes that “the horizontal distribution of artifacts may remain relatively intact.” The concerns with vertical deposits are expressed, however these transformations in stratigraphic provenience develop once the root itself has rotted away, leaving a channel for soils as well as artifacts to travel downward. The circumstances defining the excavations at the Bear Gulch site included upturned root systems that had not begun to decay and no evidence of past root voids within the excavated units. Due to the nature of root system effects on artifact provenience and the conditions observed at this site, the effects of floralturbation are also considered negligible.

Cryoturbation, the freezing and thawing of the ground, is not considered as a factor at this site due to the absence of permafrost soils in this region. The absence of larger sized artifacts concentrated at higher levels, a sign of cryoturbation, (Schweger 1985:128), was not observed at this site.

Graviturbation, the downward movement of artifacts on a slope, at the Bear Gulch site plays a small role in artifact distribution patterns and general erosion forces. The site where excavations took place occurs on a bench overlooking an unnamed stream within Bear Gulch that has an average 9.85 percent westerly downslope. This was the gentlest slope located outside of flood plains that was identified within the obsidian procurement area and tree fall area. As a result, the effects of graviturbation were of little consequence.

Argilliturbation, the expansion and contraction of clays, is a possible formation process that affects the site at Bear Gulch. After analyzing soil samples taken from both excavation units, using a standard triangular grain size diagram, results show a soil composition of silt at 15 percent, sand at 38 percent, and clay at 47 percent. This classifies the soil type as clay, but very near a sandy clay and clay loam. If during dry seasons the soil shrinks to an extent that the soil cracks enough to allow sediments or artifacts to enter the void, soil mixing may occur. This process was not observed during surveys of the area during dry seasons or noticed during excavations. Indicators of this process are larger particles moving upward, and a pavement of these large particles occurring on the surface (Schiffer 1983:216).

Storms affect this region in one particular case, wind damage to vegetation. This project was initiated by wind damage to trees and their root systems. The National Climatic Data Center (2010) was queried for storm events in this region. The results show a history of wind events that plague this area, (35 recorded storm events over the past 60 years). It is difficult to assess the effects of these storms on my specific location of study except in the case of terrain displaying a pit and mound topography, where remnants of past blow downs are still visible, or where disturbed soil horizons are apparent. At the Bear Gulch site, only the blow downs from the storm event of 2007 are visible, while no disturbance of soil horizons were witnessed within my excavation units.

The occurrence and probability of pits have been discussed previously as possible cultural formation processes. The occurrence of tree throw pits as environmental formation processes is discussed here. The tree throw pits at this site had not undergone a great deal of natural infilling during my fieldwork seasons as the storm event was fairly recent (two years after the storm for Unit 1 excavation, three years for Unit 2). The natural erosion of soil from the root system back into the pits averaged approximately 10 cm, of loose soil and was easily differentiated from the soil beneath the root system as it contained less moisture and was not compacted.

These circumstances, however easily identified, play an insignificant role in the structure and method of recordation of these excavation units. The soil fall from the bottom of the root system to the surface of the pit retains its location in the overall temporal and spatial continuum as per superposition and stratigraphy. These tree throw pits were in the early stages of infilling, and had not developed a mixed soil horizon (Figure 5). There was a small amount of soil infilling from the sides of the tree throw pit which was removed and discarded.

Figure 5. Tree throw pit with eroded soil infill from root system. (Photograph by the author, 2009)

Erosion at the Bear Gulch site was considered minimal as the effects of water movement over the bench were slight, pedestrian and livestock traffic were non-existent, ground cover in the form of plants was robust, and the occurrence of soils as opposed to sediments, were present. Every opportunity to decrease the effects of erosion on the data gathered at this site was taken. This included choosing an area outside of flood plains and on the gentlest possible terrain, as well as locations away from any moving water source able to affect the soils.

Conclusion

After careful consideration of the effects of site formation processes at the Bear Gulch site, the following determinations have been made. First, the overall effects of cultural formation processes are negligible and have not affected the integrity of this site based on reliable sources of information on the prehistory of this obsidian procurement area and the region in general. Second, the effects of non-cultural or environmental site formation processes have affected this site, but not to the extent of rendering the archaeological data, and its provenience incapable of providing reliable information. It is my conclusion that this site and its artifact assemblage fairly represent a reliable continuum of pre historic material culture. The following chapter provides illustrations, processes, parameters, and descriptions of the lithic assemblage studied at Bear Gulch.

CHAPTER IV

LITHICS

Obsidian artifacts are the subject of this project and the main focus of data analysis and interpretation. The physical classification, and interpretation of these artifacts will follow Andrefsky's (1998) *Lithics,* Crabtree's (1972) *An Introduction to Flintworking*, Kardulias' (2003) *Written in Stone*, and Odell's (2003) *Lithic Analysis*. The study of cortical flake debris is influenced by the work of Dibble et al. (2005), and Sullivan and Rozen (1985). Core reduction and lithic transport issues are informed by Roth and Dibble (1998).

With the study of lithics as a focal point in this research, an understanding of André Leroi-Gourhan's (1964), *chaîne opératoire*, or operational sequence, is of great importance. The description of this theory by Berard (2008:92) is referenced for use in this thesis. Although this concept was originally articulated by the American, William Henry Holmes (1894), Leroi-Gourhan's writings are the more recognized. Schott (2003:95) provided information on the differences between the American and French theories.

The concept is described by Berard (2008) as

> a sequence of technical facts of which the operations are articulated as a link to a process leading to a certain result, of such manner that the observer must be able to associate a technical act, even isolated, to the series in which it makes sense, technically and socially. [100]

This notion is crucial to this study in that lithic debris is the medium in which statistical analyses and inferences are constructed to test hypotheses and define the assemblage. Individual flake analysis was undertaken to categorize the artifact assemblage at the Bear Gulch site. This approach relies on understanding the technical process trajectory described by this theory.

Dating lithics by use of obsidian hydration is also relevant to this study. The benefits of obsidian hydration analysis on recovered artifacts was provided by Friedman and Long (1976), Friedman and Trembour (1983), and Origer (2010). These discussions encouraged the use of this specific analysis to place prehistoric activities at Bear Gulch in a temporal sequence, as well as to determine the integrity of the deposits. This literature also contributes to the reduction stage analysis, the study of special properties of quarried lithics, trends in reduction stages through time, problems associated with interpreting this type of assemblage, and inferring original behaviors of the pre-historic peoples utilizing this source.

Miocene and Pliocene felsic volcanic rocks, associated with the Heise and Yellowstone volcanic fields, provide the obsidian which was utilized by native groups, and subsequently this study. These formed when hot silica-rich water circulated through the young rhyolite lavas and tuffs in the Bear Gulch region (Digital Atlas of Idaho 2010).

Obsidian has characteristics that make it desirable for tool production and use. As described by Crabtree (1982:2), volcanic glasses such as obsidian have the properties of a heavy liquid, and as such maintain the qualities of elasticity and homogeneity. These qualities allow the person working the material to produce a fracture in any direction. This means it is a predictable medium to work with. Crabtree (1982:3) notes that when obsidian was available it seemed to be preferred by prehistoric hunter gatherers. This is most likely due the extremely sharp cutting edge of the worked material.

Obsidian cobble reduction sequences are shown in the following Figures 6-10 to illustrate the trajectory of raw material, to portable tool blank, to finished projectile

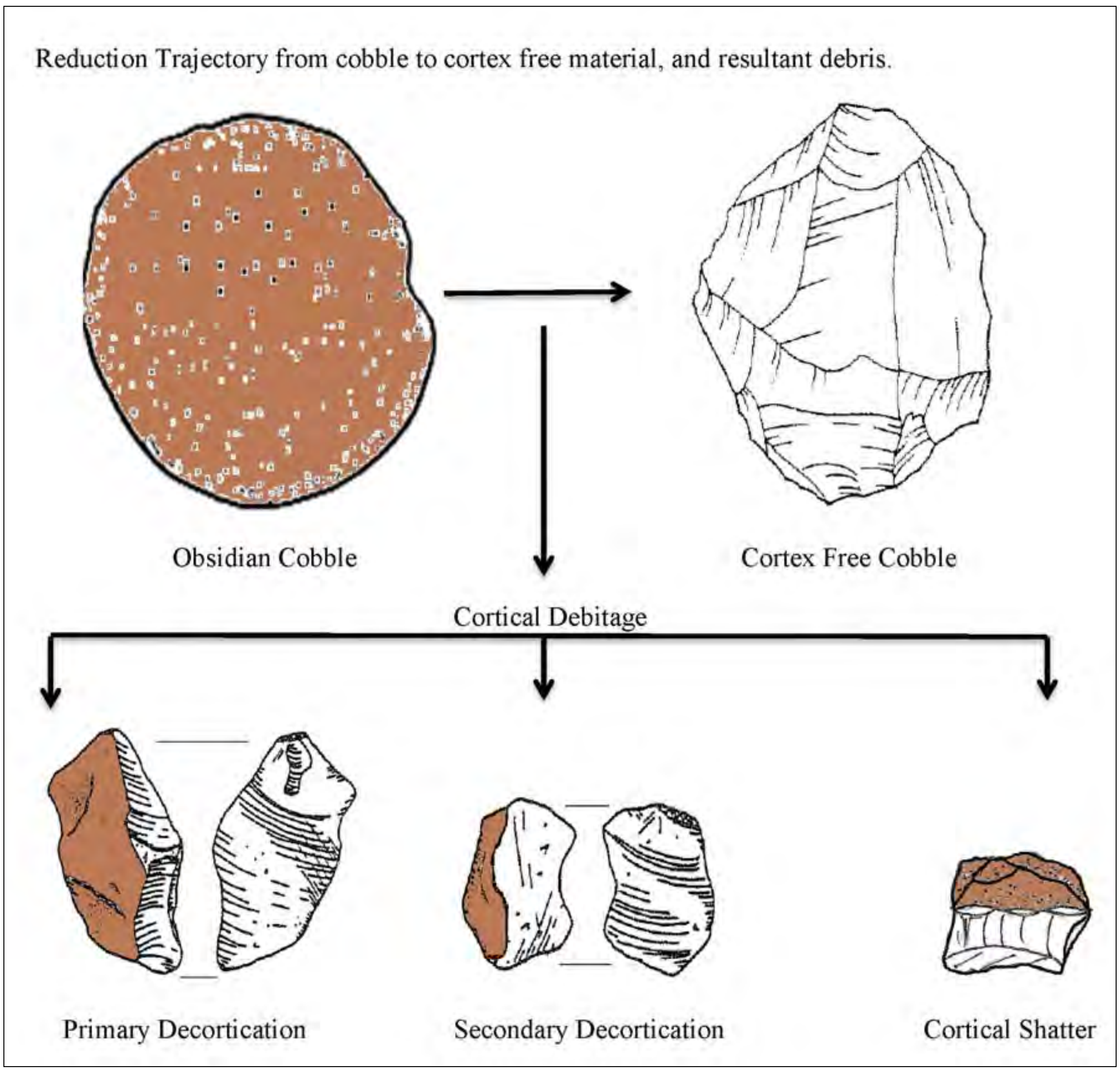

Figure 6. Early stage reduction/cortical debris trajectory. (Diagram by the author 2011)

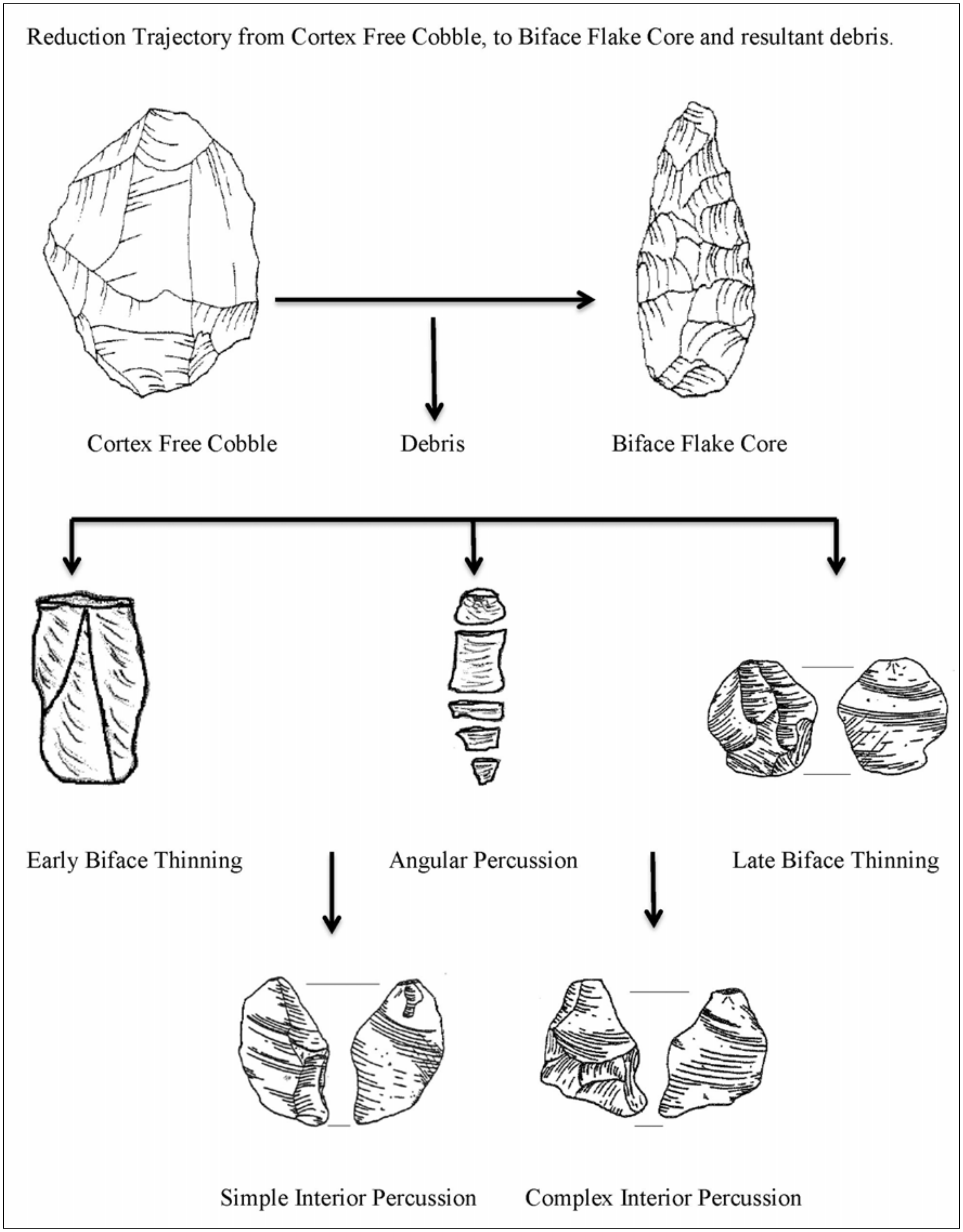

Figure 7. Cortex free cobble to biface core trajectory. (Diagram by the author 2011)

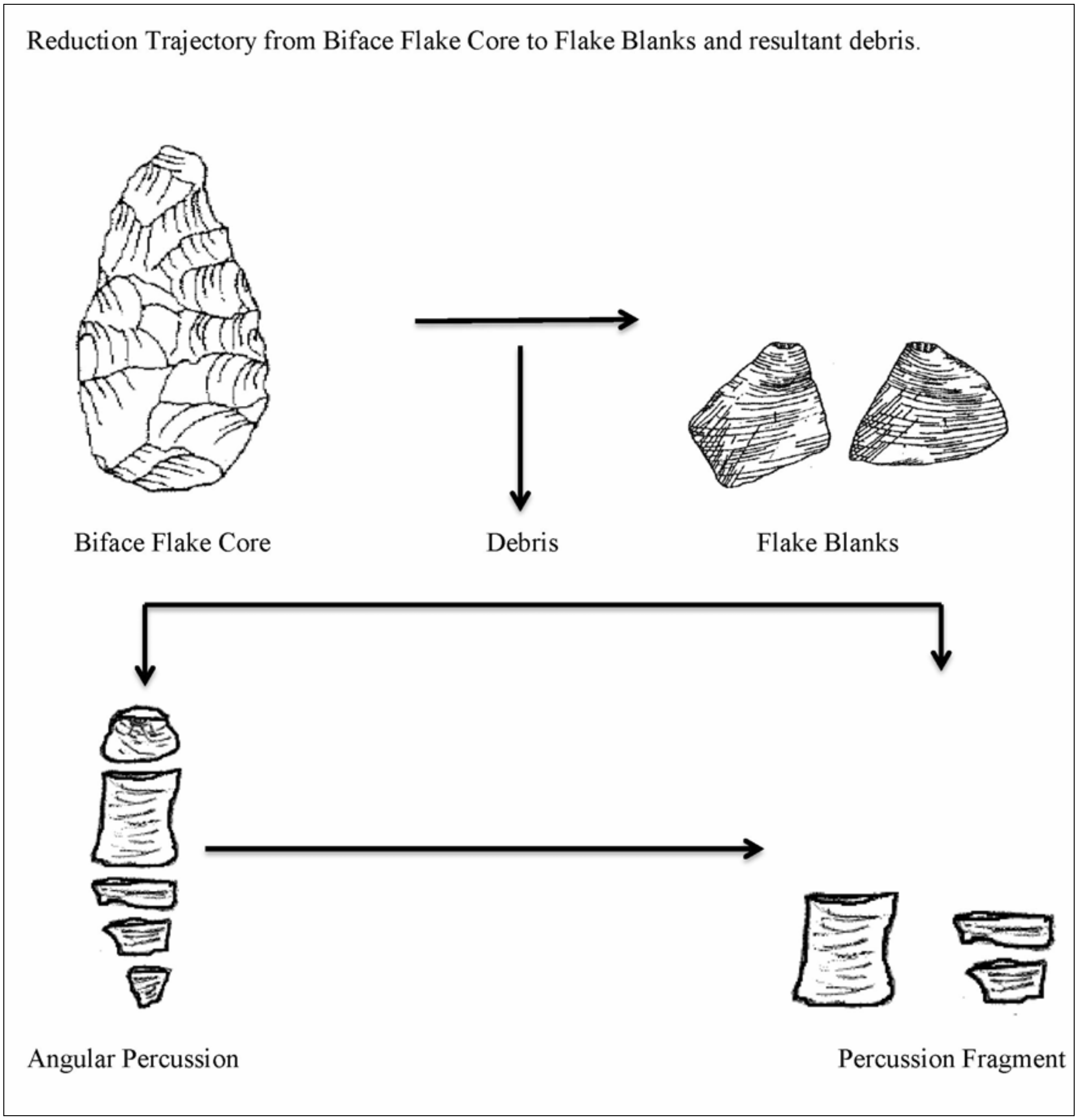

Figure 8. Core to flake blank and resultant debris. (Diagram by the author 2011)

point. The resultant debris is shown as exhibiting different morphological characteristics dependent on various stages of reduction. These reduction phase-specific artifacts are the primary focus of study at the Bear Gulch site.

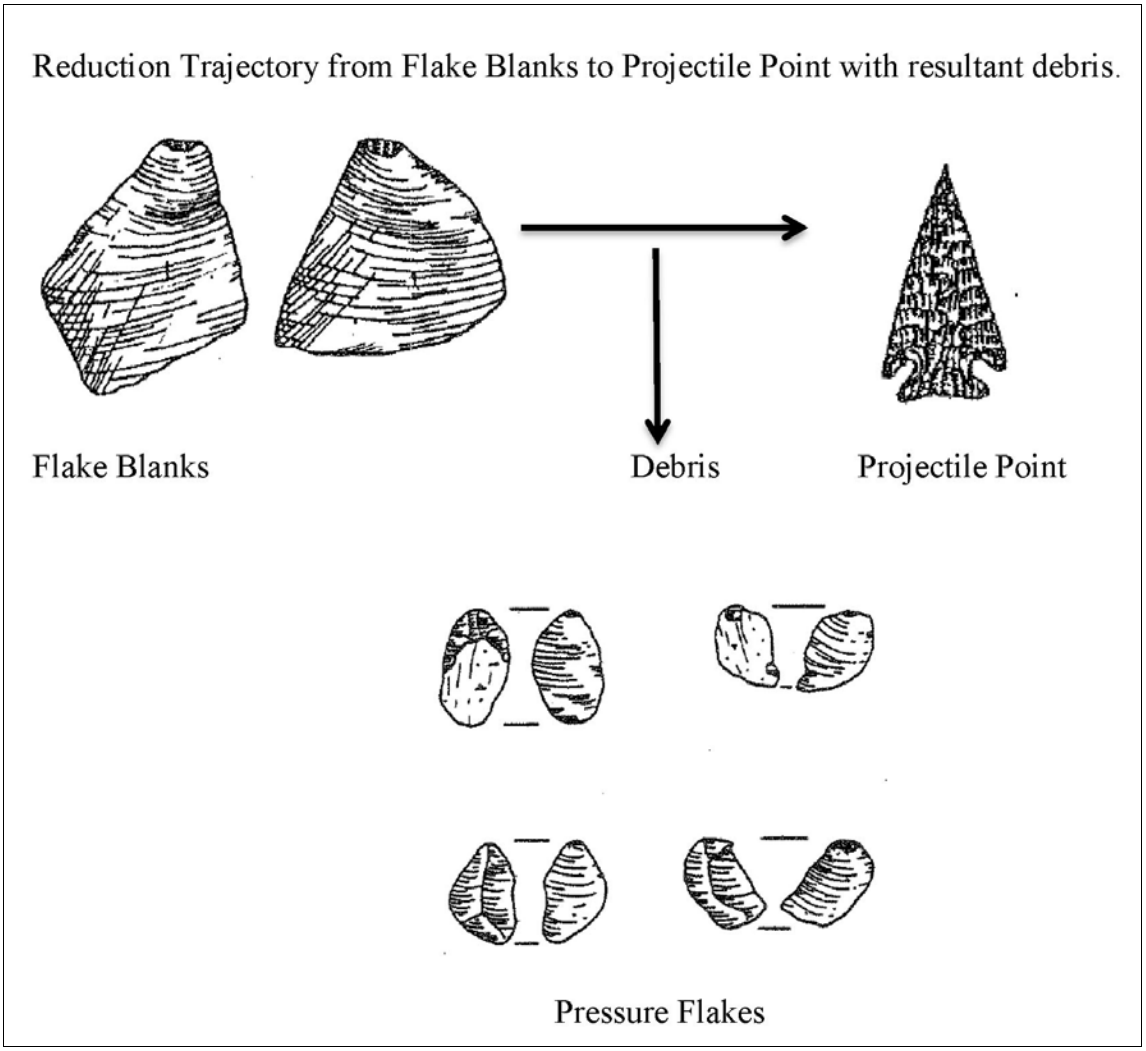

Figure 9. Flake blank to projectile point trajectory. (Diagram by the author 2011)

Material Descriptions

1. Debris: These include all recovered cultural material artifacts, such as all flake types, cores, assayed cobbles (cobbles with at least one flake removal), and flake tools; also called artifacts.

2. Debitage: Defined by Sullivan and Rozen (1985:755) debitage comprise "chipped stone artifacts that are not cores or tools."

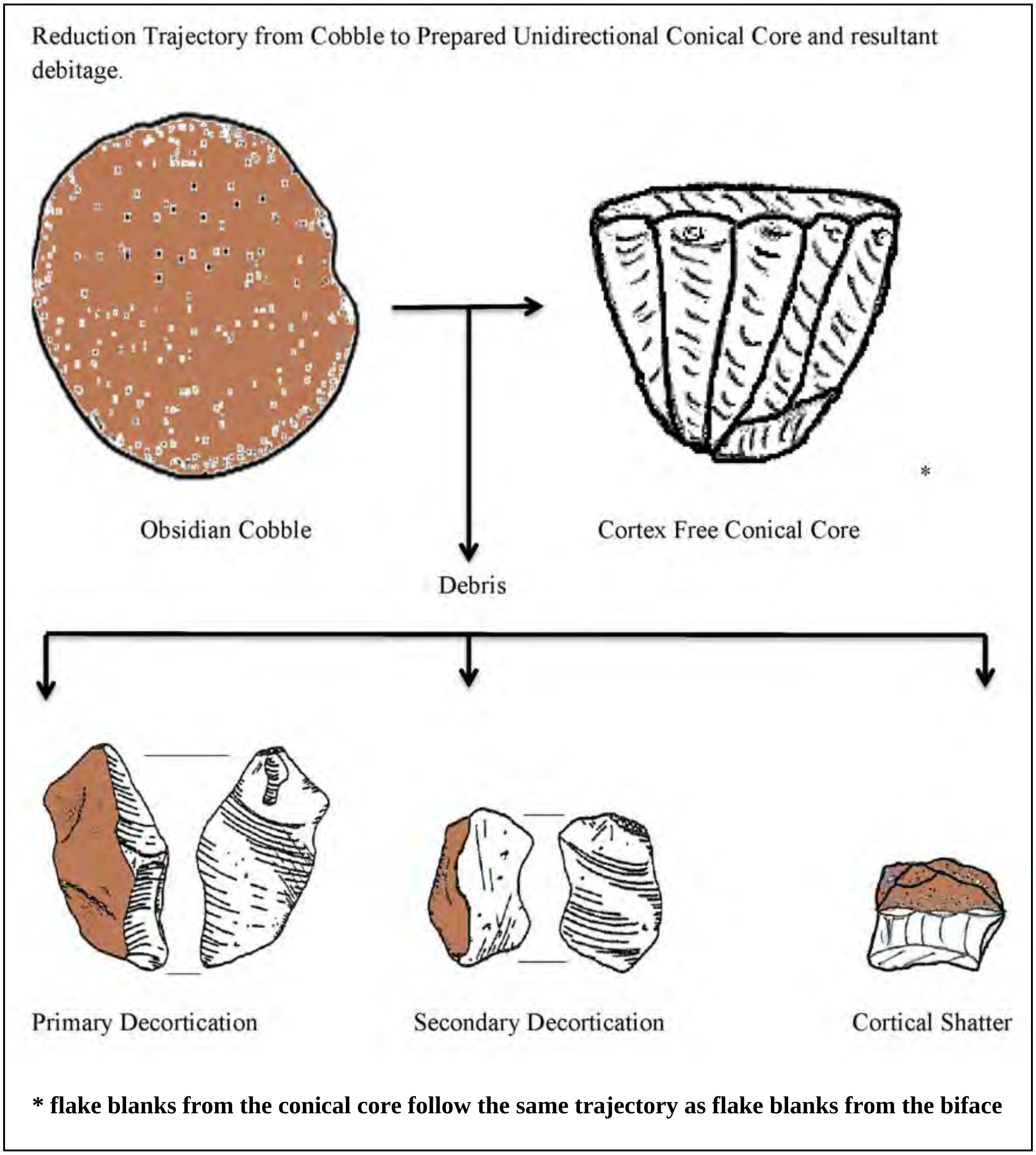

Figure 10. Cobble to conical core trajectory. (Diagram by the author 2011)

3. Flakes: These are all identifiable flake categories. Although this study focuses on cortical versus non-cortical debris, an individual flake analysis was still carried out.

Flake Descriptions

Primary Decortication

Flakes which have at least 70 percent cortex present on the dorsal surface. This is estimated by surface area of cortical versus non-cortical material. This stage is generally reflected in the most initial stage of cobble reduction. Although often large, some flakes with 70 percent cortex will be smaller, produced incidentally or in platform preparation (Figure 11).

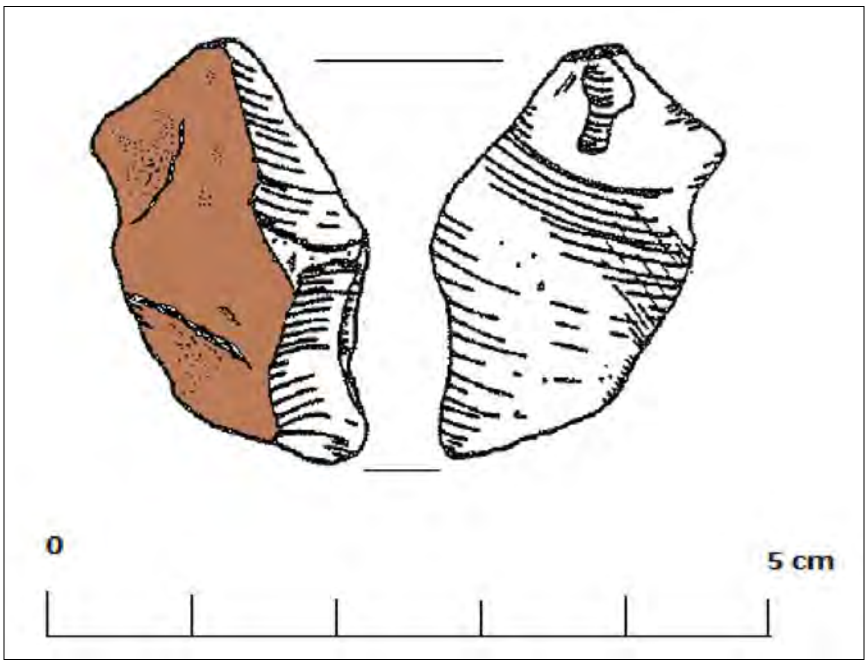

Figure 11. Primary decortication. (Sketch by the author 2011)

Secondary Decortication

Flakes with cortical surfaces represented at less than 70 percent on the dorsal surface. On average, these are smaller than primary decortication artifacts (Figure 12).

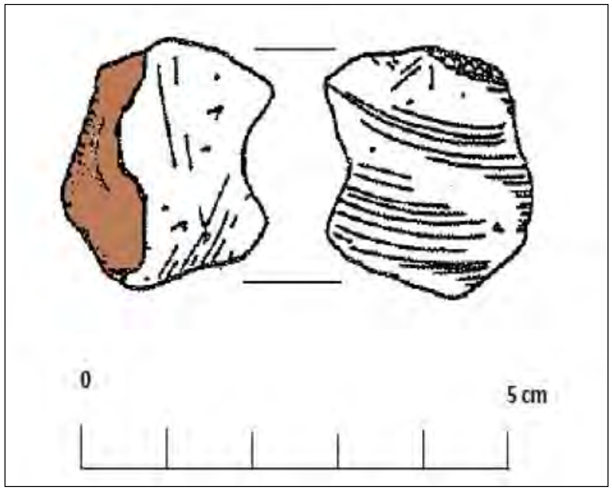

Figure 12. Secondary decortication.
(Sketch by the author 2011)

Cortical Shatter

Angular pieces of material that lack well-defined flake characteristics but retain cortex on some of the visible surface. Flakes sometimes break during the early stages of reduction when force is used to shape or trim the cobble. Shatter may also be produced through the presence of impurities or fracture planes (Figure 13).

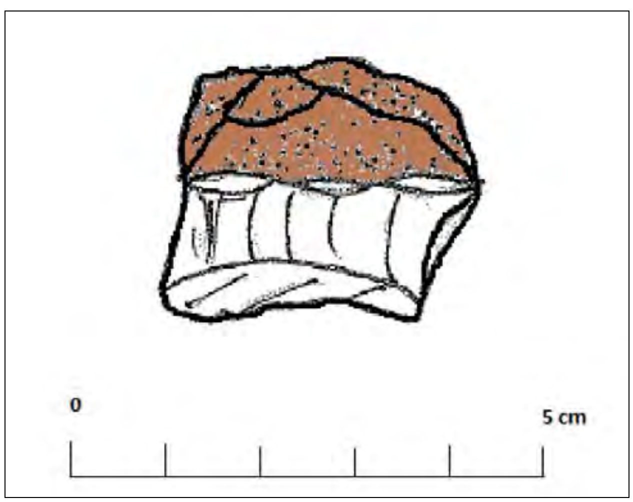

Figure 13. Cortical shatter. (Sketch by the author 2011)

Simple Interior Percussion

Made relatively early in the shaping process, these flakes tend to be fairly strait in cross section, with a platform approximating 90 degrees, and have little dorsal complexity. This means that there are few arrises from prior flake removals. At most there should be only one dorsal flake arris on these pieces (Figure 14).

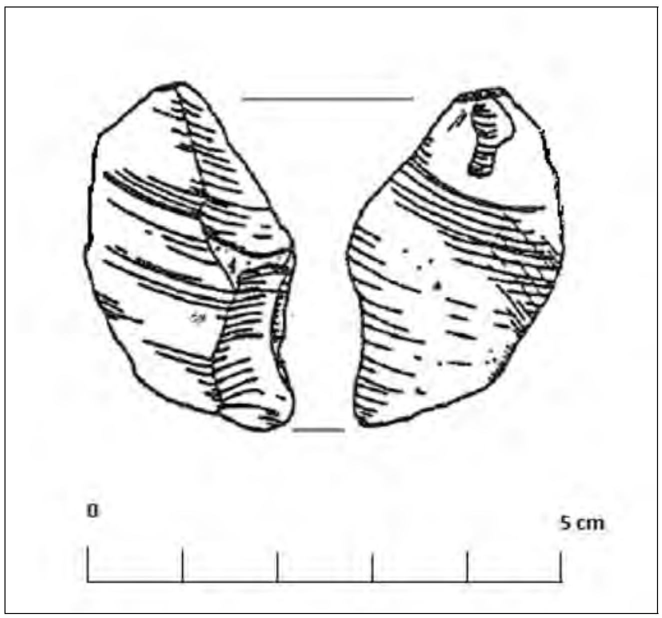

Figure 14. Simple interior percussion.
(Sketch the author 2011)

Complex Interior Percussion

These pieces still have a more-or-less straight cross section, but will have more than one arris on the dorsal surface. These flakes are made later in the shaping process, as is evidenced in the numerous flake scars on the dorsal side (Figure 15).

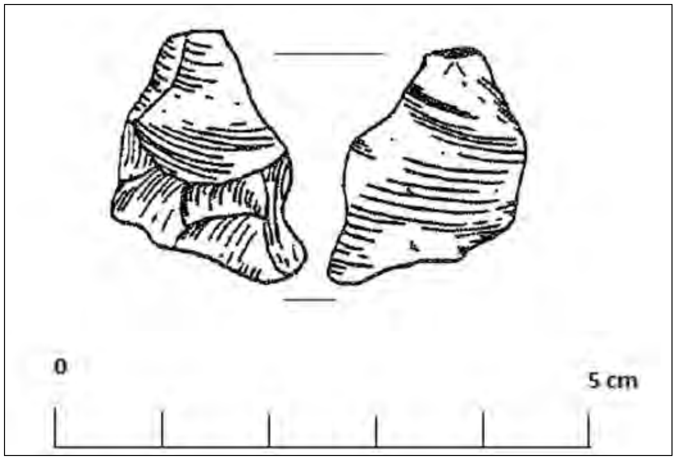

Figure 15. Complex interior percussion.
(Sketch by the author 2011)

<u>Early Biface Thinning</u>

These pieces are curved in long-section, or platform to flake termination, and have between one or two arrises on the dorsal surface. The platform, originating on the biface margin, will tend to be angled or faceted, sometimes with a lip on the ventral side of the platform. The bulb of percussion may be less pronounced than on interior percussion flakes due to less force used in flake removal (Figure 16).

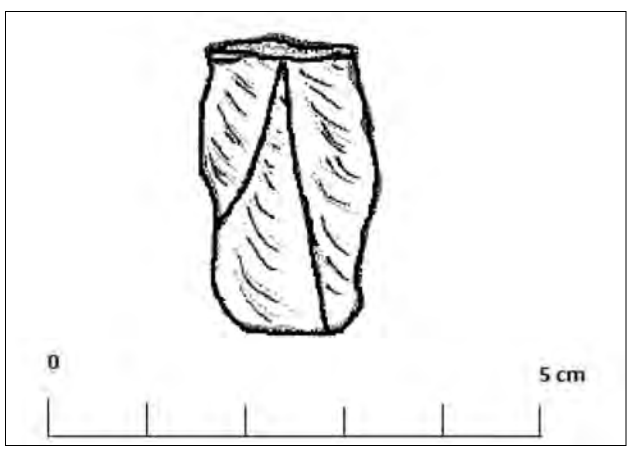

Figure16. Early biface thinning. (Sketch by the author 2011)

Late Biface Thinning

These pieces are created later in the reduction sequence and tend to have far more dorsal complexity. They may also have less obvious bifacial platforms. These will have more than two arrises on the dorsal side and will generally be smaller in size than the earlier stage counterparts (Figure 17).

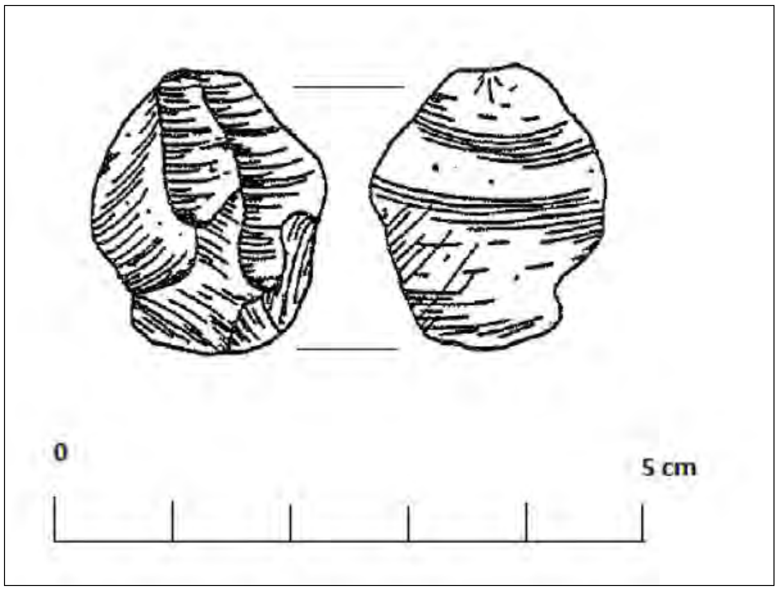

Figure 17. Late biface thinning. (Sketch by the author 2011.)

Angular Percussion

These are angular pieces, or fragments, that lack cortex. This debris is made early in the reduction process when high force is used, and many flakes break during detachment (Figure 18).

Percussion Fragments

These are obvious interior percussion flakes that lack sufficient attributes to specifically identify (Figure 19).

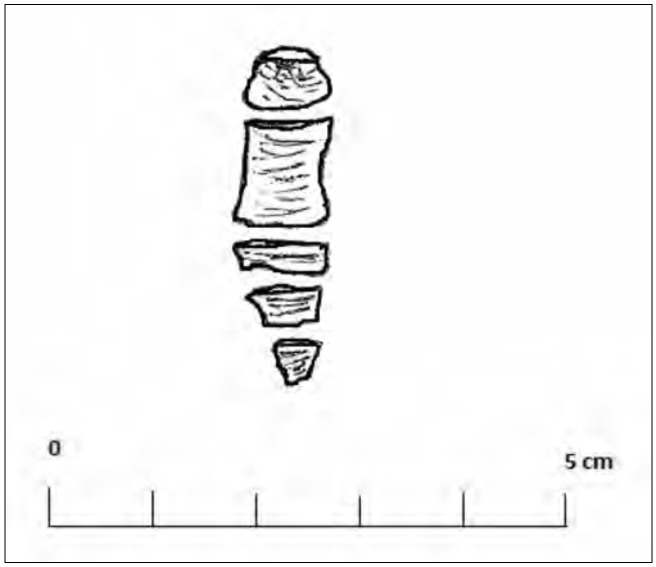

Figure 18. Angular percussion. (Sketch by the author 2011)

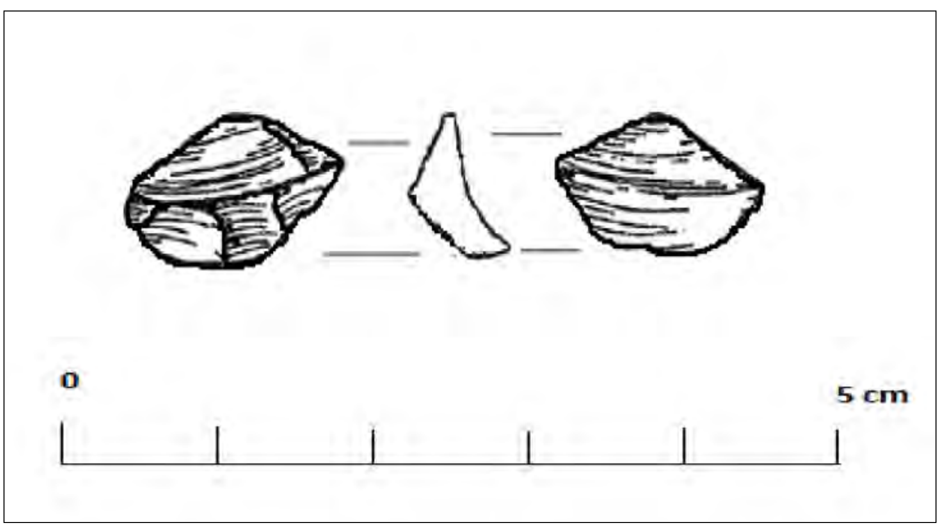

Figure 19. Percussion fragments. (Sketch by the author 2011)

<u>Pressure Flakes</u>

Pressure flakes are diagnostic indicators of the pressure shaping technique. This technique removes flakes through applied pressure instead of direct or indirect striking. They may maintain a small section of the margin and will have a fair level of dorsal complexity. These artifacts are generally made during the finishing touches on a tool (Figure 20).

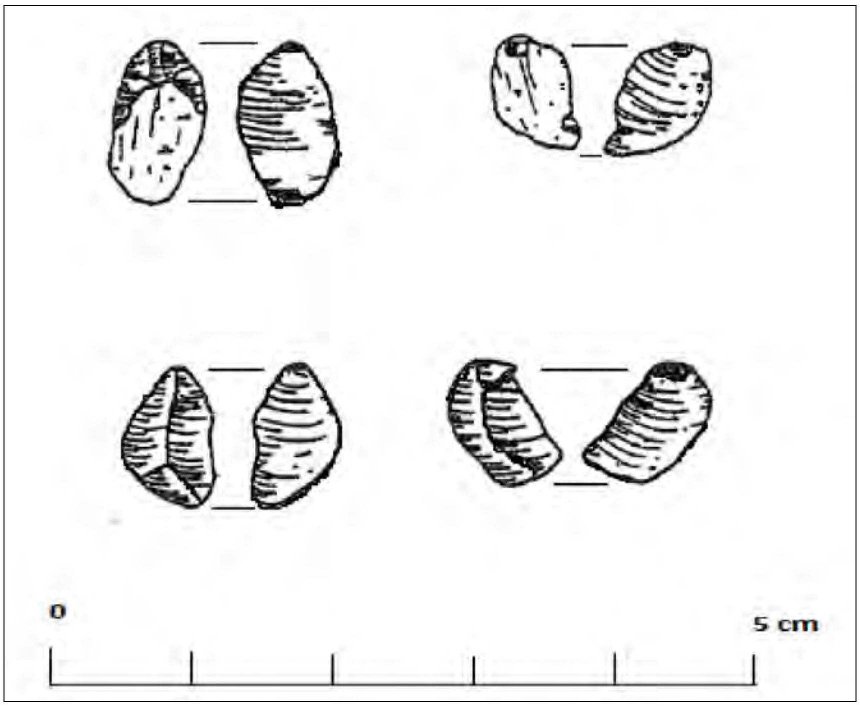

Figure 20. Pressure flake. (Sketch by the author 2011)

The illustrations, processes, and descriptions of artifacts found in this chapter are the dominant artifact types, and their most likely method of creation, that were recovered from the Bear Gulch site. Terms with definitions accompany the individual illustrations. The following chapter discusses the theoretical and methodological framework for research conducted at the Bear Gulch site.

CHAPTER V

THEORY AND METHOD

Theoretical Framework for the Bear Gulch Excavations

Proponents of Processual Archaeology believe that behaviors of ancient groups can be understood through the study of material culture with an adherence to a hypothetico-deductive model. Archaeology as an anthropological study was declared by archaeologists such as Walter Taylor (1948) Willey and Phillips (1958) and Lewis Binford (1962), among others. This was in opposition to previous researchers who concluded that the limits of the science were establishing chronologies, and engaging in simple descriptive endeavors.

The processual approach focuses on understanding cultural systems from the inside, as well as the interrelated parts of the system. The complementary perspectives of studying change as well as cultural characteristics that persist through time, allows for a stasis versus change, or functionality versus process modus operandi (Trigger 2007:314). The benefit and reason behind this is that one phenomenon must be understood to also understand the other.

Scientific objectivity is a trait of processual archaeology in that empirical data coupled with a stringent scientific method is believed to expose the closest understanding of reality possible. Processualists adhere to materialism and positivism in their work.

For my purposes, this overarching theory is followed because it provides an environment where questions regarding prehistory can be asked, tested, and proven true or false.

Behavioral Archaeology

As Schiffer states (1995:251), “The ultimate goal of Behavioral Archaeology is to furnish scientific (e.g., nomothetically based) explanations for variability and change in human behavior.” The ultimate goal of analyzing the lithic assemblage at the Bear Gulch site is also to explain the change in behavior patterns of the original users of this procurement area.

Behavioral archaeology is also a methodological study that deals with the nature of archaeological remains, and ways to reconstruct human behavior from those remains. According to Schiffer (1976: ix), the main emphasis in this method is the need for formulating, testing, and employing archaeological laws. Schiffer (1976:4) and his colleagues understand the subject of archaeology to be the relationship between human behavior and material culture in all places through time. The primary emphasis of behavioral archaeology is on behavior rather than culture (Trigger 1996:426).

This notion gives way to four strategies of archaeological enquiry (Reid et al. 1975:864; Schiffer 1976:5). I will focus on the strategy that I employ in my own research, which happens to be the traditional basis of most archaeological questions.

Schiffer’s (1976:5) first strategy is asking questions about the material culture of the past, to reveal past behaviors of cultural groups. This tactic engages in both descriptive as well as explanatory research goals. To reach these descriptions and explanations of prehistoric behavior with any semblance of credibility certain processes that form the archaeological record “spatially, quantitatively, formally, and relationally” must be accounted for (Schiffer 1976:11). These forces however numerous, do have systematic traits that can be identified and factored into the archaeological assemblages we encounter. These site formation processes, if categorized and applied to existing sites can lead to a more credible study of behavior derived from archaeological material.

When studying archaeological material data, developing inferences and explanations can only take place by accepting and following laws. These laws are created through relating human behavior to observable variations in material objects. These correlates can be recreated and tested for credibility, which is known as experimental archaeology. For example, a certain technique of reducing natural obsidian nodules to usable flank blanks leaves a specific signature on the core as well as the flake itself. This technique denotes a type of technological behavior that can be identified among many different sites as well as through different time periods. This technique can be tested in contemporary settings and scrutinized for similarities in prehistoric assemblages. This gives the archaeologist a justification for his or her inferences. Schiffer (1976:12) concludes that “*inference justification* is the archaeological knowledge and data-and their structure-that give an inference its credibility.”

As important as correlates are to the field of archaeology, by themselves they are not enough to derive credible inferences of past human behaviors from archaeological sites and artifact assemblages. Cultural as well as environmental formation processes have an impact on what the archaeologist encounters as well. These processes are described in detail in the Site Formation Processes Chapter III.

Middle Range Theory

A common question occurs when discussions of behavior archaeology take place, that question is, what is the difference between behavioral archaeology and Middle Range Theory? For the most part both approaches are similar; however, there are some distinctions that should be noted. Briefly, Middle Range Theory is concerned with how the archaeological record was formed, and how to interpret that data. This approach is also used as an argument that connects observed data in the archaeological record with interpretations of those observations. These two approaches are generally represented by Schiffer for the former and Binford for the latter.

First**,** Middle Range Theory sees formation processes and the ongoing cultural system as the same thing. Lewis Binford's (1979) approach would begin with constructing a hypothetical cultural system and deducing the actions of that system into resultant data found in the archaeological record. Schiffer however, divides cultural systems into individual processes. These processes then have a degree of independence from the cultural system as a whole. According to Tschauner (1996:8), this allows for a widely generalizable and cross-cultural application of inference creation from correlates and formation process data.

Second, Middle Range Theory (Binford 1983: 222-223, 292) is focused on “systemic organization and basic adaptive properties of systems” (Tschauner 1996:9), whereas Schiffer’s (1979:359) behavioral archaeology is concerned with individual events from which systemic properties can be derived. Tschauner (1996:9), notes that “For Schiffer (1979:353-359), culture change is to be described as behavioral change in terms of rates of activity performance. Binford (1983:215-216, 222-223) argues that the archaeological record is not a product of individual behaviors, but a precipitate of long-term institutions."

A final difference between these perspectives is their relation with developing general theory. Binford (1977) believes Middle Range Theory tests for general theory and that they both work together. Schiffer (1976), on the other hand, considers behavioral archaeology to be primarily a methodological approach, which for the time being, is not specifically engaged in theory building. The Behavioral program is not however, a plan without future possibilities of confirming laws or theories derived from human-artifact relationships (Schiffer 1995:253).

Transformation Theory

In the current project, theory directs method. This is exemplified by the theoretical concepts behind behavioral archaeology, which as the name implies, is concerned with behavior as opposed to more complex concerns such as culture. Early manifestations of this theory are illuminated by the writings of Ascher (1968), however, the guiding research of Reed, Schiffer and Rathje (1975), as well as subsequent contributions to this theoretical approach from Binford (1981), Tschauner (1996), Broughton and O'Connell (1999), and Hegmon (2003), provide parameters and focus for the project at hand. It should be noted that my definitions of behavior and cultural process are one in the same.

Beyond its methodological approach, Behavioral Archaeology employs a theoretical concept known as the "transformation" position (Schiffer 1987:10). Based in part on Ascher's (1968:43-52) entropy view of archaeological site preservation (time progressively reduces the quality and quantity of archaeological evidence); Schiffer's view states that no matter how much evidence is present, the archaeologist cannot derive behavior or organizational patterns directly from the archaeological record. This is due to natural or cultural distortions. Formation processes themselves however do exhibit patterns that can be identified, and the distortions in the archaeological record therefore rectified by using the appropriate analytical tools built on the laws governing these processes (Schiffer 1987:10).

Concepts

The following concepts define the theoretical framework for research conducted at the Bear Gulch site. These views are taken from the principles of Behavioral Archaeology as outlined by Schiffer's (1995: 251) discussion of the tenets of the discipline.

Observed generalizations in artifact assemblages are important to research at this site. One important generalization derived from analyzing the lithic assemblage at the Bear Gulch site is that the majority of observed artifacts from this lithic source are cortical debris. Although this may seem an obvious observation, this fact aided in my research design and analysis techniques that may be applied to future research in similar areas.

Correlates and transforms are the basis for inference while behavioral variability is explained through other principles such as technological change, resource quality, or availability. For the purpose of this thesis, correlating lithic reduction activities to the characteristics of the artifact assemblage, as well as accounting for transformations in the archaeological record is a primary focus. Future research may include deriving theories of why these behaviors changed.

Diverse research strategies can aid in developing correlates and transform theory. These include prehistoric as well as historic archaeology among others. Employed in this research are new methods for collecting data that may help expand the field of transform theory.

Activity is the basic unit of human behavior. Human behavior reveals itself in the artifact.

Artifacts in turn perform functions that are technological, social, or ideological. These artifacts vary in form, space, frequency, and relation. The specific activity of obsidian procurement and reduction, and the changes these activities have undergone throughout the history of the area are studied to lay the groundwork for future theories of technological, social, or ideological change.

Technical choices in artifact manufacture are determined by the maker of the artifact which effect variability. Performance of the artifact is thus affected. These capabilities influence technological, social, and ideological functions. Changes in artifact characteristics at Bear Gulch may indicate a shift in one or all of these functions.

Activities are conducted by behavioral components, or a unit of social organization. These consist of people, places, and artifacts. The behavioral components of the original users of the Bear Gulch obsidian source may be revealed through study of this site. That is, at what social level, i.e., family or entire culture group may have taken advantage of this resource. Archaeological theoretical concepts must be defined in *activities,* which are reflected in the artifact.

Larger scale behavioral changes in people-artifact relationships can restructure activity relationships. Changes in artifact assemblage characteristics at the Bear Gulch site may indicate changes in a variety of activities ranging from small-scale regional use of the resource to intensification due to population growth or increased trade in the material.

Knowledge of the prehistoric past is often based on inference. Understanding and accounting for all variability in the artifacts assemblage at Bear Gulch is undertaken by accounting for cultural and environmental formation processes. This requires understanding variability through the distinction between systemic and archaeological contexts. Formation processes may distort systemic patterns as well as introducing patterns of their own.

Behaviors of the archaeologist may create variability in the archaeological record. All reasonable steps were taken to eliminate bias in this research. Accomplishing this goal required asking general questions of the artifact assemblage without subscribing to a predetermined social theory.

Artifacts and the deposits they occur within can provide evidence for identifying formation processes. The artifact characteristics and context in which they were found at Bear Gulch provided a variety of potential formation processes. These include reduction stages of artifacts as well as the location of the deposits in root systems.

All archaeological research activities can contribute to method and theory. The research activities at Bear Gulch provide new dimensions to data collection and human artifact relationships.

As the field of Behavioral Archaeology progresses, and accumulates a body of laws and theories, larger theoretical questions may be answered (examples are provided in Schiffer 1999:168). As the first archaeological investigations into this site, this research project aims to produce a foundation of observed material culture and the behaviors that created it, in hopes that future research can build justifiable social theoretical constructs.

Following these concepts is essential in validating the excavations, analysis, and interpretations produced at the Bear Gulch site. This is in large part due to the nature of the deposits as well as the topographic, geologic and climatic characteristics of the area.

Methodology

In my research, the physical procedures of conducting archaeology were influenced more by experience than reviewing literature. This is in part due to the unique nature of the deposits I recovered, and the steps taken to control the data. That being said, one must be equipped with some form of information before field work commences. That information was provided to me by a range of archaeologists mentioned below.

When constructing my research design I consulted and followed the writings of several prominent archaeologists. Daniels (1978:29) describes the implications of bias in research and how to plan research in a manner that limits the contributions of such errors. This approach calls for no pre-conceived notions of what the data means or reflects prior to analysis. Bias may also affect artifact classification if the researcher has prior knowledge of the artifacts context. My research questions concern behavioral patterns in prehistory without delving into explanatory or interpretive models of aboriginal cognition. The reason for this approach lies in the belief that prior to interpretation at this theoretical level, a foundation of laws in correlates and formation processes must be completed. The realizations of these laws are the primary focus of this project.

Reid (1985) explains how to incorporate a consideration of site formation processes at all stages of research. Binford (2001:669) and Odell (2001:679) also helped form my research design in describing where research problems come from and how to logically construct a research question.

Methodological techniques were also acquired through an archaeological field school in 2006 where survey, excavation and data analysis were paramount. It should be noted that my adherence to Schiffer's (1976) *Behavioral Archaeology* is a foundation to my methodological approach. Schiffer's method is central to this project because all field and laboratory activities completed during the course of this study all adhered to the concepts of site formation processes' to gain a clearer picture of how my study area was formed and distorted from its original configuration.

The research design for fieldwork follows the basic tenets of archaeological survey, excavation, and analysis, which I learned in study from sources such as, Collins and Molyneaux's, *Survey* (2003), Carmichael, Lafferty, and Molyneaux's *Excavation* (2003), and Ewan's, *Artifacts* (2003). Beyond general practices common in field work, these sources provided guidance in implementing the research design, subsurface testing, and processing and cataloging artifacts. Methodological techniques were also acquired through completion of an archaeological field school in 2006 where survey, excavation and data analysis were paramount.

Known methodology for this unique type of data recovery is not prolific in the body of archaeological literature, however data collection from exposed root systems has been previously attempted by Dr. Shannon Tushingham in Northern California. “Root ball archaeology” as it was termed, was utilized in survey and auger testing to identify possible excavation sites (Tushingham, letter to author 2-10-2011). Adjusting the application of common tools and techniques of survey, excavation, and analysis of artifacts was undertaken to collect the data at this site. The methods of excavation differ in both phases of this project from standard practices in that the artifacts from uprooted trees root/soil matrices were retrieved horizontally, while the artifacts from below this level were retrieved from within a tree throw pit. The upturned root systems and the resultant tree throw pits offered a challenge in data recovery that required careful planning and execution.

Laboratory methodology follows the guidelines of Ewan (2003) for cleaning, sorting and labeling artifacts, and Odell (2003), Andrefsky (1998), and Crabtree (1982), in identifying attributes for measuring and classifying lithic debitage.

Categories of data for this project are as follows:

1. Debris: All recovered cultural material artifacts. This includes all flake types, cores, assayed cobbles, and flake tools. Assayed cobbles are defined as displaying one or more flake removals with the majority of cortex still intact.

2. Debitage: Described by Sullivan and Rozen (1985:755) as “Chipped stone artifacts that are not cores or tools.”

3. Flakes: All identifiable flake categories. Although this study focuses on cortical versus non-cortical debris, an individual flake analysis was still carried out. Descriptions of these types appear in Chapter IV. The categories are:

a. Primary decortication
b. Secondary decortication
c. Cortical shatter
d. Simple interior percussion
e. Complex interior percussion
f. Early biface thinning
g. Late biface thinning
h. Angular percussion
i. Percussion fragments
j. Pressure flakes

Preliminary Research

Initially the prospect for conducting excavations at Bear Gulch was realized during a horseback trip through the area on the way to an archaeological survey for an addition to the Continental Divide Trail on the Idaho-Montana border. Obsidian artifacts were observed in upturned root systems from wind-blown trees. I was familiar with this area and knew it contained an abundance of natural obsidian cobbles and surface assemblages of flaked obsidian lithic scatters. Initial interest in researching the area began in the early summer of 2009.

Record searches for previously recorded sites and completed surveys through the Caribou-Targhee National Forest database revealed heavy concentrations of documented obsidian lithic scatters, lithic workshops, and obsidian quarries as well as two sites in the area labeled as base camps (Forest Service designations TG-247, TG-694, TG-572, TG-245, TG-711). The records accessed were map locations of sites, as well as site and survey reports submitted to the U.S. Forest Service Heritage Program and the Idaho State Historic Preservation Officer.

My subsequent inventory in July 2009 included an intensive pedestrian survey which was conducted in the areas affected by the storm that created the exposed root systems. The survey resulted in the identification of hundreds of uprooted trees that contained obsidian artifacts bound in the root/soil matrices as well as surface lithic scatters and evidence of artifacts in the tree throw pits. I then gained permission to conduct research from the United States Forest Service, and the CSU Chico, Department of Anthropology.

Test Excavations

Shovel probes were conducted on one root system and one tree throw pit in June of 2009. These specific locations were selected because they had artifacts visible in the soil. These tests consisted of shovel probes through the root system and down through the tree throw pit to sterile soil. Sterile soil levels were determined by lack of artifacts, and large, 30 to 45 cm, length boulders approximately 60 cm, into the pit. Both tests on the root/soil matrix and subsurface tree throw pit produced artifacts at all depths. These artifacts were returned to the Forest Service district office that day where they were cleaned with brush and water, and identified as obsidian debris in various stages of reduction. After testing was completed and cultural deposition identified, the test excavation unit was backfilled and abandoned. Preparation for full scale excavations later that summer at similar sites then took place.

Tools Adapted for Excavation

Due to the unique position of the deposits (upturned root wad and resultant tree throw pit) (see Figures 21 and 22), specialized screening boxes were needed to guarantee control of each excavated level. These 1 x 1/2 m, 1/8 in. screen boxes were constructed, tested, and proved reliable (Figure 23). A reciprocating saw was also utilized to cut exposed roots after each 10 cm, level was removed.

Figure 21. Upturned root/soil matrix. (Photograph by the author 2009)

Figure 22. Tree throw pit. (Photograph by the author 2009)

Data Collection

Collection methods described herein refer to both seasons of work conducted during the summer months of 2009 and 2010. Unit 1 was excavated in August 2009. Unit 2 was excavated in June 2010.

Surface Collection

Surface collection of artifacts for Unit 1 was conducted in August 2009 prior to the first excavation. Surface Collection of artifacts for Unit 2 was conducted in June of 2010. The surface collection areas lie within a dense lithic scatter adjacent to the tree throw pits. Dense lithic scatters define the surface area surrounding the excavation unit as well as the entire bench and hillside in this specific area. The dimensions of the larger

Figure 23. Screening box. (Photograph by the author 2010)

obsidian procurement area cover approximately 28 square kilometers, although source and quarry areas are not contiguous (Willingham, 1995:3). A survey to define the exact boundaries of the obsidian procurement area has never been attempted.

Surface collections could not take place directly over the top of the excavated unit. This is due to the ground being turned over by the fallen tree and its root system. The orientation of the fallen Douglas Fir determined the placement of a 1x1 meter square directly adjacent to the tree in an undisturbed location (Figure 24). These collection areas fairly represent undisturbed surface lithic assemblages of the site. A string line and steel spikes marked the collection area. A surface collection was then performed; these artifacts were bagged and labeled for future identification and analysis.

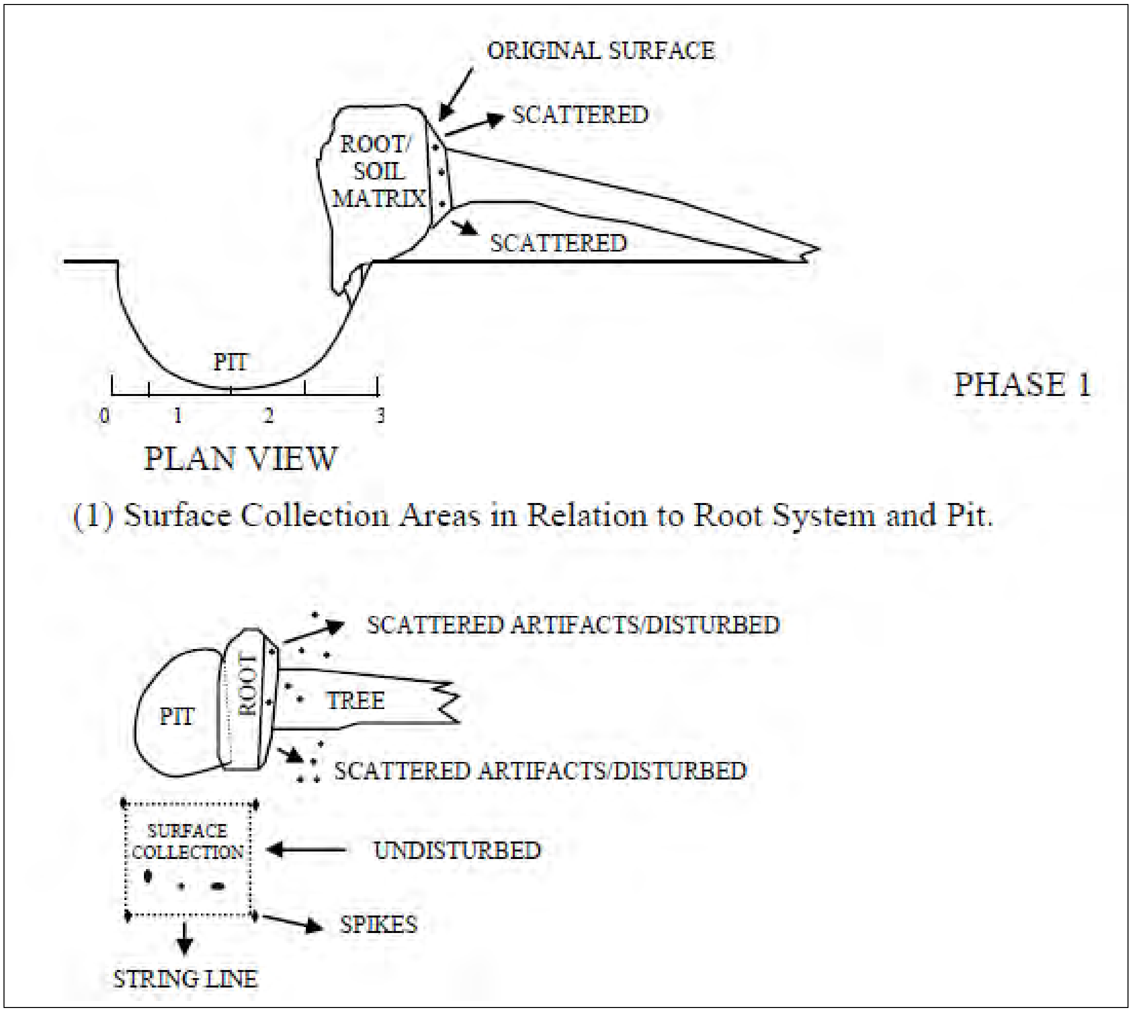

Figure 24. Surface collection diagram. (Sketch by the author 2010)

<u>Excavations</u>

Excavations in these contexts are considered stratigraphically reliable and capable of producing valuable scientific data, because of the belief that “All sites, to a greater or lesser degree, are stratified” (Harris 1979:111). Units were chosen by identifying root systems that displayed artifacts as well as possessing the greatest amount of available soil to excavate. The soil volume was important in determining potential dig locations within root systems because it was assumed a greater amount of artifacts could be retrieved as well as potentially limiting the effects of the roots themselves on the artifact assemblage. The units were located within the bounds of a large, dense lithic scatter which was representative of the overall procurement area. UTM grid coordinates were taken for the site which was then photographed (Figures 25, 26, and 27).

Figure 25. Site location overview facing west. (Photograph by the author, 2009)

Two to three seasons of erosion produced an amount of fallen soil from the root system into the tree throw pits that equaled nearly five gallons of soil per unit. The fallen soil from the root system was identifiable due to the lack of compaction that the remainder of the tree throw pit exhibited. The soil was collected, screened, and artifacts recovered were labeled as coming from this erosion of the root wad. This level was

Figure 26. Unit 1 root/soil matrix. (Photograph by the author, 2009)

incorporated into the overall depth of the excavated unit as a ten cm, level directly below the existing root/soil matrix, and directly above the first excavated level of the tree throw pit.

The root/soil matrix was then excavated in 10 cm, unit levels from the bottom of the root system horizontally towards the top where the tree protruded. This was accomplished through defining a 1x1 m, unit by use of a string line, removing soil levels with trowels and archaeological picks, and removing roots with a reciprocating saw. The excavated soil levels fell into the screening box positioned below the root system. This excavated soil was caught entirely by the screen (Figure 28).

Figure 27. Unit 2 root/soil matrix. (Photograph by the author, 2010)

Plan view sketches to identify artifact provenience were not possible due to the obsidian being completely coated with clay and unidentifiable until the screening process took place. This fact will not affect my research in that horizontal artifact provenience is not a factor in my research design. In addition, due to floralturbation (hydraulic forcing due to root growth), the location of the artifacts within the root system may have been horizontally transported within the arbitrary 10 cm, excavation levels and away from their primary point of disposal. Once again, limited horizontal movement of artifacts due to root growth is not considered detrimental to analyzing vertical stratigraphic relationships. The final depth of the root/soil matrix was 60 cm, for Unit 1,

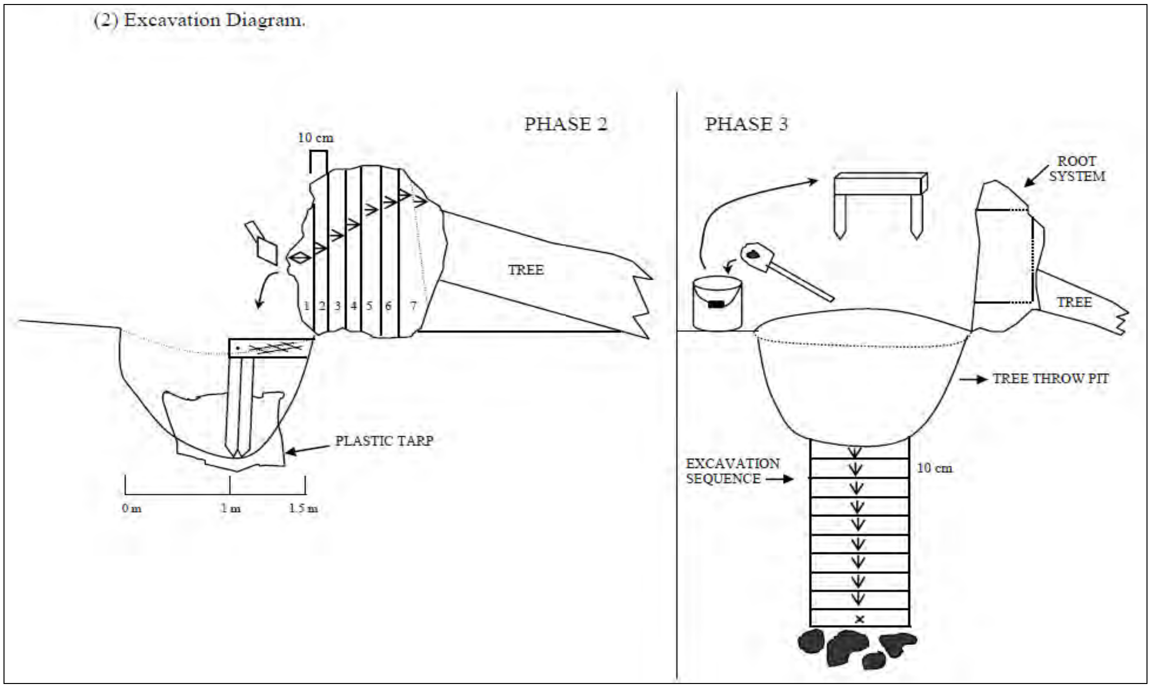

Figure 28. Excavation diagram. (Sketch by the author 2010.)

and 120 cm, for Unit 2. These depths include the 10 cm, soil fall from the root system located within the tree throw pit.

The final excavation sequence was conducted within the tree throw pits, 60 cm, below the surface for Unit 1, and 60 cm, below the surface for Unit 2. Arbitrary 10 cm, levels were excavated separately from the surface of the tree throw pit, until sterile soil was encountered. This gave a complete depth of 120 cm, of material below the natural surface of the land for Unit 1 and 180 cm, for Unit 2. Excavations ceased when it was determined there were no more cultural deposits. This was evidenced through the abundance of large, 20 to 30 cm, length rocks, minimal soil deposits and lack of obsidian artifacts in the screening process for two consecutive 10 cm, intervals (see soil profile, Figure 29). The difference in soil depths at the two excavation sites is a factor of differential soil accumulation.

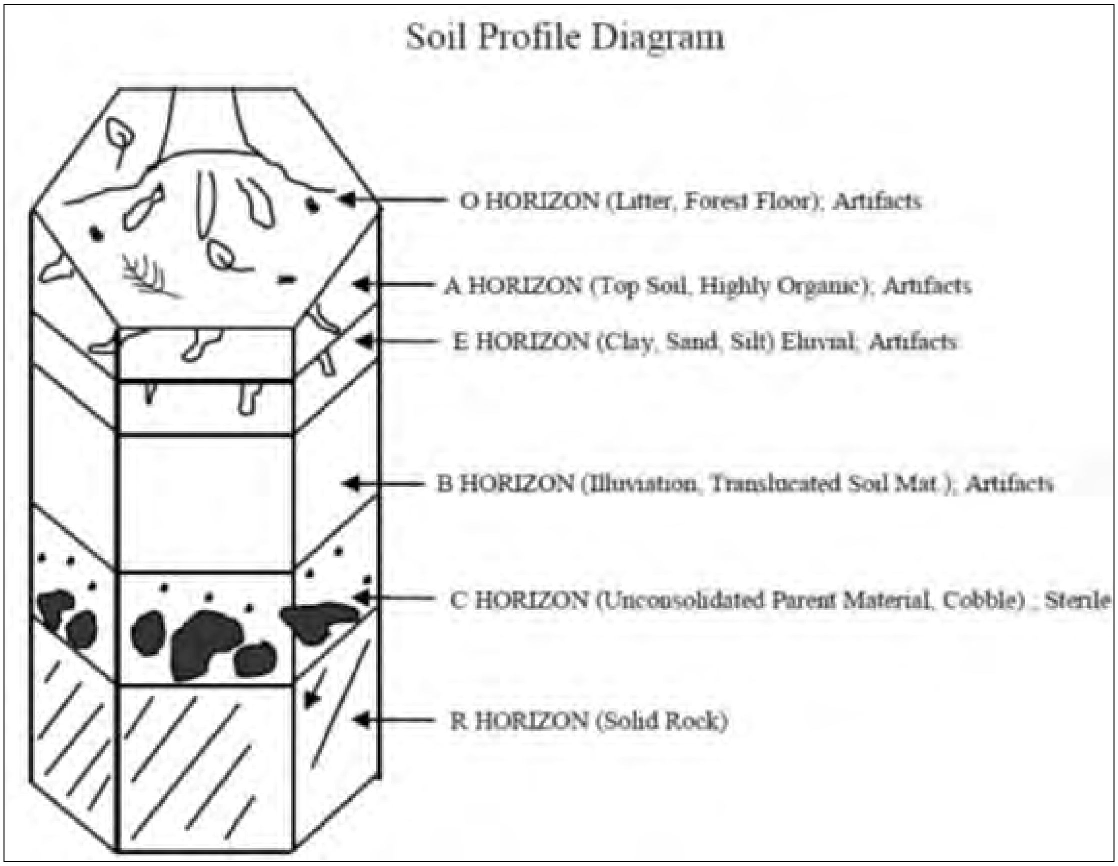

Figure 29. Soil profile diagram. (Sketch by the author 2010)

All soil levels were dry screened on site with the exception of Unit 2 sub-surface Levels 40-60, which were wet screened off site due to soil moisture levels hindering dry screening effectiveness (Figure 30). Artifacts as well as unmodified obsidian nodules were placed in plastic bags and labeled as to excavation unit and level.

Laboratory Methods

The artifacts were transported from Idaho to California in October of 2009 for Unit 1, and November of 2010 for Unit 2. They were then placed in the CSU Chico archaeology lab for storage. All artifacts were washed using water, toothbrushes, and screens.

Figure 30. Wet screening station. (Photograph by the author, 2010)

The next step was to identify cultural versus non-cultural material and separate the two for ease of analysis. This step was performed in the fall of 2009 for Unit 1 data, and the fall of 2010 for Unit 2 data. Crabtree (1972; 1982), Odell (2003), and Andrefsky (1998) were used as primary references in identifying cultural modified materials. The first step in separating artifacts from natural cobble or other culturally unmodified pieces of obsidian was to remove pieces with complete cortical surfaces from the analysis. The second step was to identify artifacts possessing percussion rings from direct or indirect forced pressure. The Cone Principle (Crabtree 1982:3) describes how percussion on certain materials, in this case the volcanic glass obsidian, creates a cone shape from radiating waves of force. These waves are seen in the removed flake as well as the material it was detached from. It is this marker that helped identify cultural from non-cultural materials at Bear Gulch. Once this was accomplished, weighing, measuring, and classifying the cultural artifacts began.

Metrics on the artifacts include weight (grams), maximum length (centimeters), maximum width (centimeters), maximum thickness (centimeters), platform width (centimeters), and platform thickness (centimeters). Flake termination type, bulb of percussion present or absent, cortex percentage, flake type, and ratio of cultural to non-cultural material was recorded.

Weight is recorded for use in volume analysis, or what flake types represent what percentage of the assemblage in weight as well as fluctuations in lithic debris volume through time. Length, width, and thickness are recorded to determine lithic reduction stages, flake type, and their statistical representation in the assemblage. Flake termination type is recorded to establish the occurrence of failed techniques versus successful strikes.

The presence of a bulb of percussion is noted for future identification of flake removal strategy. For example, direct percussion strategies leave a bulb of percussion, while bi-polar techniques do not (Crabtree 1982:5). A bulb of percussion is produced at the point of impact between parent material and the tool used for removing flakes, usually a stone. Using the cone example, this area would be the tip of the cone (Figure 31).

Platform width and thickness are also recorded to define reduction trajectories (Odell 2003:97-102). Cortex percentages on flakes are noted to identify primary and secondary flake removals from the parent cobble or nodule. This can give a statistical

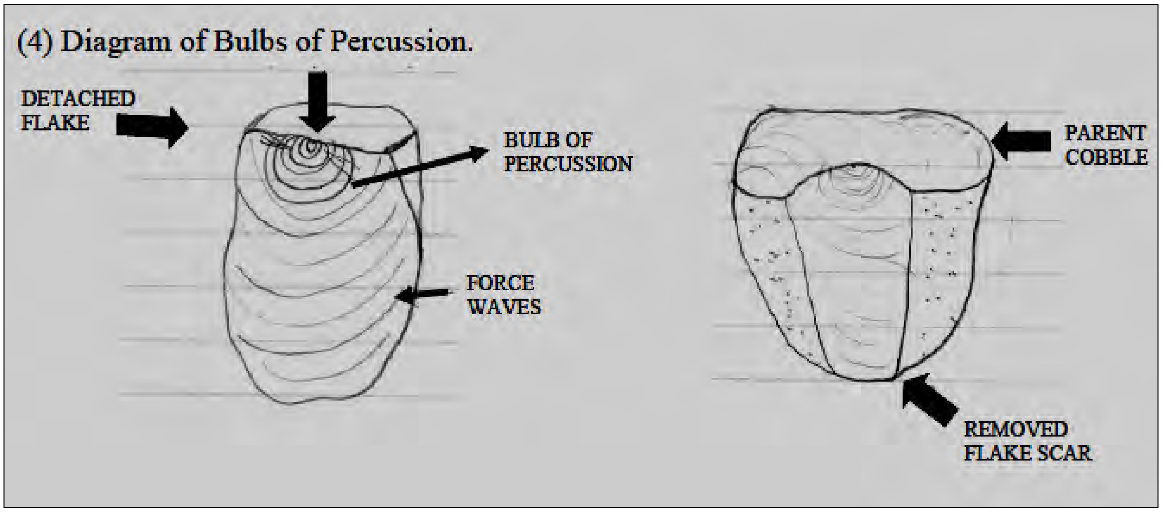

Figure 31. Bulb of percussion. (Sketch by the author 2010)

value to what stages of reduction are more or less prominent. Flake types such as primary decortication, secondary decortication, or interior percussion, aids in identifying reduction stages. The ratio of cultural artifacts to non-cultural natural obsidian cobbles can show what percentages of materials are not selected for tool use. Once again, Don Crabtree's, *An Introduction to Flintworking* (1972:22) was used as a reference (See lithics chapter for more detailed explanation).

There is more than one technique available to the researcher who studies lithic debitage. Individual flake analysis was undertaken to best classify and define the assemblage at Bear Gulch. This strategy was adopted due to the material type, amount of data acquired, and its reliability. Although the flake characteristics analyzed in the current study depend mostly on cortical versus non-cortical debris, the classification of individual flakes may prove useful in future studies of this site.

The problems associated with this technique include, analyses only being performed on complete, unbroken flakes, too time consuming, shortcuts often being taken that omit data, subjectively defined categories that prevent replication, and this strategy may not accurately show technology specific activities due to problems associated with equifinality (Ahler,1989:86-87). These problems were avoided by collecting data on all artifacts excavated, eliminating bias by avoiding shortcuts in recording that would result in omitting data deemed insignificant, utilizing well-known and used artifact categories and descriptions, and not asking questions directly related to lithic technological change. Further discussions on debitage analysis are informed by the work of Sullivan and Rozen (1985), and Prentiss (1998) in debitage typology strategies, as well as Morrison (1990), in validating analysis methods.

Of the data gathered during post-field activities, only flake type, weights, cortex ratios, and artifact frequencies were utilized. These are the only types of data that pertain directly to my research hypotheses. The remaining data were collected for possible future research questions.

My first task involving data organization was to visually represent the data in histograms or line graphs. Histograms and line graphs are labeled on the horizontal axis in stratigraphic 10 cm, levels as youngest to oldest as per Nicolas Steno’s (1669) Law of Superposition which states, sedimentary layers are deposited in a time sequence, with the oldest on the bottom and the youngest on the top. These graphs were developed to answer hypothesis specific questions;

The graphs are discussed in Chapter VI. Hypothesis 1 states that artifacts possessing cortex will increase in frequency and weight as time progresses in the use history of the site. Hypothesis 2 states that the presence of artifacts devoid of cortex, otherwise considered interior or later reduction stage flakes, will become less prominent in frequency and weight as time progresses in the use history of the site. Hypothesis 3 states that the overall frequency and weight of all artifacts increases as time progresses in the use history of the site.

The graphs dedicated to Hypothesis 1 are broken into categories of frequency, weight, and ratio. In the frequency category are early reduction stage flake counts for Units 1 and 2. Early reduction stage flakes are identified by the presence of cortex. In the weight category are early reduction stage weights per level for Units 1 and 2. Weight categories are measured in grams and compared in grams. In the ratio category are percentages of cortical debris compared with non-cortical debris per level for Units 1 and 2.

Graphs dedicated to Hypothesis 2 are divided into the categories of frequency, weight and ratio as well. In the frequency category are late reduction stage flake counts for Units 1 and 2. Late reduction stage flakes are identified as possessing no cortex. In the weight category are late stage reduction weights per level for Units 1 and 2. In the ratio category are percentages of non-cortical debris compared with cortical debris per level for Units 1 and 2.

Histograms dedicated to Hypothesis 3 are divided into categories of frequency and weight. In the frequency category are total flake counts per level for Units 1 and 2. In the weight category are weights per level for Units 1 and 2.

Polynomial regression is used to identify trends in the data which are labeled on each individual histogram. A polynomial trend-line is a curved line that is used when data fluctuates. It is useful for analyzing gains and losses over a large data set. The order of the polynomial can be determined by the number of fluctuations in the data. This strategy is explained in detail in the Data Analysis and Interpretation Chapter (VI).

Eight artifacts were selected from the excavated units to be submitted to Tom Origer's Obsidian Hydration Laboratory in Northern California to determine date ranges within the studied units (absolute dating), as well as ensuring the integrity of the deposits (relative dating). The integrity of the excavated units was tested by checking hydration dates against stratigraphic levels. If the older artifacts occur at the bottom of the unit and consistently return younger ages as they near the ground surface, then we can assume the soil at these sites has not been disturbed to the extent that the information has lost scientific value. Complete investigations into site formation processes at the site, as well as an acknowledgement of the Law of Superposition, solidify the validity of this correlation.

Obsidian hydration band analysis is a technique utilized in determining either absolute or relative dates from obsidian artifacts. As described by Rogers (2010:3239), "Obsidian hydration dating (OHD) is based on the principle that, when a freshly-created surface of obsidian is exposed to the atmosphere, water molecules diffuse into the glass at a predictable rate. If the rate of hydration is known or can be inferred, the time since the surface was exposed can be estimated." The original users of this obsidian source created an assemblage of artifacts through time that possess surfaces which provide the opportunity to estimate their date of creation.

The artifacts submitted for analysis were prepared first by selecting locations within the deposits that covered the entirety of the use life of the site. That is, earliest samples (surface assemblage), to latest samples (artifacts retrieved from greatest depths), as well as stratigraphic levels in between (root system and tree throw pit). Second, artifacts from these levels were chosen by their potential to yield the most reliable data. That is, artifacts that displayed clean surfaces free of corrosion, as well as suitable surface areas for testing.

Obsidian hydration dating is recognized as a valuable tool by many archaeological researchers (Friedman and Long 1976; Friedman and Trembour 1983; Michels 1986; Origer 2010). However, this does not mean it exists without critics. Anovitz et al. (1999:735) describes the problems with obsidian hydration dating in two broad areas. First, they feel the process of hydration is not fully understood and therefore improperly modeled. Second, they believe the analytical techniques used in determining dates are flawed. The models and analytical techniques used and performed in this study on obsidian artifacts conform to established and accepted practices for both the interpretation of empirical findings and the methods used to reach these findings. The methods employed in this area are fully explained in the reports submitted by Origer's Obsidian Laboratory in Appendix B.

Unit 1 provided one artifact from the surface collection, one artifact from the 10-20 cm, level, one from the 30-40 cm, level, and one artifact from the 70-80 cm, level. Unit 2 provided one surface collected artifact, one artifact from the 40-50 cm, level, one artifact from the 100-110 cm, level, and one artifact from the 160-170 cm, level.

Specimens from the greatest depths of these units were not selected due to the poor quality of the flakes available at those levels. The artifacts selected provide a range of dates that reveal the antiquity of this site. Timelines have been created to look for change in patterns during known historic or geologic events such as the advent of the atlatl dart technology, or bow and arrow technology. Time progression as applied to stratigraphic levels are approximated by using the range of dates provided through obsidian hydration bandwidth analysis and the difference between them and the 10 cm, soil levels separating the dates. This is used assuming soil accumulation remains at a constant. Analysis and interpretation of collected data is discussed in the following chapter.

CHAPTER VI

DATA ANALYSIS AND INTERPRETATION

One of the main sources for gathering information on statistical analysis techniques specifically for archaeology and lithic analysis come from Christenson (1979), who explains how simple statistical analysis provides clearer information when asking questions related to broad patterns in human history. Drennan (1996) is utilized for understanding the underlying principles of statistical analysis in archaeology. Polynomial regression is defined and explained by Lutus (2009), and McDonald (2009). I will utilize the instructional manual written by Dretzke (2005) in computing data in Microsoft® Excel.

In researching models for explaining lithic variability, Dibble et al. (2005), provided explanations that considered technological change, Beck et al. (2002), applied the Central Foraging Theory, Kuhn (1994), discussed transport cost and utility, Andrefsky (1991) and Rafferty (1985) considered mobility and sedentism as a factor, Andrefsky (1994), provided studies in resource availability, and finally, Jeske (1992), and Kelly (1992), discussed the ramifications of competition for resources. In explaining fluctuations in data, Clarkson's (2008) lithic studies in Australia were reviewed.

General Overview of the Data

Being an obsidian source area, the Bear Gulch site exhibits an artifact assemblage that is dominated by obsidian cortical debris. Figures 32 and 33 give a broad picture of the cortical debris compared to non-cortical debris per level through time, as

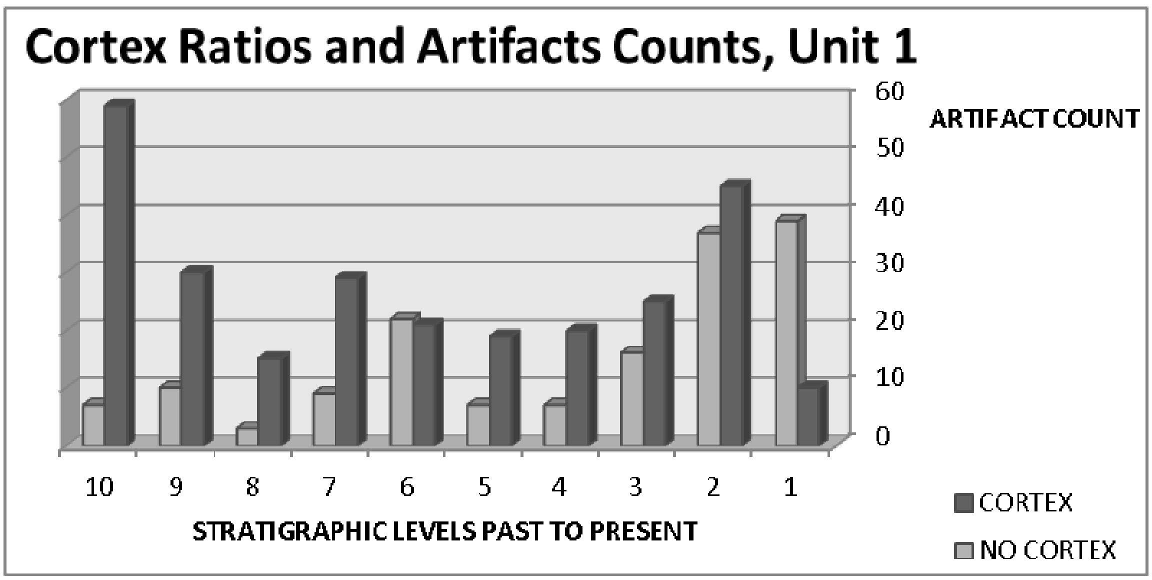

Figure 32. Cortex ratios and artifact counts, Unit 1.

well as the frequency of artifact per level. From a behavioral standpoint, we can see that human activity has produced a greater quantity of cortical debris than non-cortical debris in eight of ten stratigraphic levels representing the use history at Unit 1 excavation site, and more cortical debris than non-cortical debris in thirteen of eighteen stratigraphic levels in Unit 2. These ratios indicate that initial reduction of raw material was the dominant activity at the site through time.

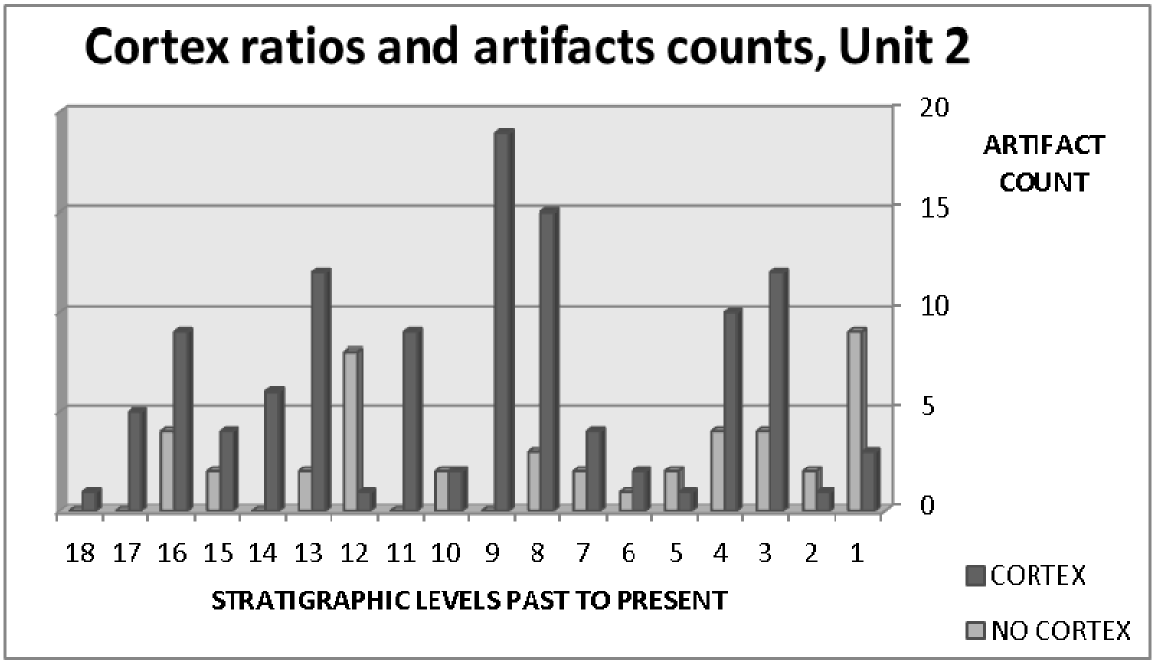

Figure 33. Cortex ratios and artifact counts, Unit 2.

<u>Obsidian Hydration Bandwidth Analysis</u>

The results of obsidian hydration band analysis from Origer's Obsidian Laboratory (2010) revealed the following information. For excavation Unit 1, the surface artifact provided a date of 393 years before present (BP), or A.D.1618, the artifact from the root/soil system (10-20 cm, depth) returned a date of 1,474 BP (A.D. 537), and the artifact from below the tree throw pit (70-80 cm, depth) was calculated at 2,454 BP (B.C. 443). A second specimen from the root/soil system (30-40 cm, depth) was corrupted by corrosion on the specimen surface which led to an unreliable date. This sample artifact may have been exposed to fire. This date has been excluded from the study.

Excavation Unit 2 hydration band analysis results are as follows. The surface artifact provided a date of 554 BP (A.D. 1457), the artifact from the root/soil system (40-50 cm, depth) returned a date of 884 BP (A.D. 1127), and the artifact from sub-surface tree throw pit (150-160 cm, depth) was calculated at 4,148 BP (B.C. 2137). A second artifact from the root/soil system (70-80 cm, depth) was submitted for hydration band width analysis, and was also corrupted by corrosion on the specimen surface. This fact prevented the laboratory from providing reliable dates from this specimen, and as such has been excluded from the study. It is believed the same fire episode corrupted these separate samples as they occur in comparable stratigraphic settings.

With the exclusion of the corrupted obsidian flake samples, the specimen dates returned from these excavation units follow a gradual increase in time as the stratigraphic levels fall deeper into the earth. This fact has allowed me to confidently assume these deposits have maintained their integrity through time as well as identifying the antiquity of the deposits. A visual representation of the stratigraphic levels with their associated dates can be seen in Table 1. The full analysis from Origer's Obsidian Laboratory can be found in Appendix B.

Timelines depicting the obsidian hydration dates from excavation Units 1 and 2 from the Bear Gulch site are shown in Figures 34 and 35.

Statistical Analysis

I have analyzed the data using polynomial regression, applied to specific data characteristics. These formulas appear in histograms and are represented in the form of trend lines. This strategy is used to predict trends within the data set in order to answer hypothesis specific questions of change over time. The description and application of this statistical formula is informed by Paul Lutus (2009), and John McDonald (2009:224).

Table 1. Stratigraphic Levels with Associated Dates

Unit 1		Unit 2	
393 BP	Surface	554 BP	Surface
	0-10 cm.		0-10 cm.
1,474 BP	10-20 cm.		10-20 cm.
	20-30 cm.		20-30 cm.
	30-40 cm.		30-40 cm.
	40-50 cm.	884 BP	40-50 cm.
	50-60 cm.		50-60 cm.
	60-70 cm.		60-70 cm.
2,454 BP	70-80 cm.		70-80 cm.
	80-90 cm.		80-90 cm.
Sterile Soil	90-100 cm.		90-100 cm.
			100-110 cm.
			110-120 cm.
			120-130 cm.
			130-140 cm.
			140-150 cm.
		4,148 BP	150-160 cm.
			160-170 cm.
		Sterile Soil	170-180 cm.

Polynomial regression is a form of linear regression in which the relationship between the independent variable X and the dependent variable Y is modeled as an nth order polynomial. Polynomial regression fits a nonlinear relationship between the value of X and the corresponding conditional mean of Y. The independent variable in this study is always the time line represented by stratigraphic levels. The dependent variables are either frequency, weight, or proportion. Although polynomial regression fits a nonlinear model to the data, as a statistical estimation problem it is linear, in the sense that the regression function $E(y|x)$ is linear in the unknown parameters that are estimated from the

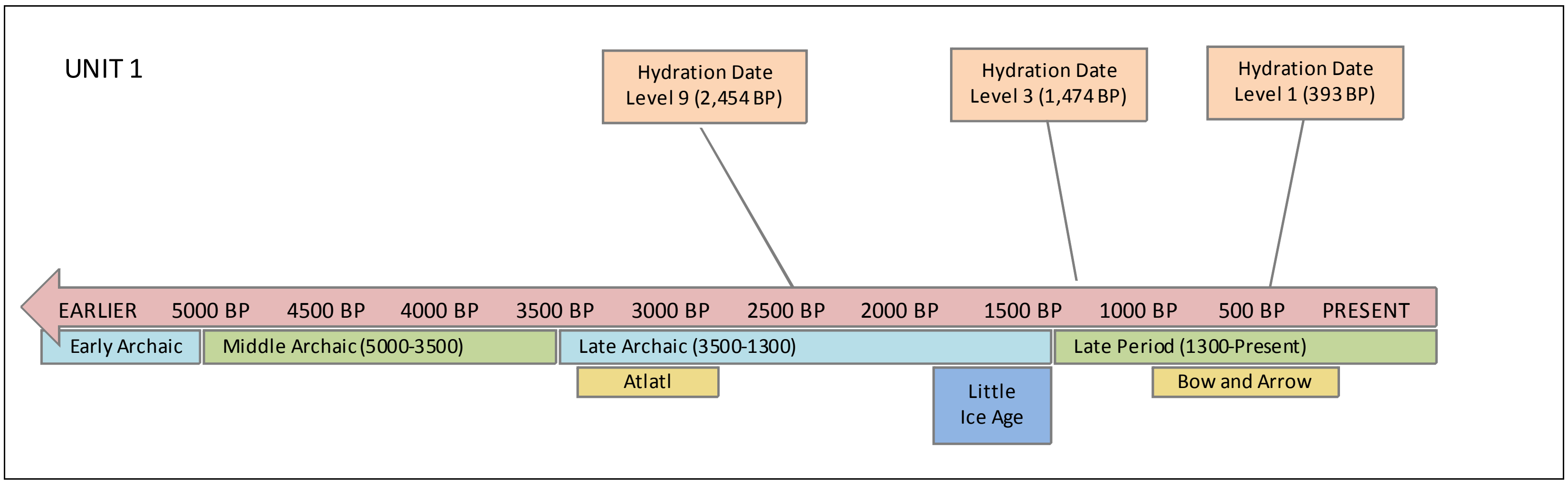

Figure 34. Timeline encompassing obsidian hydration dates, excavation, Unit 1.

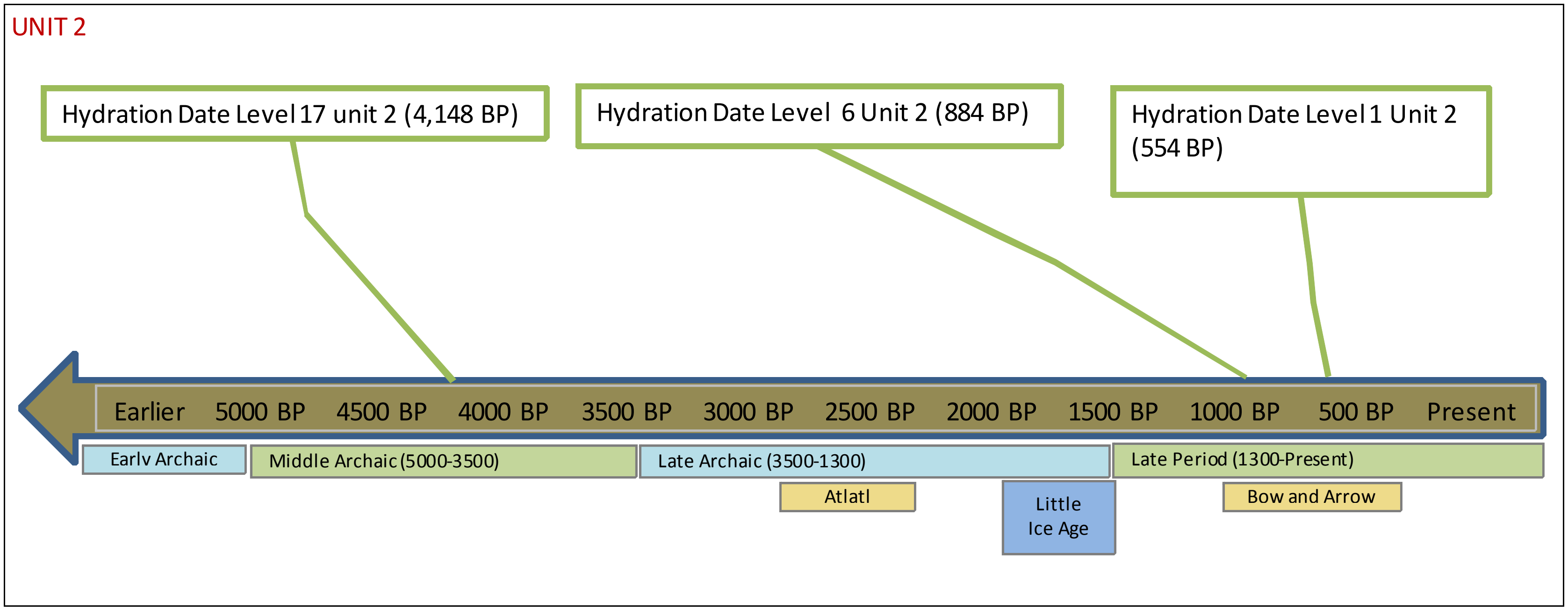

Figure 35. Timeline encompassing obsidian hydration dates, excavation, Unit 2.

data. For this reason, polynomial regression is considered to be a special case of multiple linear regression.

The goal of regression analysis is to model the expected value of a dependent variable Y in terms of the value of an independent variable X.

John McDonald (2009:224) describes the polynomial equation in the following paragraphs:

> A polynomial equation has X raised to integer powers such as X^2 and X^3. A quadratic equation has the form $Y=a+b_1X+b_2X^2$, where *a* is the Y-intercept and b_1 and b_2 are constants. It produces a parabola. A cubic equation has the form $Y=a+b_1X+b_2X^2+b_3X^3$ and produces an S-shaped curve, while a quartic equation has the form $Y=a+b_1X+b_2X^2+b_3X^3+b_4X^4$ and can produce M or W shaped curves.
>
> Several null hypotheses are tested while doing polynomial regression. The first null hypothesis is that a quadratic equation does not fit the data significantly better than a linear equation; the next null hypothesis may be that a cubic equation does not fit the data significantly better than a quadratic equation, and so on. There is also a null hypothesis for each equation that says that it does not fit the data significantly better than a horizontal line; in other words, that there is no relationship between the X and Y variables.
>
> In polynomial regression, different powers of the X variable (X, X^2, X^3…) are added to an equation to see whether they increase the r^2 significantly. First a linear regression is done, fitting an equation of the form $Y=a+bX$ to the data. Then an equation of the form $Y=a+b_1X+b_2X^2$, which produces a parabola, is fit to the data. Next, an equation of the form $Y=a+b_1X+b_2X^2+b_3X^3$, which produces an S-shaped line, is fit and the increase in r^2 is tested. This can continue until adding another term does not increase r^2 significantly. Once the best-fitting equation is chosen, it is tested to see whether it fits the data significantly better than an equation of the form $Y=a$; in other words, a horizontal line.
>
> Even though the usual procedure is to test the linear regression first, then the quadratic, then the cubic, you don't need to stop if one of these is not significant. For example, if the graph looks U-shaped, the linear regression may not be significant, but the quadratic will be. [McDonald, 2009:224]

I have applied polynomial powers (orders) with a coefficient of determination that best fits the data and produces the best possible correlation coefficient without dismissing dominant trends. Five separate order tests (2-6) per data set were conducted to verify dominant trends in the data. This means the most common trends informed my determination of increases or decreases of frequency, weight, or proportions of the lithic materials tested.

Coefficient of determination or R^2 is a statistic that will give some information about the goodness of fit of a model. In regression, the R^2 coefficient of determination is a statistical measure of how well the regression line approximates the real data points. An R^2 of 1.0 indicates that the regression line perfectly fits the data. The correlation coefficient is a value that provides information regarding the relationship between two variables, in this case, time represented in stratigraphic levels, and either proportion, frequency, or weight. To determine the correlation coefficient, the square root of the coefficient of determination is taken. A correlation coefficient is defined as weak in the 0 to .3 range, moderate in the .3 to .7 range and strong in the .7 to 1.0 range. These numbers are indicated on each data set. The formula used for each regression also appears on the graph.

Hypothesis #1 Data

Hypothesis 1 states: Early reduction stage debris in the form of cortical debris will increase in proportion, frequency and weight as time progresses (via superposition), with the null hypothesis stating that there will be no increase in cortical debris through time in these categories. Again, testing this hypothesis will help answer the problem of recognizing a change in manufacture trajectory.

All recovered artifacts are included in the frequency and proportion analyses. Included are, all flake types, cores and assayed cobbles, as well as simple flake tools exhibiting any degree of cortex. Cores and flake tools do not directly fit the definition of debitage given by Sullivan and Rozen (1985:755) as “Chipped stone artifacts that are not cores or tools”; however, the presence of these artifacts in the assemblage is an important indicator of activities undertaken at the site and must be reflected in percentages of the data as well as frequencies. They are not included in weight analyses because these artifacts represent a small overall count in the assemblage, but by their nature are exponentially heavier than the average piece of debris. This fact skews the data which leads to unreliable interpretations. Cores and assayed cobbles are separated from debitage weight analyses also because they are the origin of debitage, not debitage themselves.

Results

Early reduction stage debris counts per level for Unit 1 (Figure 36) show a polynomial regression trend line at the third order, or a cubic equation. This gives a

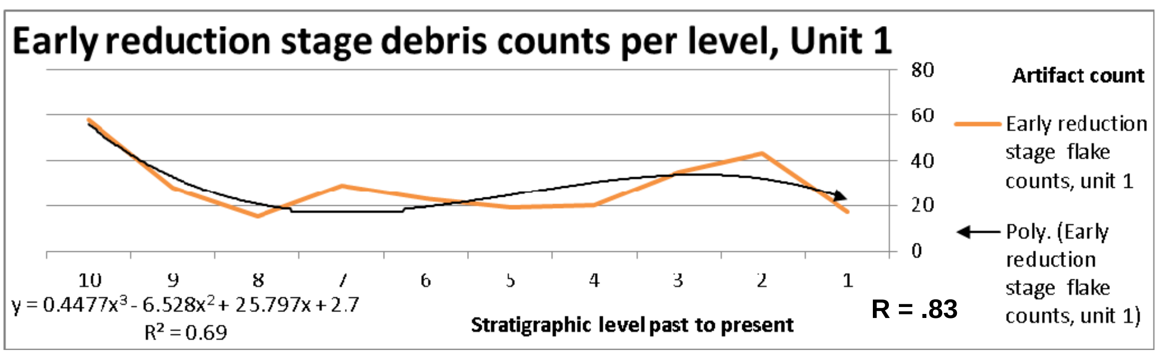

Figure 36. Early reduction stage debris counts per level, Unit 1.

coefficient of determination of .69, or a 69 percent goodness of fit. This produces a correlation coefficient of .83, or a strong relationship between the progression of time and the downward trend in frequency of cortical debris. The overall trend in cortical debris from the oldest deposits at Level10, to the most recent at Level 1, shows a decrease in frequency. Therefore, the null hypothesis must be accepted for this data set. Put simply, the first stages in lithic reduction represented by cortical debris are decreasing. This could indicate a change in the technological approach to lithic reduction, or an overall decrease in manufacture activity at the site. Descriptive statistics for this data set are shown in Table 2.

Table 2. Descriptive Statistics for Figure 36

Early reduction stage debris counts, Unit 1	
Mean	28.7
Standard Error	4.255846
Median	25.5
Mode	#N/A
Standard Deviation	13.45817
Sample Variance	181.1222
Kurtosis	1.315784
Skewness	1.276222
Range	43
Minimum	15
Maximum	58
Sum	287
Count	10
Confidence Level (95.0%)	9.627392

Early reduction stage debris counts per level for Unit 2 (Figure 37) shows a polynomial regression trend line at the fourth order, or a quartic equation. This gives a coefficient of determination of .15, or 15 percent goodness of fit. The correlation coefficient value of .39 shows a low moderate relationship between the progression of time and artifact frequencies. The nature of this data set is extremely episodic in nature. By this, I mean the frequencies of the debris fluctuate greatly through time leaving the goal of determining trends unreliable at best. Although this data does accurately represent

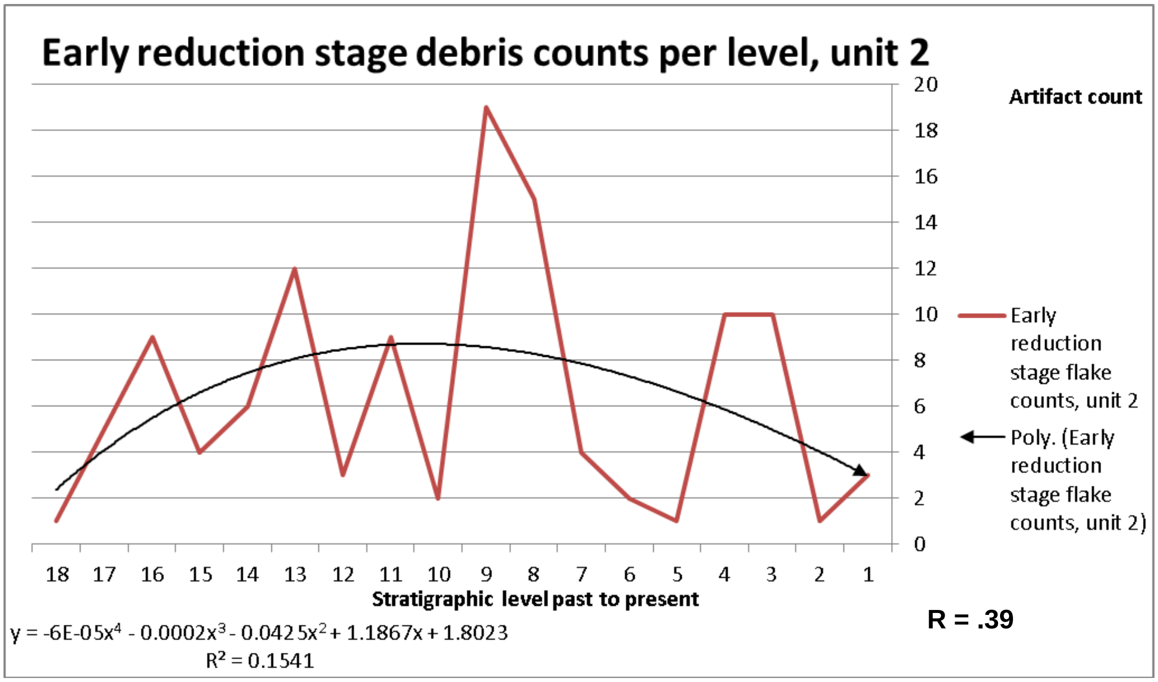

Figure 37. Early reduction stage debris counts per level, Unit 2.

use patterns at this location, the overall trend is not evident. Neither Hypothesis 1 nor the null are accepted Descriptive statistics for this data set are shown in Table 3.

Table 3. Descriptive Statistics for Figure 37.

Early Reduction Stage Debris Counts, Unit 2	
Mean	6.444444
Standard Error	1.234637
Median	4.5
Mode	1
Standard Deviation	5.238121
Sample Variance	27.43791
Kurtosis	0.322375
Skewness	0.979132
Range	18
Minimum	1
Maximum	19
Sum	116
Count	18
Confidence Level (95.0%)	2.604856

Early reduction stage flake weights per level for Unit 1 (Figure 38) shows a polynomial regression trend line at the fourth order, or a quartic equation. This gives a coefficient of determination of .48, or a goodness of fit of 48 percent. This produces a correlation coefficient of .70, or a strong relationship.

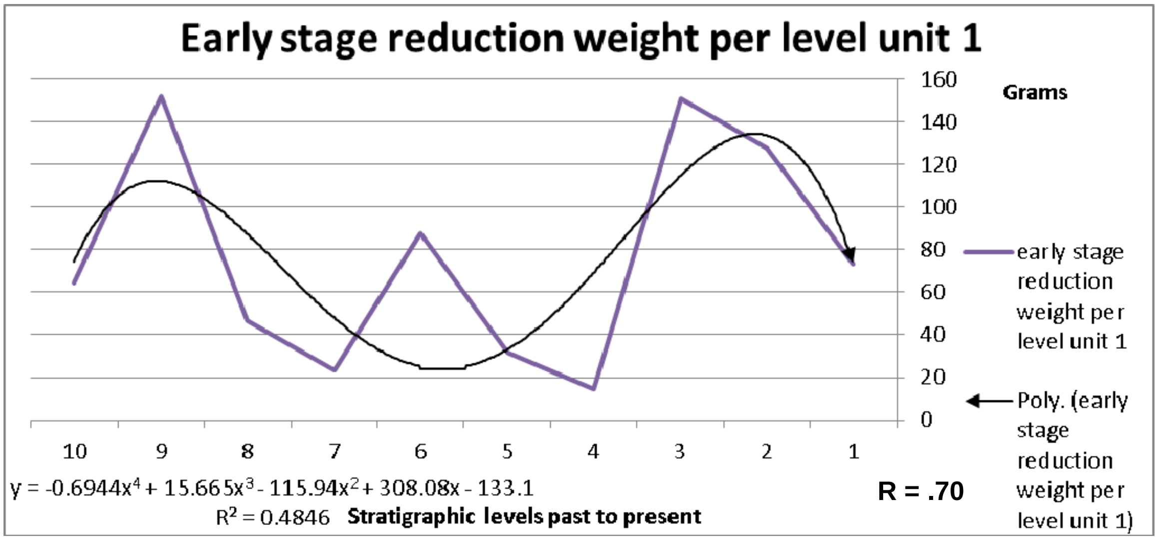

Figure 38. Early stage reduction weight per level, Unit 1.

The overall trend in cortical debitage weight from the oldest deposits at level 10, to the youngest deposits at level 1, shows no observable trend other than three obvious peaks in artifact weights during the use life of this site. Noting this fact, the data will be dismissed on the basis of an unreliable trend-line. This means that no accurate determination of an increase or decrease in cortical debitage can be made. Neither Hypothesis 1 nor the null is accepted.

The episodes in weight increase and decrease throughout this data set may be explained by several factors. However, in testing Hypothesis 1, the data fails to provide pertinent information for reaching a conclusion Descriptive statistics for this data set are shown in Table 4.

Table 4. Descriptive Statistics for Figure 38.

Early Stage Reduction Weights Per Level Unit 1	
Mean	77.139
Standard Error	16.21547
Median	68.75
Mode	#N/A
Standard Deviation	51.27782
Sample Variance	2629.415
Kurtosis	-1.30482
Skewness	0.434147
Range	137.2
Minimum	14.7
Maximum	151.9
Sum	771.39
Count	10
Confidence Level (95.0%)	36.68194

Early reduction stage flake weights per level for Unit 2 (Figure 39) show a polynomial regression trend line at the fourth order, or a quartic equation. This gives a coefficient of determination of .07 or 7 percent goodness of fit. This produces a correlation coefficient of .26, or a weak linear relationship. A decisive trend in this debitage category through time is not visible in the data set. The episodic nature of this data limits any reliable interpretation in trends. Therefore, Hypothesis 1 is neither accepted nor rejected.

As was stated in the previous data set (Figure 38), several factors may explain why the data occurs the way it does. However, the data fails to provide a reliable determination in accepting the hypothesis or the null Descriptive statistics for this data set are shown in Table 5.

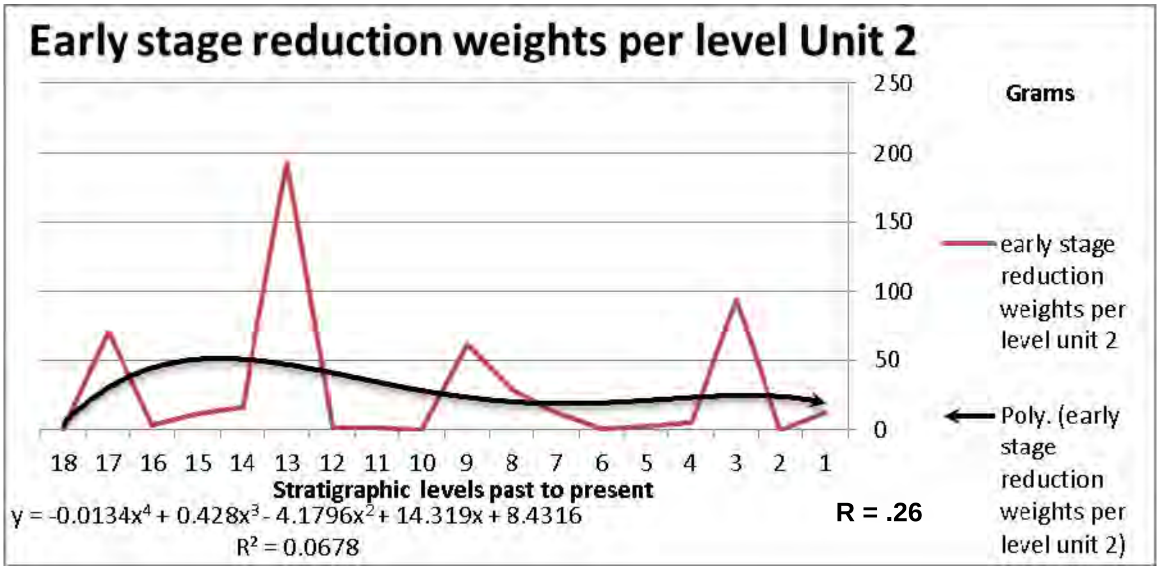

Figure 39. Early stage reduction weights per level, Unit 2.

Table 5. Descriptive Statistics for Figure 39.

Early Stage Reduction Weight Per Level Unit 2	
Mean	28.73889
Standard Error	11.63911
Median	8.35
Mode	0.1
Standard Deviation	49.38056
Sample Variance	2438.44
Kurtosis	6.987867
Skewness	2.532688
Range	192.7
Minimum	0.1
Maximum	192.8
Sum	517.3
Count	18
Confidence Level (95.0%)	24.55638

Cortical debitage as a percentage of all debitage collected in excavation Unit 1 is shown in Figure 40. A polynomial regression of the second order, or a quadratic

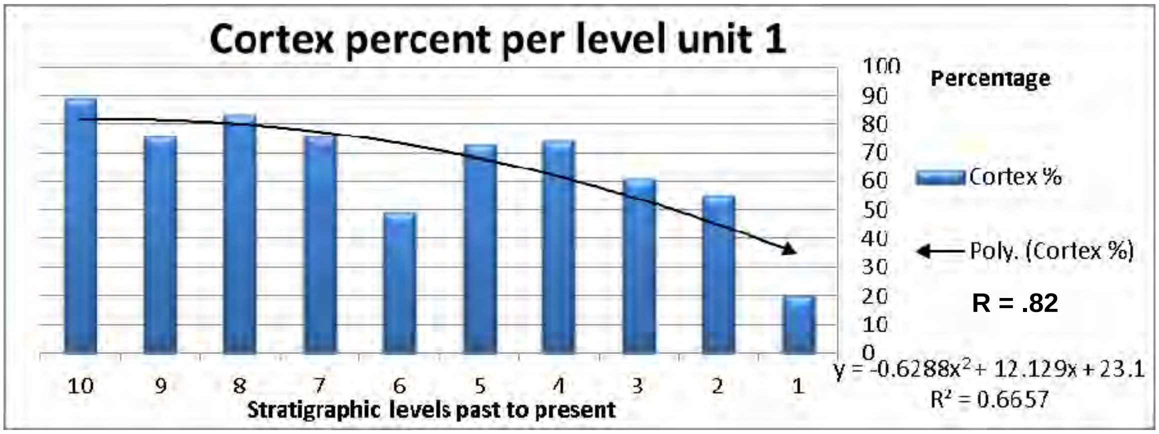

Figure 40. Cortex percentage per level, Unit 1.

equation, was overlaid as a trend line on the histogram. This gives a coefficient of determination, of .67, or a 67 percent goodness of fit. This produces a correlation coefficient of .82, or a strong linear relationship. The overall trend from the oldest deposits at Level 10, to the youngest at Level 1 shows a steady decrease in the percentage of cortical debitage in the assemblage over time. Therefore, the null hypothesis is accepted.

Simply stated, as an overall percentage of the entire artifact assemblage, cortical debris is decreasing. Unlike data sets in frequency or weight, proportion analyses such as this, are mutually exclusive, this means that if cortical artifact percentages drop, then non-cortical percentages must rise. Therefore, these tests provide the opportunity to understand change at the technological level of lithic reduction as opposed to amount of work being done in quantity at the site. Explanations for this trend are discussed in the following section, *Results and Discussion*.

Cortical debitage as a percentage of all debitage collected in excavation Unit 2 is shown in Figure 41. A polynomial regression of the third order, or a cubic equation, was overlaid as a trend line on the histogram. This gives a coefficient of determination value of .35 or a 35 percent goodness of fit. This produces a correlation coefficient of .59, or a moderate linear relationship.

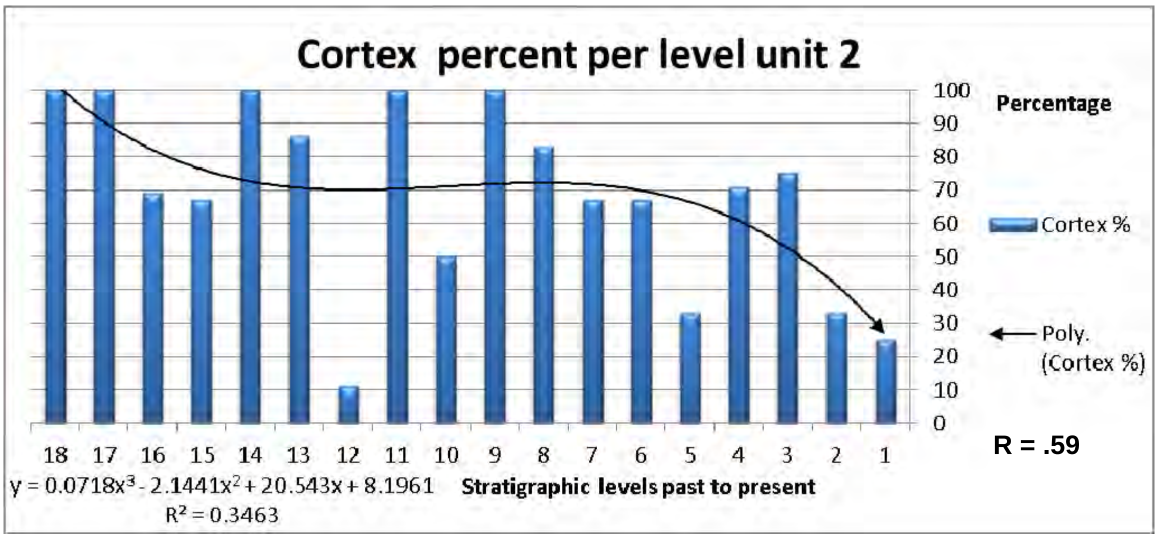

Figure 41. Cortex percentage per level, Unit 2.

The overall trend from the oldest deposits at Level 18, to the youngest at Level 1 shows a steady decrease in the percentage of cortical debitage in the assemblage over time. Therefore, the null hypothesis is accepted. As stated in the previous data set, this represents a change at the technological level of lithic reduction, and will be discussed in the following section.

Hypothesis # 2 Data

Hypothesis 2 states: Later stages of lithic reduction flakes in the form of non-cortical debitage will decrease in frequency, proportion, and weight as time progresses, with the null hypothesis stating that there will be no decrease in non-cortical debitage in the same categories through time. Again, testing this hypothesis will help answer the same question of change in manufacture trajectory.

Results

Late reduction stage flake counts per level for Unit 1 is shown in Figure 42. A polynomial regression of the second order, or a quadratic equation, is shown as a trend

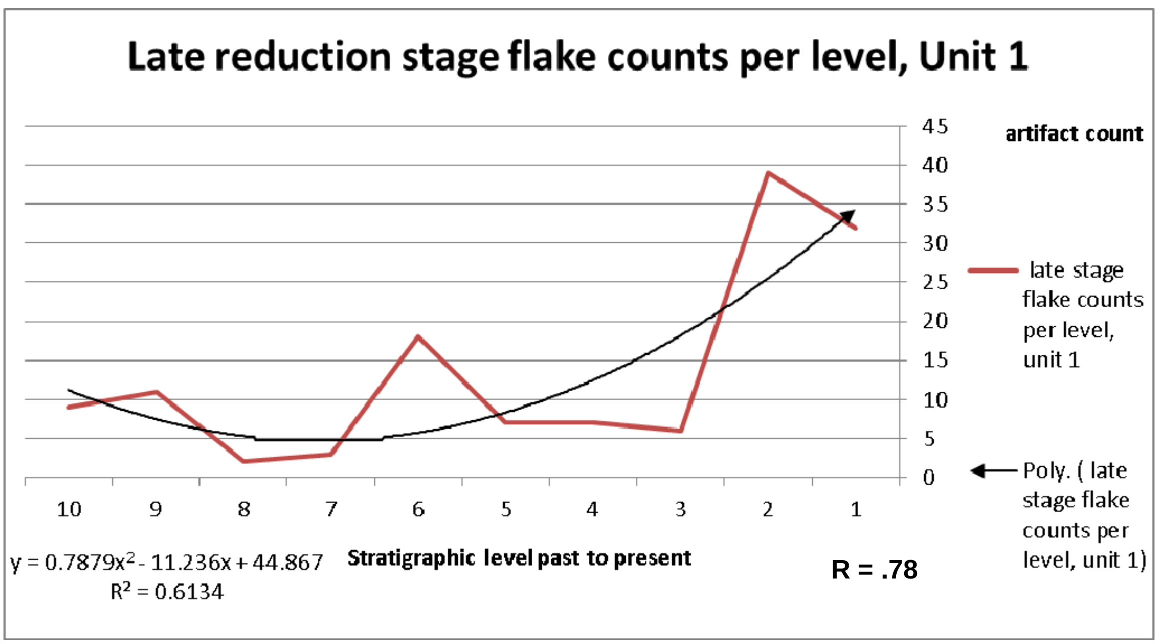

Figure 42. Late reduction stage flake counts per level, Unit 1.

line on the line graph. This gives a coefficient of determination of .61, or a 61 percent goodness of fit. This produces a correlation coefficient of .78, or a strong linear relationship. The overall trend of non-cortical debitage from the oldest deposits at level 10 to the youngest at level 1 show a steady increase of this debitage type through time. Therefore, the null hypothesis is accepted.

In simple terms, the results of this test indicate either an increase in overall activity at the site, increased reduction intensity, or a change in reduction strategy that created this trend. These possibilities are discussed in the following section, *Results and Discussion*.

The increases in this debitage type in stratigraphic Levels 1 and 2 are due to the occurrence of 28 Pressure Flakes in Level 2, and the occurrence of 26 Complex Interior Percussion flakes in the surface collection. Both cases offer valid data in testing Hypothesis 2 and as such, remained in the data set to derive trends Descriptive statistics for this data set are shown in Table 6.

Table 6. Descriptive Statistics for Figure 42.

Late Stage Flake Counts Per Level, Unit 1 Descriptive Statistics	
Mean	13.4
Standard Error	3.97548
Median	8
Mode	7
Standard Deviation	12.57157
Sample Variance	158.0444
Kurtosis	0.772198
Skewness	1.375314
Range	37
Minimum	2
Maximum	39
Sum	134
Count	10
Confidence Level (95.0%)	8.993161

Late reduction stage flake counts per level for Unit 2 is shown in Figure 43. A polynomial regression of the 3rd order, or a cubic equation, is shown as a trend line on

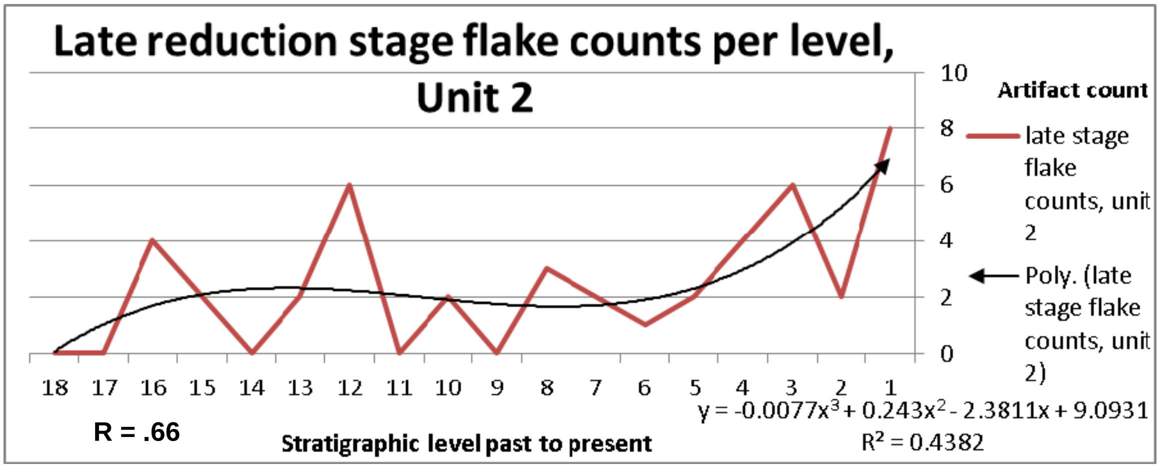

Figure 43. Late reduction stage flake counts per level, Unit 2.

the line graph. This gives a coefficient of determination of .44, or a 44 percent goodness of fit. This produces a correlation coefficient of .66, or a high moderate linear relationship. The overall trend of non-cortical debitage from the oldest deposits at Level 18, to the youngest at Level 1, shows a steady increase of this debitage type through time. Therefore, the null hypothesis is accepted Descriptive statistics for this data set are shown in Table 7.

Late stage reduction artifact weights per level for excavation Unit 1 is shown in Figure 44. A polynomial regression of the second order, or a quadratic equation, is shown as a trend line on the line graph. This gives a coefficient of determination of .34, or a 34 percent goodness of fit. This produces a correlation coefficient of .58, or a moderate linear relationship. The overall trend of non-cortical debitage from the oldest

Table 7. Descriptive Statistics for Figure 43.

Late Reduction Stage Flake Counts, Unit 2	
Mean	2.444444
Standard Error	0.555556
Median	2
Mode	2
Standard Deviation	2.357023
Sample Variance	5.555556
Kurtosis	0.372113
Skewness	0.972813
Range	8
Minimum	0
Maximum	8
Sum	44
Count	18
Confidence Level (95.0%)	1.17212

deposits at Level 10, to the youngest at Level 1, shows a slight increase of this debitage type through time. Therefore, the null hypothesis is accepted.

As in previous tests on frequencies, the results of this test indicate either an increase in overall activity at the site, increased reduction intensity, or a change in reduction strategy that created this trend. These possibilities are discussed in the following section, *Results and Discussion*.

The spike in weight at stratigraphic Level 2 is caused by one 58.8 gram Simple Interior Percussion flake. Without this artifact, the remaining weight would have been 4.4 grams which is still greater than the weight of Level 3. The upward trend would have still been evident as well as produced a better correlation. However, this artifact will remain part of the analysis as it represents a stage in the lithic reduction process and a specific human activity. That is, removal of material, post decortication Descriptive statistics for this data set are shown in Table 8.

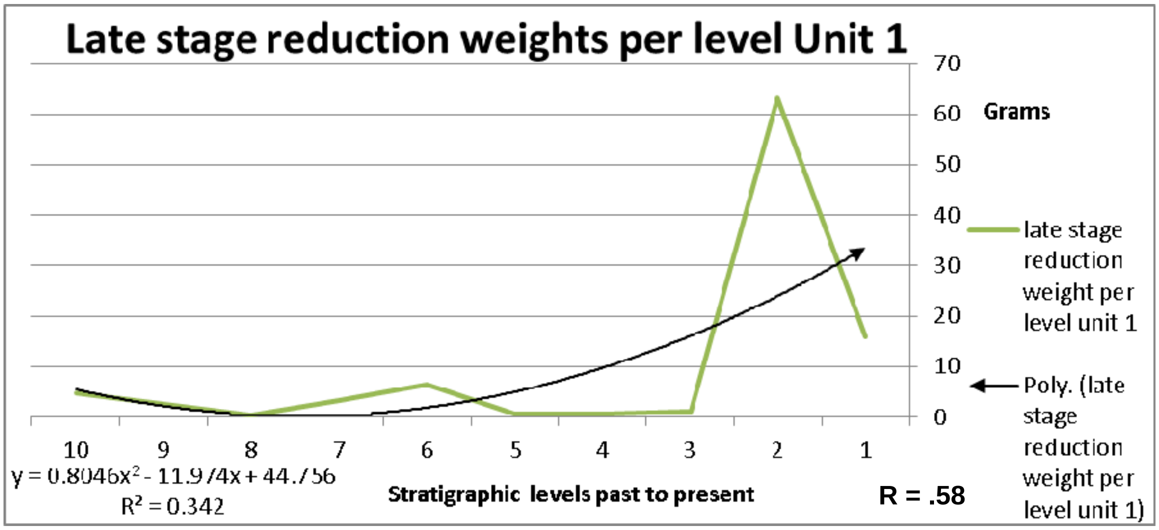

Figure 44. Late stage reduction weights per level, Unit 1.

Table 8. Descriptive Statistics for Figure 44.

Late Stage Reduction Weights Per Level, Unit 1	
Mean	9.878
Standard Error	6.102771
Median	2.9
Mode	#N/A
Standard Deviation	19.29866
Sample Variance	372.4382
Kurtosis	8.436443
Skewness	2.856839
Range	62.9
Minimum	0.3
Maximum	63.2
Sum	98.78
Count	10
Confidence Level (95.0%)	13.80543

Late stage reduction artifact weights per level for excavation Unit 2 are shown in Figure 45. A polynomial regression of the second order, or a quadratic equation, is

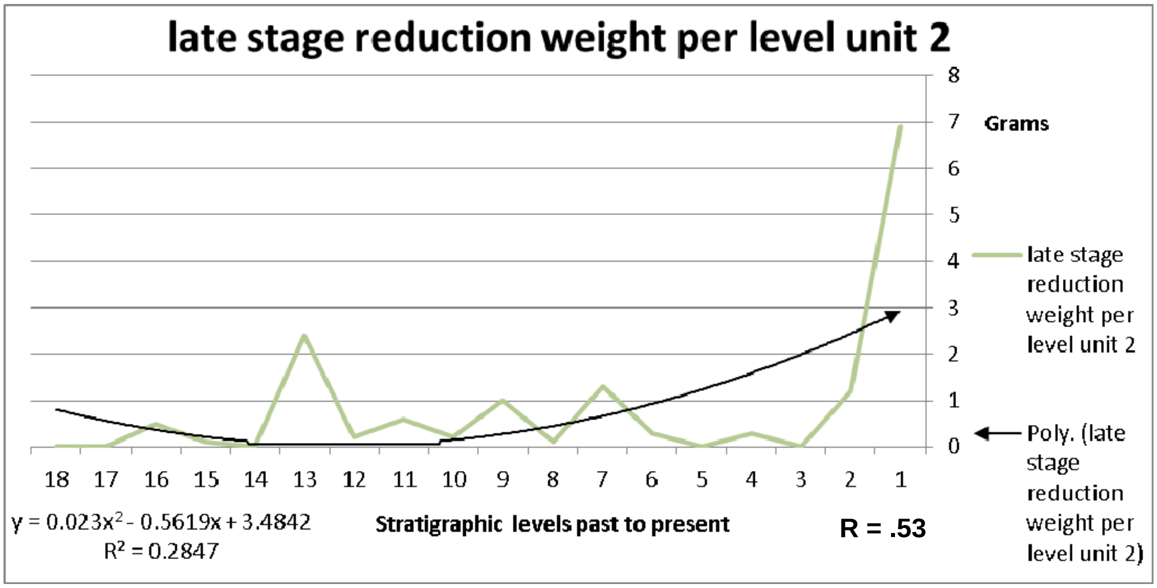

Figure 45. Late stage reduction weights per level, Unit 2.

shown as a trend line on the line graph. This gives a coefficient of determination of .28, or a 28 percent goodness of fit. This produces a .53 correlation coefficient, or a moderate linear relationship. The trend of non-cortical debitage weights from the oldest deposits at Level 18, to the youngest at Level 1 shows a gradual increase through time. This trend is only defined by the surface assemblage weights in stratigraphic level one, and more specifically, one 4.1 oz. Simple Interior Percussion flake. If not for this fact, it is doubtful any type of trend could be reliably noted in this data set. Therefore, Hypothesis 2 and the null are neither accepted nor rejected Descriptive statistics for this data set are shown in Table 9.

Non cortical debitage percentages as part of the entire assemblage of excavation Unit 1 are shown in Figure 46. A polynomial regression of the second order, or a quadratic equation, is shown as a trend line on the histogram. This gives a coefficient of determination of .67, or a goodness of fit of 67 percent. This produces a correlation

Table 9. Descriptive Statistics for Figure 45.

Late Stage Reduction Weight Per Level Unit 2	
Mean	0.839444
Standard Error	0.387062
Median	0.25
Mode	0
Standard Deviation	1.642167
Sample Variance	2.696711
Kurtosis	12.15156
Skewness	3.332444
Range	6.91
Minimum	0
Maximum	6.91
Sum	15.11
Count	18
Confidence Level (95.0%)	0.81663

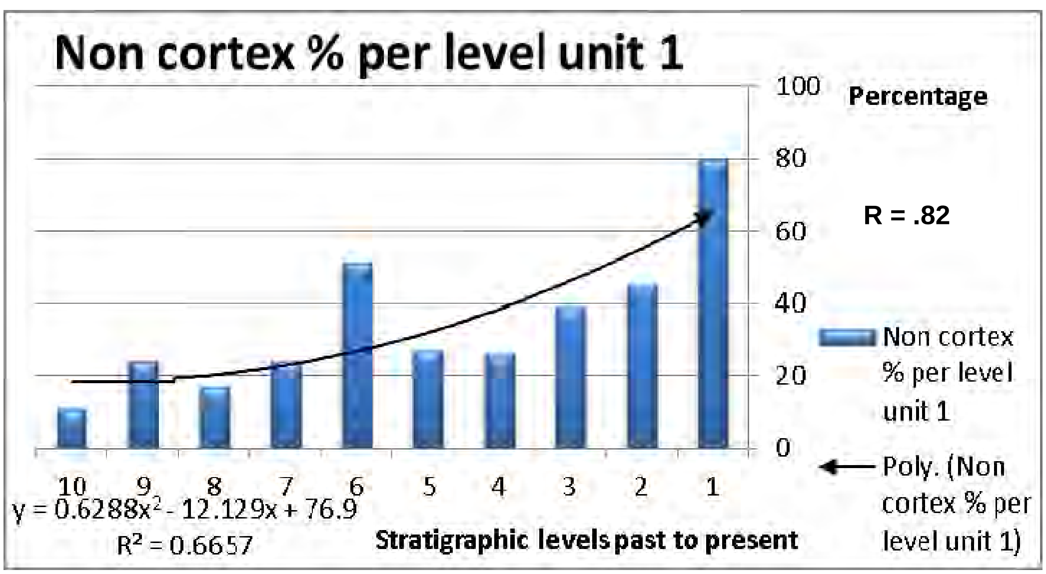

Figure 46. Non-cortex percent per level, Unit 1.

coefficient of .82, or a strong linear relationship. The overall trend of non-cortical debitage percentage from the oldest deposits at level 10 to the youngest at level one show a steady increase in this debitage category. Therefore, the null hypothesis is accepted.

The tests on proportions for cortical versus non-cortical debris are related to each other in that the data is mutually exclusive as described in the previous proportion tests. This being the case, the following tests make up the remainder of the assemblage percentages in non-cortical debris and as such follow the same logic as was described in tests on cortical debris. As this test shows, the decrease in cortical debitage from previous tests, results in an increase in non-cortical debitage. The ramifications of the results are described in the Interpretation of *Trends within the Theoretical Framework* section of this chapter, as well as Chapter VII.

Non-cortical debitage percentages as part of the entire assemblage of excavation Unit 2 are shown in Figure 47. A polynomial regression of the third order, or a cubic equation, is shown as a trend line on the histogram. This gives a coefficient of determination of .35, or a 35 percent goodness of fit. This produces a correlation coefficient of .59, or a moderate linear relationship. The overall trend of non-cortical debitage percentage from the oldest deposits at Level 18 to the youngest at Level 1 show a steady increase in this debitage category. Therefore the null hypothesis is accepted.

The large percentage increase at Stratigraphic Level 12 is due to the occurrence of a high number of Angular Percussion fragments that may have been produced as a result of high force levels of percussion during earlier stages of blank production. These stages generally produce a number of broken flakes that fit this

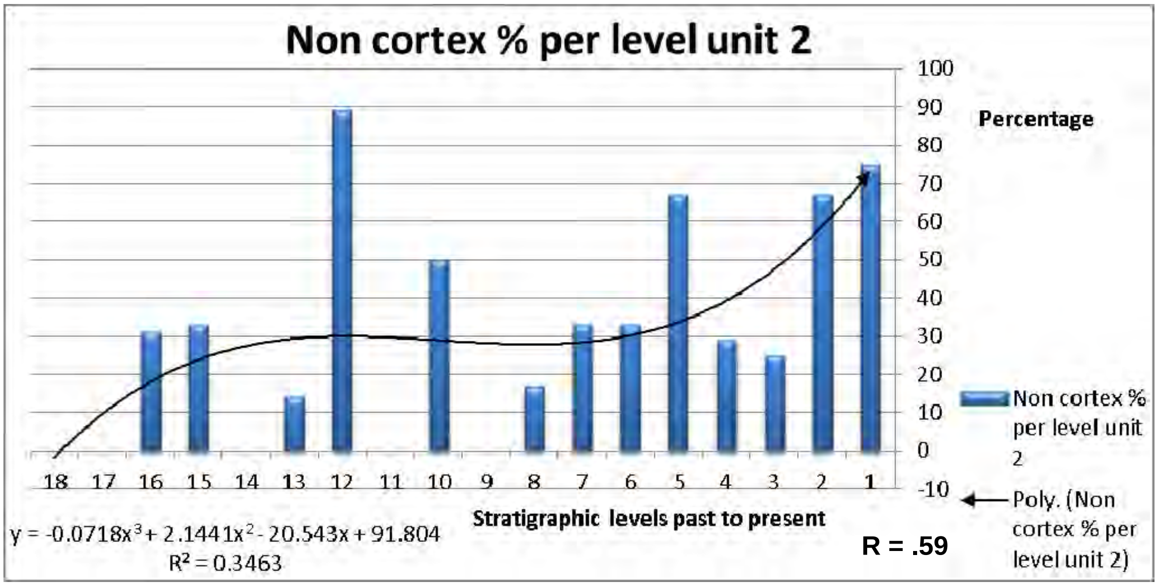

Figure 47. Non-cortex percent per level, Unit 2.

category. The increase is considered an acceptable chance occurrence in the continuum of activities at the site and does not affect the overall trend.

Hypothesis # 3 Data

Hypothesis 3 states: The overall volume of lithic debris increases in frequency and weight over time. The null hypothesis states, there will be no increase in overall volume of lithic debris. Once again, testing this hypothesis will aid in answering the question of resource intensification at the site.

Results

Total debris counts per level for excavation Unit 1 is shown in Figure 48. A polynomial regression of the second order, or a quadratic equation, is shown as a trend line on the line graph. This gives a coefficient of determination of .46, or a 46 percent goodness of fit. This produces a correlation coefficient of .68, or a high moderate linear

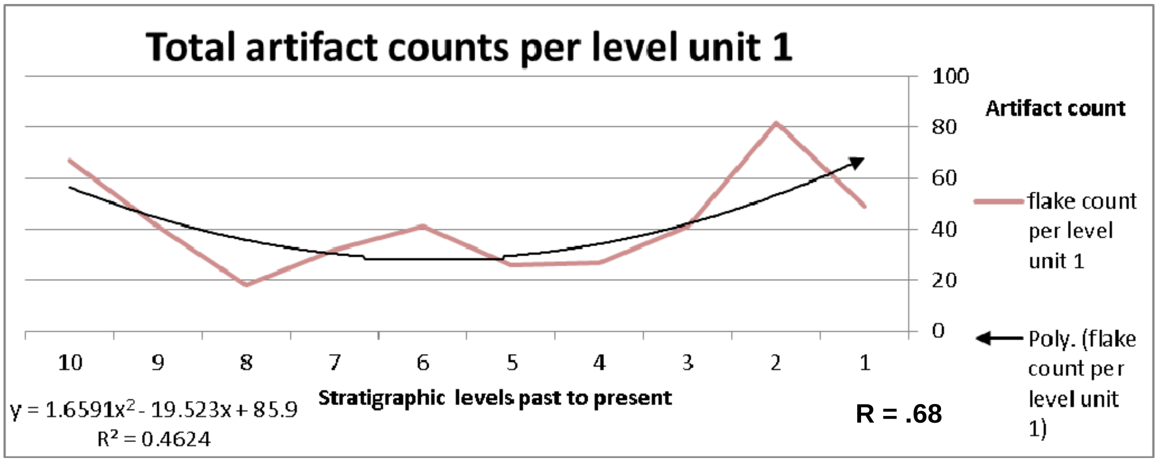

Figure 48. Total artifact counts per level, Unit 1.

relationship. The overall trend from the oldest deposits at Level 10, to the youngest at Level 1, shows a slight increase in overall lithic debris frequency through time. Therefore, hypothesis three is accepted. These results may indicate increased production, or a change in reduction strategy that increased the frequency of debris Descriptive statistics for this data set are shown in Table 10.

Table 10. Descriptive Statistics for Figure 48.

Total Debris Counts Per Level Unit 1	
Mean	42.4
Standard Error	6.175579
Median	41
Mode	41
Standard Deviation	19.5289
Sample Variance	381.3778
Kurtosis	0.645537
Skewness	0.998614
Range	64
Minimum	18
Maximum	82
Sum	424
Count	10
Confidence Level (95.0%)	13.97013

Total artifact counts per level for excavation Unit 2 are shown in Figure 49. A polynomial regression of the fourth order, or a quartic equation, is shown as a trend line

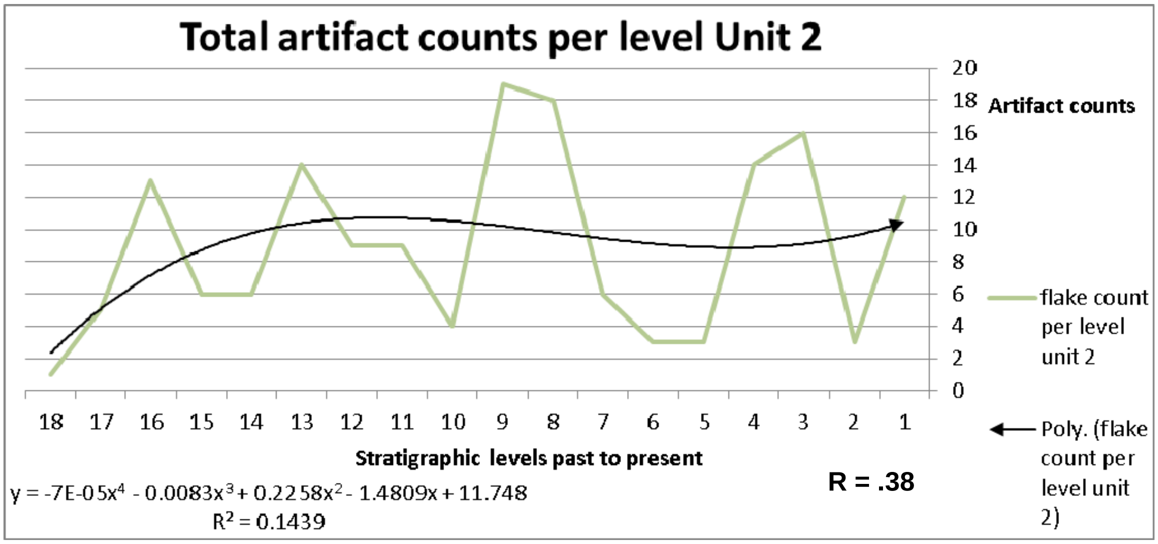

Figure 49. Total artifact counts per level, Unit 2.

on the line graph. This gives a coefficient of determination of .14, or a 14 percent goodness of fit. This produces a correlation coefficient of .38, or a low moderate linear relationship. This is due to the episodic nature of the data. This means that the data fluctuates greatly which in turn makes determining trends more difficult. Due to the episodic nature of this data, no reliable trend can be determined in increase or decrease of total artifact counts per level for Unit 2. Neither Hypothesis 3, nor the null are accepted. Possible explanations for the observed episodes are provided in the following section, *Review and Discussion* Descriptive statistics for this data set are shown in Table 11.

Total debitage weights per level for Unit 1 are shown in Figure 50. A polynomial regression of the fourth order, or a quartic equation, is shown as a trend line on the histogram. This gives a coefficient of determination of .29, or a 29 percent

Table 11. Descriptive Statistics for Figure 49.

Artifact Counts Per Level Unit 2	
Mean	8.944444
Standard Error	1.33449
Median	7.5
Mode	3
Standard Deviation	5.661763
Sample Variance	32.05556
Kurtosis	-1.17457
Skewness	0.391546
Range	18
Minimum	1
Maximum	19
Sum	161
Count	18
Confidence Level (95.0%)	2.815528

goodness of fit. This produces a correlation coefficient of .54, or a moderate linear relationship. The overall trend at this excavation unit could be interpreted as a slight increase in weight over time. However, the episodic nature of the data is not reliable for deriving a conclusive trend in weights per level for Unit 1. Hypothesis 3 is neither accepted nor rejected. Descriptive statistics for this data set are shown in Table 12.

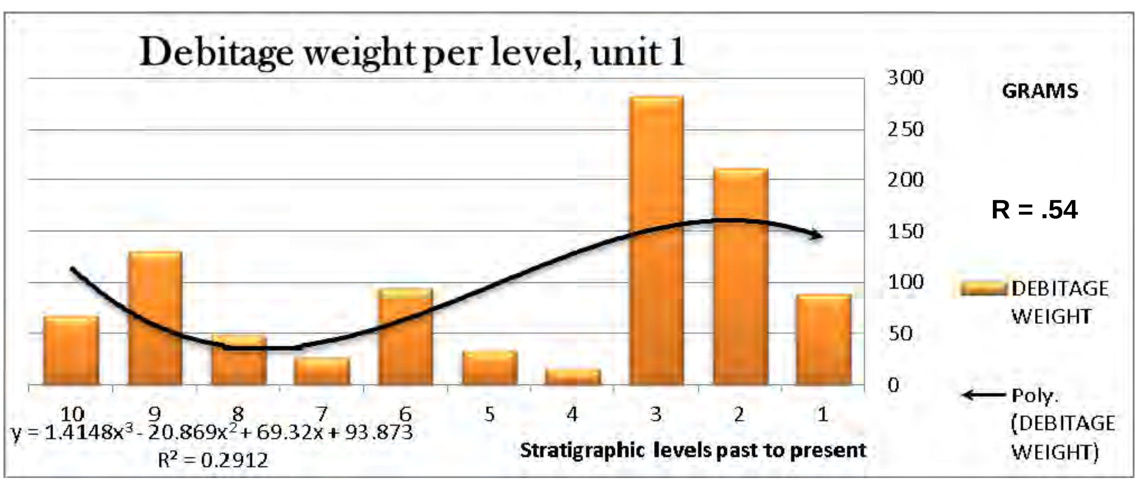

Figure 50. Debitage weights per level, Unit 1.

Table 12. Descriptive Statistics for Figure 50.

Debitage Weight Per Level Unit 1	
Mean	478.46
Standard Error	102.4284
Median	421.65
Mode	#N/A
Standard Deviation	323.9071
Sample Variance	104915.8
Kurtosis	-0.88654
Skewness	0.050032
Range	936.8
Minimum	15.3
Maximum	952.1
Sum	4784.6
Count	10
Confidence Level (95.0%)	231.7091

Total debitage weights per level for Unit 2 are shown in Figure 51. A polynomial regression of the third order, or a cubic equation, is shown as a trend line on the histogram. This gives a coefficient of determination of .07, or a 7 percent goodness of

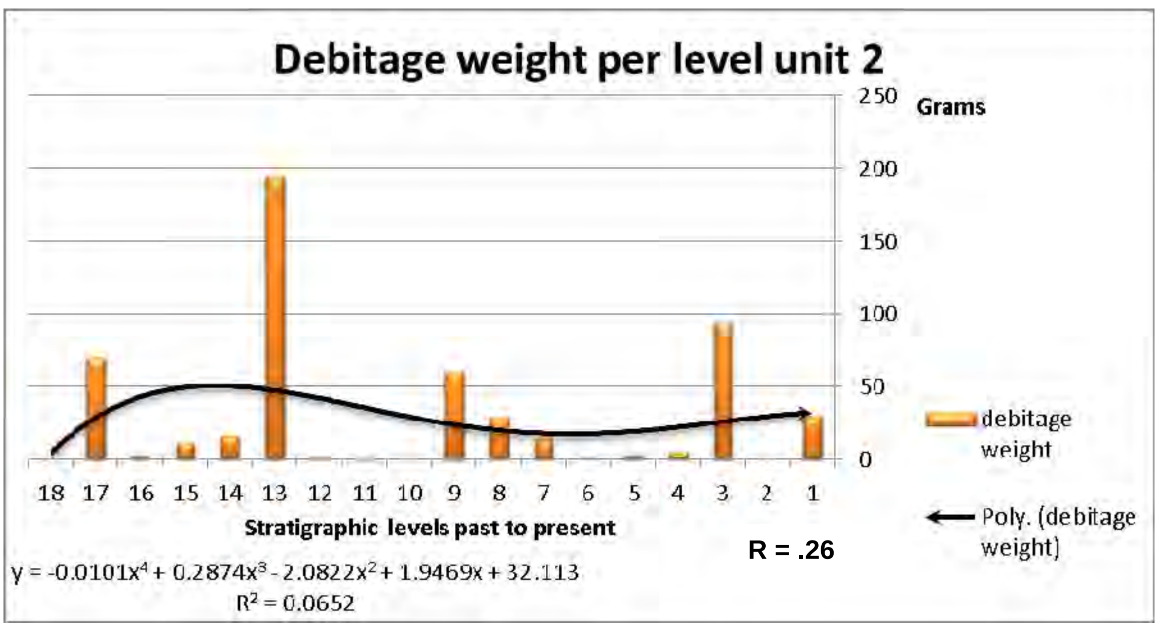

Figure 51. Debitage weight per level, Unit 2.

fit. This produces a correlation coefficient of .26, or a weak linear relationship. This is due to the episodic nature of the data. This means that the data fluctuates greatly which makes determining trends more difficult. A reliable determination of trends in weight per level for Unit 2 is not possible due to the nature of this data. Hypothesis 3 is neither accepted nor rejected.

Determining increases in overall artifact weights in order to infer behaviors of the original users of this lithic source proved inconclusive. Questions of increased activity at the site, or change in reduction technique using weight, must be answered by more reliable data sets. Descriptive statistics for this data set are shown in Table 13.

Table 13. Descriptive Statistics for Figure 51.

Debitage Weight Per Level Unit 2	
Mean	30.09444
Standard Error	11.69433
Median	8.5
Mode	#N/A
Standard Deviation	49.61484
Sample Variance	2461.632
Kurtosis	7.038486
Skewness	2.521409
Range	195.1
Minimum	0.1
Maximum	195.2
Sum	541.7
Count	18
Confidence Level (95.0%)	24.67288

Comparisons in the following three graphs are meant to show the relationship between cortical and non-cortical debris frequencies and proportions. Only reliable trends from previous analyses are used. The goal of these comparisons is to answer the question of lithic reduction intensity changes through time. Reliable trends are defined as having at least a Moderate linear relationship between variables as shown in the correlation coefficient.

Cortical and non-cortical artifact frequency from Unit 1 is compared in Figure 52. The trend lines shown in this graph are for simple trend identification. This is

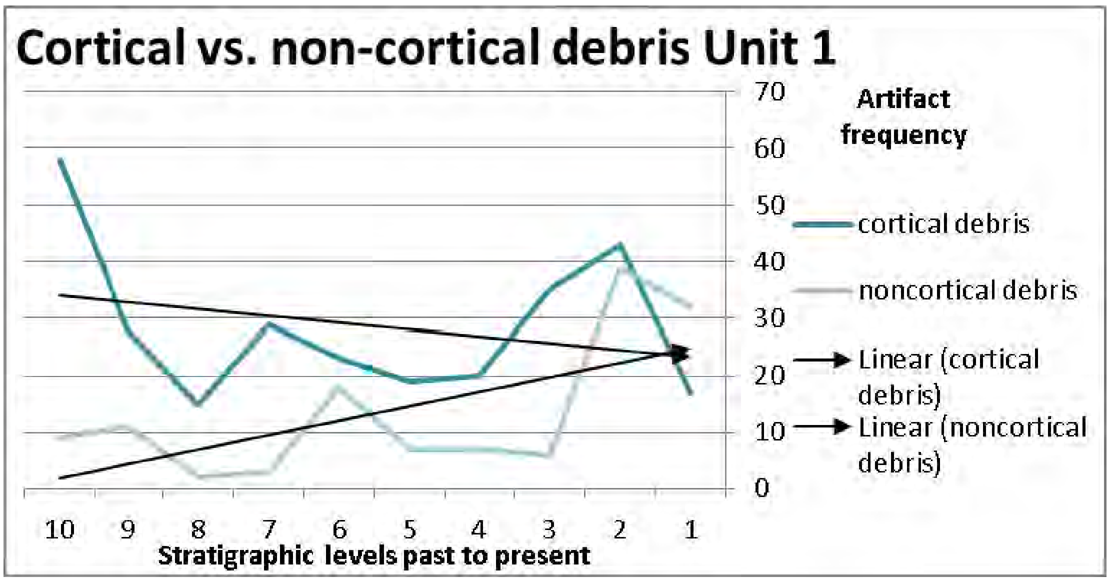

Figure 52. Cortical vs. non-cortical debris frequency, Unit 1.

accomplished through use of simple linear regression. The polynomial regression formulas were previously applied to the individual data sets in which the same general trends were identified. In this comparison we see a decline in cortical debris while at the same time observe an increase in non-cortical debris.

Cortical and non-cortical debris proportion relationships for Unit 1 are shown in Figure 53. As we can see, the overall percentage of cortical debris as part of the entire assemblage of Unit 1 is in decline through time. The overall percentage of non-cortical debris is at the same time increasing.

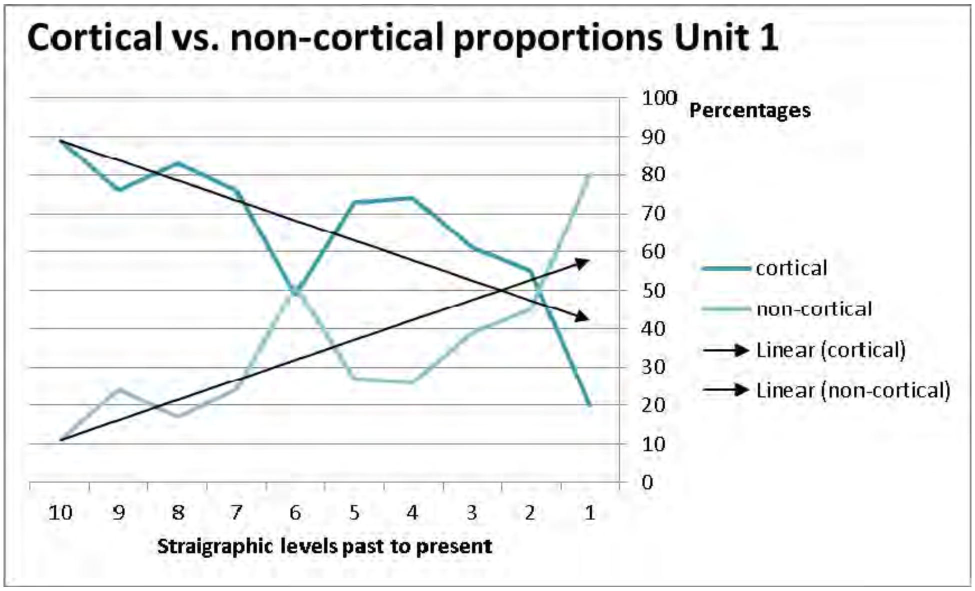

Figure 53. Cortical and non-cortical debris proportions, Unit 1.

Cortical and non-cortical debris proportions for Unit 2 are shown in Figure 54. The same trend is seen in Unit 2 as we saw in Unit 1, a decline in cortical debris and an increase in non-cortical debris.

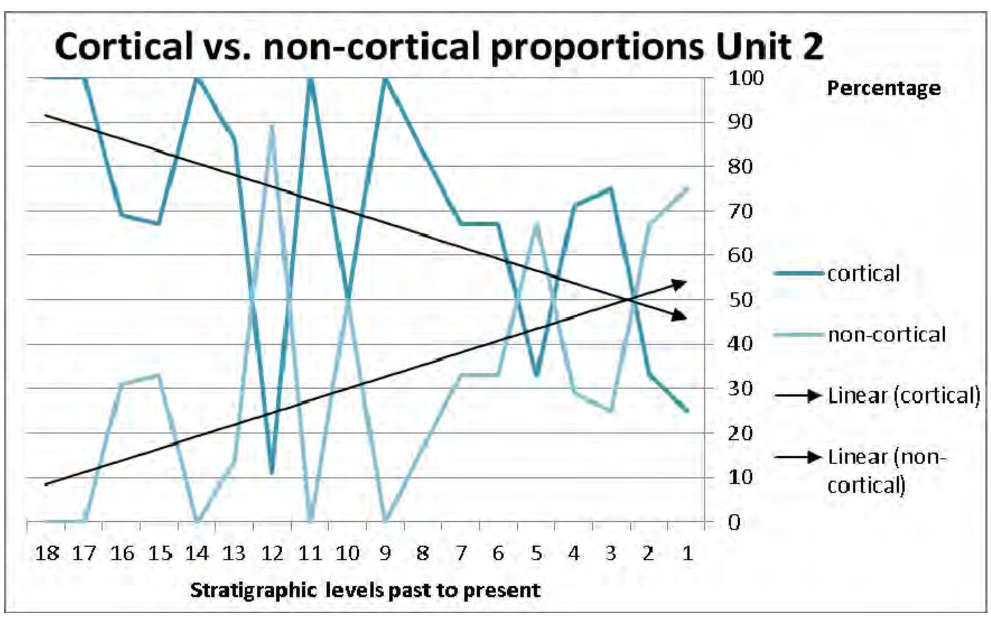

Figure 54. Cortical and non-cortical debris proportions, Unit 2.

Results and Discussion

Lithic procurement activities at the Bear Gulch obsidian source can accurately be defined as episodic in nature. This does not mean that trends are not shown in the data, but that these trends are only seen in the greatest expanses of time, and only in data sets that present reliable relationships between the variables. Before discussing the episodic nature of procurement activities at the site, a closer look at what the hypotheses tests produced in regards to our questions of change in reduction intensity is required. Possible explanations for these trends are then posed.

In review, the hypotheses are as follows. The first hypothesis states: Initial reduction stages in lithic production in the form of cortical debitage will increase in frequency, proportion and weight, through time as observed through successive stratigraphic levels, with the null hypothesis stating that there will be no increase in cortical debitage through time.

The second hypothesis states: Later stages of reduction recognized by non-cortical debris, will decrease in frequency, proportion and weight, through time as observed through successive stratigraphic levels, with the null hypothesis stating, there will be no decrease in non-cortical debris through time.

The third hypothesis states: The overall weight and frequency of lithic debris increases through time as observed through stratigraphic levels, with the null hypothesis stating that there will be no increase in lithic debris volume and frequency through time.

To eliminate discussions on data that did not produce reliable trends, focus on three data sets that compare cortical to non-cortical debris and two individual sets of data that support the same trends are discussed. These data sets are;

1. Frequencies of cortical and non-cortical debris from Unit 1 (Figure 52).
2. Late reduction stage (non-cortical) debris frequencies from Unit 2 (Figure 43).
3. Late reduction stage (non-cortical) debris weights from Unit 1(Figure 44).
4. Cortical and non-cortical proportions from Unit 1 (Figure 53).
5. Proportions of cortical and non-cortical debris from Unit 2 (Figure 54).

Frequencies of Cortical and Non-cortical Debris from Unit 1

The data shows a decline in cortical debris frequency and an increase in non-cortical debris frequency through time (Figure 52). These trends may indicate first, a change in lithic reduction technology, or a trend towards greater reduction intensity of the natural resource prior to export from the site, or both. The decrease in cortical debris could indicate less overall procurement activities at the site; however, the increase in non-cortical debris at the same time belies this assumption. These observations rely on previously tested assumptions concerning the nature of lithic debitage, such as the noted correlation that more reduction creates more debris. This data refutes Hypotheses 1 and 2.

Non-cortical Debris Frequencies from Unit 2

The data showed a reliable trend towards an overall increase in this artifact type through time (Figure 43). Although the cortical debris data from Unit 2 proved unreliable, the upward trend of non-cortical debris supports the assumption that a greater effort in reducing material at this site was taking place. This data refutes Hypothesis 2.

Non-cortical Debris Weights from Unit 1

The data follows the same trends seen in the previous tests, in that a reliable upward trend in this artifact type is observed (Figure 44). This indicates an increasing trend in weight of late reduction stage artifacts through time. As stated earlier, technological changes as well as overall increased activity at the site may have been responsible for this shift. The data for cortical debris weight in this unit proved unreliable and was not used for comparative purposes. This data refutes Hypothesis 2, and accepts Hypothesis 3.

Cortical and Non-cortical Proportion Comparisons for Unit 1

The data shows a downward trend in cortical debris percentage, and an upward trend in non-cortical debris percentage (Figure 53). The percentages of each artifact category are taken as part of the entire assemblage. These percentages point to the fact that a change in reduction intensity is occurring. More reduction of the natural resource through time is taking place prior to export. The decrease in cortical debris percentage may point to changes in reduction technique. This data refutes Hypotheses 1 and 2.

Cortical and Non-cortical Proportion Comparisons for Unit 2

The data shows a downward trend in cortical debris percentage, and an upward trend in non-cortical debris percentage (Figure 54). The percentages of each artifact category are taken as part of the entire assemblage. Just as Unit 1 showed, these percentages point to the fact that a change in reduction intensity is occurring. More reduction of the natural resource is taking place prior to export. This data refutes Hypotheses 1 and 2.

Interpretation of Trends Within the Theoretical Framework

The ultimate purpose of this project is to describe and explain the relationship between the material culture encountered at Bear Gulch, and the human behaviors that created it. That is, what the people actually did to create the site, and why. Having described the assemblage, the following models are presented as possible explanations for the trends encountered through time at Bear Gulch.

Lithic variability in general can be attributed to a host of factors. These include population size, change in technologies, resource availability, distance to other raw material sources, raw material quality and abundance, and group mobility among others (Roth and Dibble 1998:59). The factors determined most likely to be effecting the variability at Bear Gulch are, change in technology, distance of export, transport cost and utility, change in mobility, raw material quality and abundance, and resource availability.

Previous research as well as experience informs this research in that variability in any phenomenon is not likely explained by one factor alone, but that of many interacting forces. This concept is noted by Bamforth (1991:217) in his observation that “specific technological strategies are not determined by any single characteristic of any society’s way of life, but by the interactions between many factors and the environment that society inhabits.” Rolland and Dibble (1990:493) also conclude that “the correct interpretation of assemblage variability must consider a wide range of possible causes that interact simultaneously.” It is the purpose of this inventory to include all reasonable possibilities. Future research may focus on factors of special interest or those with the most promise in discovering dominant behaviors.

The first possible explanation for these trends is a change in technology that results in more non-cortical debris through time. Examples of this are changes from unidirectional core technology, to biface technology or similar techniques that differ in the amount of non-cortical debris produced (Dibble et al. 2005:546). Technological changes in tool type may affect the debris or debitage patterns found at Bear Gulch.

"Crabtree's Law" a corollary to the Frison Effect, states in part that it is necessary to study quarry and workshop debris to better understand the technological processes that took place at the procurement site. Examples of this are sequential trends towards smaller tools such as spear points during the Big Game Hunting Period, to atlatl darts during the Late Archaic Period, to arrow head projectiles associated with the Late Prehistoric Period. The technologies employed in reducing the necessary core tools for these separate type projectiles would have an effect on the artifact assemblage. Examples of these disparate technologies are unidirectional conical core technology which was discovered at the Bear Gulch site in a previous surface survey (Figure 55), and biface blank technology, which has also been identified at the Bear Gulch site (Figure 56). The presence of both types of cores indicates a separate reduction strategy employed by the users of this site. Each strategy produces a different assemblage of reduction debris.

Another explanation for our observed trend has been documented in previous studies by Beck et al. (2002:489) as an indicator of distance required to travel from the lithic source. The Central Foraging Model has been used to explain this trend. Beck et al. (2002:495) describes this model as a predictor "that foragers will invest greater or lesser time processing toolstone at a quarry depending on how far they intend to travel upon their departure." The farther one must travel, the smaller the artifact becomes. Providing

Figure 55. Unidirectional conical core. (Photograph by the author, 2009).

Figure 56. Biface tool blank. (Photograph by the author 2010)

this is a reliable statement, the greater the distance of export, the more reduction takes place. If materials from Bear Gulch were being exported at greater distances through time this would reveal itself in the archaeological record as a trend towards more non-cortical debris as observed at Bear Gulch. This is one possible explanation for the trends observed at Bear Gulch. A complete study of the Central Foraging Model is beyond the scope of this thesis, but may prove beneficial for future investigation.

Transport cost and utility of materials exported from lithic sources is another avenue explored to explain variability in lithic assemblages (Kuhn 1994). The premise behind this approach is that users of a lithic resource will balance the cost of transporting an amount of material with the overall best fit utility of the material. This model assumes an optimum balance and may fit with the data gathered at Bear Gulch. The reason for this is the fact that the assemblage at Bear Gulch was undergoing constant change in one direction that could indicate a change in transport and utility needs of the groups using this source. Future research could illuminate the reasons for the trends observed.

A change in mobility patterns is also a possible reason for the variability in the lithic assemblage at Bear Gulch. According to Andrefsky (1991:130), the difference between formalized and expedient tool types may be an indicator of what level of mobility, or sedentism a group exists at. These tool types in turn produce an identifiable assemblage of waste flakes. As in the Bear Gulch example, a greater level, or intensity of lithic reduction is occurring through time. This may indicate changes toward increased mobility. Rafferty (1985:132) also notes that a more settled life facilitates the use of heavier tools that a more nomadic life would find unreasonable. Heavier tools require less reduction while the opposite is true for a smaller easier transportable tool.

Raw material quality and abundance may also affect lithic variability. The reason behind this assumption is that “The quality and abundance of lithic raw materials played a direct role in prehistoric tool makers' decisions to produce various types of stone tools” (Andrefsky 1994:31). The results of Andrefsky’s study showed that resource areas displaying high quality materials as well as abundance resulted in both formal and informal tool production. This model does not fit well with the data observed at bear gulch. The limited number of artifacts associated with formal tool manufacture belies this assumption and may point to other factors effecting variability at this site. This is not to say that the factors of quality and abundance should not be considered when researching variability, however other factors such as availability of the resource may show why artifacts associated with formal tool types are little represented at this site.

Resource availability due to environmental constraints is another factor to be investigated. Historically, the region in which Bear Gulch occurs is snow bound for seven months a year. If periods of accessibility became longer, changes in reduction intensity may have taken place. Andrefsky (1994:23) states that, “The availability of lithic raw materials may be the most important factor in the organization of technology.” Although resources are not available year-round at Bear Gulch, it does not necessarily mean that this was the only source utilized by the population during the year. In fact if any degree of mobility of the population is assumed, which it should be due to the lack of archaeological evidence to the contrary, it should also be assumed that other lithic sources were included in the groups travel circuit. Therefore the dual factors of availability and quality of the resource should be taken into account simultaneously. If Bear Gulch obsidian was preferred over other materials used during the course of a settlement pattern, then variability in the assemblage could reflect that. Further research into defining quality and comparative studies of archaeological sites in the region may help in answering these questions.

A final explanatory model that may have introduced variability in the lithic assemblage at Bear Gulch is competition for the lithic resource through time. Jeske (1992:468), in his study of an Upper Mississippian village lithic assemblage, suggests that "increases in the time and energy devoted to subsistence activities as well as competition for resources between sedentary groups resulted in a shift in energy input from lithic technology to other aspects of life." This would have the result of decreases in overall lithic production if native groups of the area were experiencing a trend towards sedentism. The data observed at Bear Gulch does not support this hypothesis as the increased intensity of reduction through time points towards a more mobile society. Kelly (1992:58) also attributes competition to increased territoriality due to increased sedentism. Neither archaeological nor historical research have confirmed the presence of sedentary communities at or near the Bear Gulch locale within the time frames provided by the current data. Due to the available data, this model is not considered as a major factor in explaining variability at the site.

The trends in material culture at Bear Gulch through time reveal a reliable trajectory of decreases in cortical debitage and increases in non-cortical debitage. The behaviors that created this assemblage point to a greater emphasis on lithic reduction intensity. That is, more effort being put into reducing natural obsidian cobbles prior to export from the site. The explanations for this trend are not clear cut, but may involve one or more of the factors described in previous models. Future research designed to specifically address one or more of these models are required to accept or refute pertinent hypotheses.

The body of data acquired through current research at Bear Gulch seems to favor no one specific model for the trends observed, but elements of several. First, changes in technology are documented in the archaeological record of this region. The timelines established for Bear Gulch encompass the Archaic Period (7,800-1300 BP), defined as the time the shift from lanceolate points were replaced by side-notched and stemmed points, and the Late Period (1300-150 BP), defined as the time a shift towards the advent of bow and arrow technology took place (Lohse 1994:135-156). An increase in artifact frequency during the advent of the bow and arrow has been documented at Bear Gulch (Tables 14, 15, and Figures 58, 59). In explaining the trends observed, the progression from larger tool types to smaller tool types through time may have had an effect on reduction strategies at the lithic source. This trajectory may have included processes that favored core types that required more reduction than previous core types. This in turn would create an assemblage that trends toward a greater frequency or proportion of late stage, non-cortical debris.

The Central Foraging Model posed by Beck et al. (2002:489) is another possibility for variation in the Bear Gulch assemblage. The reason for including this model is the fact that Bear Gulch obsidian has been found in distant locations in the midwestern United States and dated to approximately 2,500 BP (Hughes 1992:519). This time frame occurs within established dates at the Bear Gulch excavation site and may well explain the level of reduction taking place prior to this long distance export. As was previously described in this model, the farther a resource travels, the more intense the reduction.

Transport cost and utility are also considered for explaining variation at this site. This model posed by Kuhn (1994) was earlier described as an optimization problem. Simply stated, what is the least amount of material one can transport while still retaining the tools required for time away from the resource? This problem addresses the data at Bear Gulch in two distinct ways. First, if technology was changing, the amount of material needed may have changed at the same time. This distorts the level of reduction encountered at the site. Second, a change in the use of the material may have taken place.

I refer to the fact that Bear Gulch obsidian was found in distant locations in the middle of the use history of the site. This may indicate that the resource assumed a new purpose in trade as opposed to its use in simple tool function. If this was the case, tradeoffs in materials carried by the users of this source may have occurred. In other words, if the economic goal of a group is focused in trade rather than other resource procurement the “gear” they carry would change. This scenario could affect the lithic assemblage in trends of increased site intensification as well as reduction intensification. The latter trend has been observed at Bear Gulch. Overall resource intensification data at the site unfortunately proved inconclusive. Additional excavations may answer this question.

Mobility patterns and their effect on lithic variability as described by Andrefsky (1991), and Rafferty (1985), may also contribute to explanations behind the behaviors that created the Bear Gulch assemblage. Briefly, these authors conclude that highly mobile groups exhibit smaller item “tool kits” than more sedentary populations.

This equates to greater reduction intensity at the procurement site. Archaeological evidence suggests temporary camps are the dominant site type at the Bear Gulch obsidian source for the majority of its use life (Willingham 1995:3). Only later in Julian Stewards (1938:136 &189) research on basin-plateau aboriginal groups was the nearby permanent village of Pagadut, (approximately 40 families), directly north of the Bear Gulch site identified. The antiquity of this village is unknown, but they most likely utilized this source. Testing of this model is not undertaken in this thesis, but may provide valuable results in understanding mobility and its effects on lithic variability.

Resource availability may play an important role in explaining lithic variation at Bear Gulch, but only if, as described earlier, the dual factors of quality of material and use patterns of various lithic sources in the region are objectively defined and fully investigated as to adequately describe the importance of the Bear Gulch resources. Goodale et.al. (2008:332), bolster this point in relaying that availability and quality both play a role in balancing the diversity of lithic assemblages.

In determining the explanation for the lithic assemblage characteristics encountered at Bear Gulch, several factors appear to contribute to the overall trends of greater lithic reduction intensity which are described above. These factors are in many cases intertwined and accordingly act in concert with one another. To focus on one specific model would not express the range of behavioral possibilities that created the trends observed. As Kuhn (1991:76), notes “Arguments over which variable is most important may actually divert attention from the real issues.”

Data Episodes

In interpreting the episodic nature of the data gathered at Bear Gulch, three broad possibilities are first questioned. Those are, behavioral explanations, environmental explanations, or a combination of both. Behavioral explanation examples may be variable resource procurement episodes, resource intensification during shifts in technology, or change in distance required for exported items. Environmental explanations may include, weather or climate episodes or natural disasters that changes accessibility to the site. Figure 57 shows the episodic nature of artifact frequencies through time in excavation Unit 1. The majority of collected data at Bear Gulch displayed the same pattern.

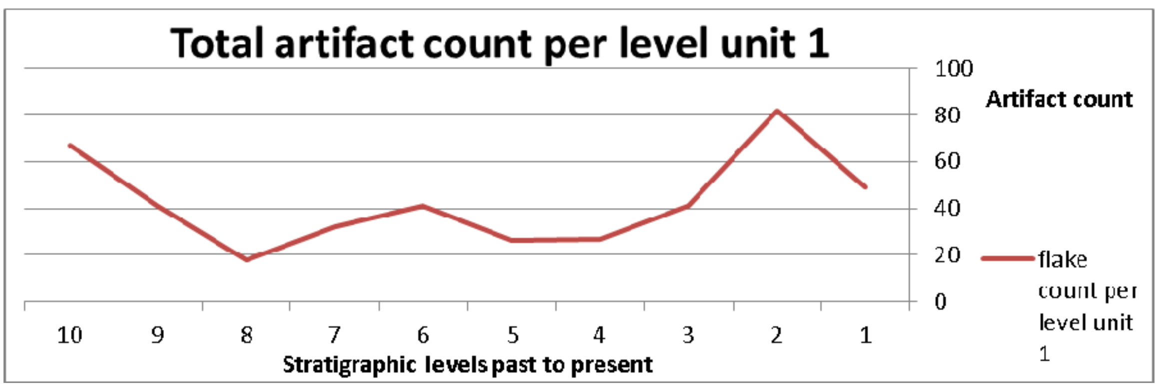

Figure 57. Total artifact counts, Unit 1.

Behavioral Factors

The episodic use patterns at this lithic procurement site may indicate that resource gathering episodes supplied needed materials for extended periods of time between other resource areas. If mobile groups existed on determined paths of subsistence and resource areas throughout the region, Bear Gulch may have been one procurement area of many that were visited throughout the course of a group’s existence.

These trends are well documented in the literature dealing with lithic resource areas (Roth and Dibble 1998; Kuhn 1991:78; Andrefsky 1994:23). These studies describe in various degrees the episodic nature of procurement episodes.

Bear Gulch however, displays peaks in debris frequency and weights about every 775 years. The times between these episodes are surprisingly uniform and indicate greater time spans than could be explained by “stops along the way” resource procurement patterns. Investigation of peaks in debitage frequencies and weights, compared to large-scale shifts in technology such as the appearance of atlatl technology, and bow and arrow technology in the region suggest a comparable time frame when acquired obsidian hydration dates were applied. The same concept applies to the frequencies and weights of debitage significantly declining. Similar trends have been recorded by Clarkson (2008:300) in Australia that are associated with a shift in tool technology, specifically the advent of heavily reduced scrapers and burins.

Environmental Factors

Peak and trough events in the data often occur simultaneously with large scale historic climate events. Obsidian hydration dates were used to verify these relationships. One trough is roughly coinciding with the Little Ice Age, followed by a peak during the Medieval Warm Period. Similar trends have been documented in studies by Chris Clarkson in Australian lithic sites (Clarkson 2008:297) where peaks in artifact frequencies coincide with warm stable climatic periods. These relationships at Bear Gulch are shown in Tables 14 and 15 as well as Figures 58 and 59.

To verify these relationships additional obsidian hydration or radiocarbon 14 tests are recommended to obtain a fuller range of dates for as many stratigraphic levels as

Table 14. Hydration Dates, Stratigraphic Provenience and Associated Events Unit 1.

Dates	Stratigraphy	Peak/Trough	Events
393 BP	Surface	Trough	
	0-10 Cm.	Peak	Bow & Arrow
1,474 BP	10-20 Cm.		
	20-30 Cm.	Trough	Little Ice Age
	30-40 Cm.		
	40-50 Cm.	Peak	
	50-60 Cm.		
	60-70 Cm.	Trough	
2,454 BP	70-80 Cm.		
	80-90 Cm.	Peak	Atlatl
Sterile Soil	90-100 Cm.		

Table 15. Hydration Dates, Stratigraphic Provenience and Associated Events Unit 2.

Dates	Stratigraphy	Peak/Trough	Events
554 BP	Surface	Peak	Bow & Arrow
	0-10 Cm.	Trough	
	10-20 Cm.	Peak	
	20-30 Cm.		
	30-40 Cm.	Trough	
884 BP	40-50 Cm.		
	50-60 Cm.		
	60-70 Cm.	Peak	Medieval Warm Period
	70-80 Cm.		Little Ice Age
	80-90 Cm.	Trough	
	90-100 Cm.		
	100-110 Cm.		Atlatl
	110-120 Cm.	Peak	
	120-130 Cm.	Trough	
	130-140 Cm.		
	140-150 Cm.	Peak	
4,148 BP	150-160 Cm.		
	160-170 Cm.	Trough	
Sterile Soil	170-180 Cm.		

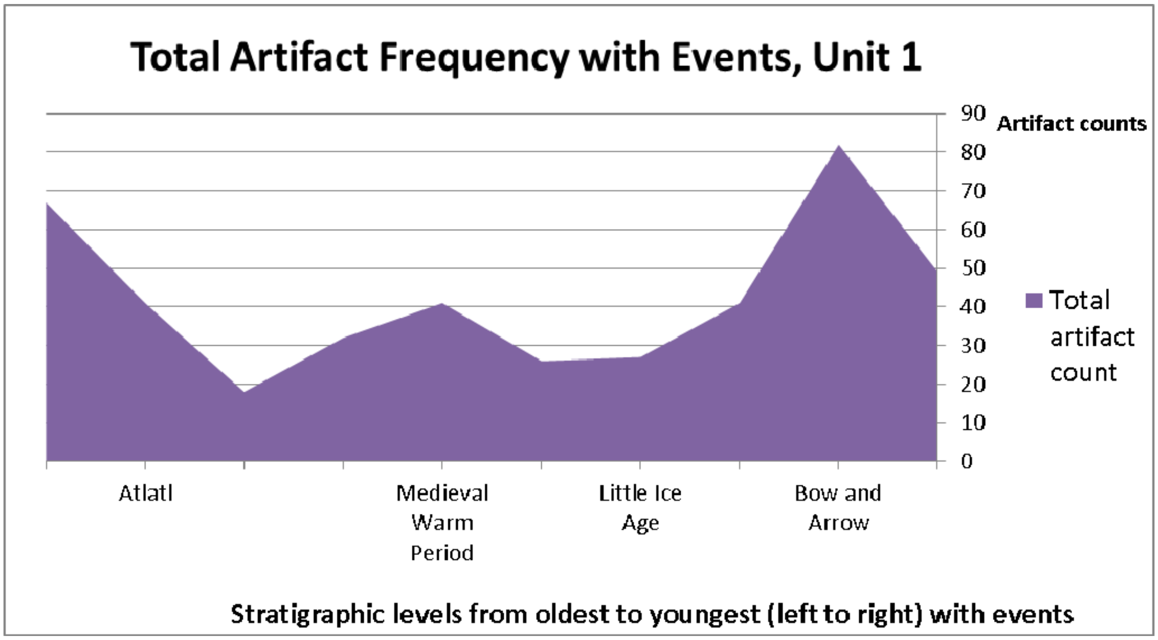

Figure 58. Artifact frequency with events, Unit 1.

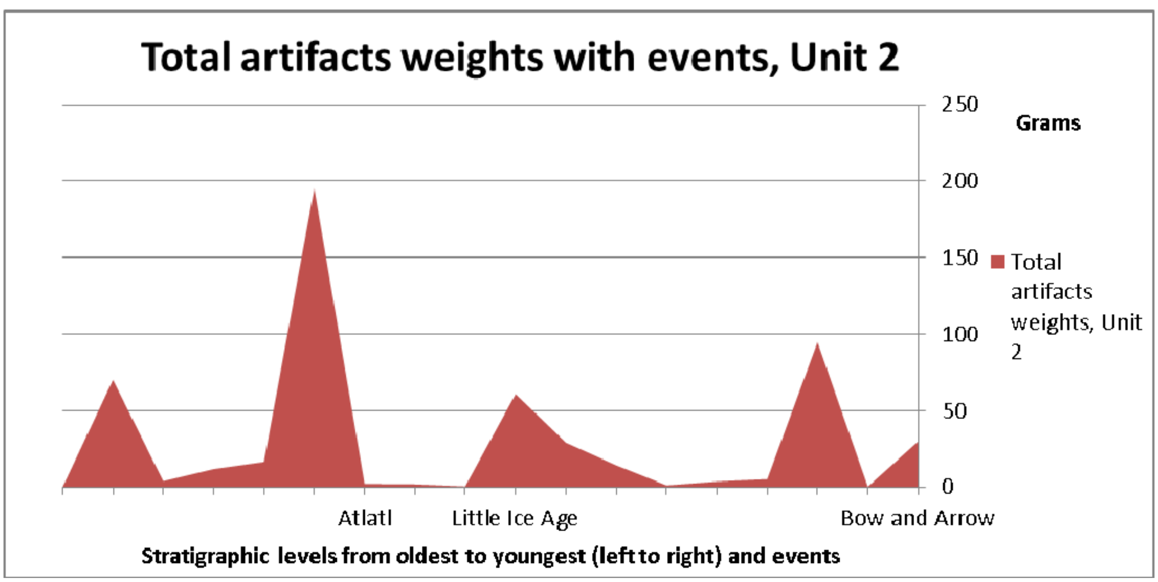

Figure 59. Total artifact weights with events, Unit 2.

possible. Future research in this area may point to increased activity during times of technological change, and decreases in activity during known climate events.

Environmental site formation processes were investigated to derive possible explanations for these episodes as well. No known site formation processes have been attributed to the episodes observed. The most likely explanation for the episodic nature of the data observed at Bear Gulch is due to both behavioral and environmental factors. Shifts in technology, and access to the resource because of climate seem most likely.

Whether it is one dominant factor, or the interaction of many responsible for the variability at Bear Gulch, it can be assumed that the native groups utilizing this resource were subject to both cultural and environmental pressures that shaped the way manufacture and export of the material were conducted through time. From periods of inaccessibility to the obsidian, to changes in subsistence or technological strategies, it is the people who created this assemblage who are the primary focus of this study. It is their story that defines the final objective of this thesis and anthropology in general.

The summary and conclusions of research conducted at Bear Gulch with suggested future directions of research are discussed in the following chapter.

CHAPTER VII

SUMMARY AND CONCLUSIONS

Through surface collections and excavations, this study has analyzed lithic reduction intensity in order to define and explain the lithic use patterns at the Bear Gulch obsidian procurement area. The nature of work done at this site included understanding the special properties of quarried lithics, examining trends in reduction intensity through time, studying site formation processes, identifying problems associated with interpreting this type of assemblage, and finally, inferring original behaviors of the pre-historic peoples utilizing the lithic source.

Components of two excavated units have accurately defined what type of assemblage one may encounter at an obsidian procurement area as well as in this specific context. This includes lithic reduction stages and intensity of reduction activities, artifact frequency comparisons, and properties of quarried lithics.

A concentrated effort at identifying and understanding site formation processes, coupled with the utilization of geoarchaeological principles has led to a clearer picture of how the site was formed and underwent change by natural and human processes. This has provided a more reliable interpretation of the data gathered in regards to inferring human behavior from the archaeological record at this site. A unique and effective method for collecting data at sites that exhibit upturned root systems may provide future researchers a way to study areas that were once considered off limits for archaeological data recovery.

A comparison of the lithic deposits per stratigraphic level of both excavated units has allowed for use patterns as well as trends through time to be identified and interpreted. This was accomplished through the use of obsidian hydration band analysis, as well as statistical applications on data including frequencies, weights, and proportions of artifacts. Use patterns appeared episodic in nature, but revealed trends in some data sets.

The analysis resulted in the acceptance of the null hypothesis for both Hypotheses 1 and 2, and resulted in inconclusive evidence for Hypothesis 3. Overall, we see a decline in early stage lithic reduction flakes in the form of cortical debitage in frequency, and proportion. At the same time, an increase in late stage reduction debitage in the form of non-cortical debris was observed in frequency, and proportion.

Interpretation of the data in regards to past human behaviors at this site was done only after all analysis of the data was completed. Only through adherence to previous models and logical assumptions did the final conclusion of trends towards increased lithic reduction become apparent.

The survey and excavation methods used this study worked well, and could prove beneficial for future research. Specifically beneficial was utilizing upturned tree root systems for identifying archaeological deposits spatially and temporally. Also, the approach used in excavation of the root/soil matrix and tree throw pit worked very well in controlling data through stratigraphic excavation.

In data analysis, I found that using polynomial regression to identify trends worked well with the episodic nature of the data encountered at this site. Although trends were not always clear, which resulted in the exclusion of some data sets, two of three hypotheses were satisfactorily answered through use of this method.

The use of Behavioral Archaeology as a theoretical and methodological framework also worked well in this study as the concepts defining the approach provided the most reliable foundation for inferring prehistoric behaviors. The Transform Position, describing the importance of identifying and accounting for site formation processes, and the concept of correlating human behavior to observable artifacts was the first essential step. Considering competing explanatory models was the second. Understanding the similarities and differences between behavioral archaeology and Middle Range Theory, as discussed in Chapter V, was also useful in the interpretation of data as well as in inferring behavior from the assemblage.

Overall, the research at Bear Gulch went smoothly, but this does not mean it was without its problems. Maintaining control of stratigraphic levels in these deposits required the introduction of new methods and tools that were at first unfamiliar, but in the end proved reliable and ultimately necessary. Some of these include constructing unique collection screens, and using root extraction tools like reciprocating saws.

The original users of this obsidian source had a sporadic, albeit long relationship with this resource area. The specific deposits analyzed in this study show visitation and use of the area occurring at over 4,000 years ago. Periods of higher resource exploitation are punctuated by steep declines in activity lasting sometimes hundreds of years. The reasons for these episodes are at once intuitive and arcane. Shifts in climate provide easier explanations for phenomena that may just as well have occurred due to variable settlement patterns. Due to these possibilities, accounting for all logical factors in lithic assemblage variability is crucial. This research has provided the catalyst for better understanding the behaviors that created this record.

Conclusions of the study indicate a variety of explanatory models including, shifts in technology, foraging models, transport costs and utility, mobility patterns, and environmental constraints, playing an important role in explaining the lithic variability at this site. Recognizing multiple factors affecting artifact assemblages led to a more complete and reliable interpretation of the data.

Suggested future research at Bear Gulch includes developing a more complete and accurate timeline of events utilizing additional obsidian hydration tests as well as radiocarbon tests. Testing specific model hypotheses to determine dominant factors in variability, and additional excavations in root systems and undisturbed areas for comparative purposes, as well as to increase sample size could augment current data. Also, as this study focused on cortical versus non-cortical artifacts, a subsequent study in individual flake analysis may provide greater detail in explaining specific lithic reduction behaviors.

This research has shown trends and episodes in the material culture of a people who experienced a variety of environmental and cultural pressures that affected the decisions they made over the course of thousands of years. Studying and understanding the artifact assemblage at Bear Gulch takes us one step closer to solving the mysteries of indigenous activities at this specific site, and the region in general. The focus on lithic materials in this thesis should not obscure the ultimate objective of understanding the lives of the people who created them.

REFERENCES CITED

REFERENCES CITED

Ahler, S. A.
1989 Mass Analysis of Flaking Debris: Studying the Forest Rather Than the Trees. In *Alternative Approaches to Lithic Analysis. Archaeological Papers of the Anthropological Association*¸ edited by D.O. Henry, and G. H. Odell, pp. 85–118. Archaeological Papers of the Anthropological Association Number 1.

Andrefsky, W.
1991 Inferring Trends in Prehistoric Settlement Behavior from Lithic Production Technology in the Southern Plains. *North American Archaeology* 12(2):129-144.

Andrefsky, W.
1994 Raw Material Availability and the Organization of Technology. *American Antiquity* 59(1):21-34

Andrefsky, W.
1998 *Lithics: Macroscopic Approaches to Analysis*. Cambridge University Press, Cambridge.

Andrefsky, W.
2008 *Lithic Technology*. Cambridge University Press, New York.

Anovitz, L. M., M. J. Elam, L. R. Riciputi, and D. R. Cole
1999 The Failure of Obsidian Hydration Dating: Sources, Implications, and New Directions. *Journal of Archaeological Science* 26:735–752.

Ascher, R.
1968 Time's Arrow and the Archaeology of a Contemporary Community. In *Settlement Archaeology,* edited by K.C. Chang, pp. 43-52. National Press Books, Palo Alto.

Bamforth, D. B.
1990 Technological Organization and Hunter-Gatherer Land Use: A California Example. *American Antiquity* 56(2):216-234.

Beck, C., A. K. Taylor, G. T. Jones, C. M. Fadem, C. R. Cook, and S. A. Millwarde
2002 Rocks Are Heavy: Transport Costs and Paleoarchaic Quarry Behavior in the Great Basin. *Journal of Anthropological Archaeology* 21:481–507.

Berard, B.
2008 Lithic Technology: A way to More Complex Diversity in Caribbean Archaeology. In *Crossing the Borders: New Methods and Techniques In the Study of Archaeological Materials from the Caribbean*, edited by Corine L. Hofman, Menno L.P. Hoogland, and Annelou L.Van Gijn, pp. 90-100. The University of Alabama Press, Tuscaloosa.

Binford, L. R.
1962 Archaeology as Anthropology. *American Antiquity* 28(2):217-225.

Binford, L. R.
1977 General Introduction. In *For Theory Building in Archaeology*, edited by L. R. Binford, pp. 1-10. Academic Press, New York.

Binford, L. R.
1979 Organization and Formation Processes: Looking at Curated Technologies. *Journal of Anthropological Research* 35(3):255-273.

Binford, L. R.
1981 Behavioral Archaeology and the “Pompeii Premise.” *Journal of Anthropological Research* 37:195-208.

Binford, L. R.
1983 *Working at Archaeology*. Academic Press, New York.

Binford, L. R.
2001 Where Do Research Problems Come From? *American Antiquity* 66(4):669-678.

Broughton, J. M., and J. F. O’Connell.
1999 On Evolutionary Ecology, Selectionist Archaeology, and Behavioral Archaeology. *American Antiquity* 64(1):153-165.

Butler, B. R.
1978 *A Guide to Understanding Idaho Archaeology. Upper Snake and Salmon River Country*. Idaho Museum of Natural History, Pocatello.

Butler, B. R.
1981 *When Did the Shoshoni Begin to Occupy Southern Idaho? Essays on Late Prehistoric Cultural Remains from the Upper Snake and Salmon River Country. Occasional Papers of the Idaho Museum of Natural History, No. 32.* Idaho Museum of Natural History, Pocatello.

Butler, B. R.
1986 Prehistory of the Snake and Salmon River Area. In *Handbook of North American Indians*, Vol. 11, edited by William C. Sturtevant, pp.127-134. Smithsonian Institution, Washington, DC.

Caldwell, J. R.
1959 The New American Archaeology. *Science* 129(3345):303-307.

Cannon, K. P.
1993 Paleoindian Use of Obsidian in the Greater Yellowstone Area. *Yellowstone Science* 6-9.

Carmichael, D., L., Lafferty, R. H. Molyneaux, and B. Leigh.
2003 *Excavation, Vol. 3: Archaeologist's Toolkit*. AltaMira Press, Walnut Creek.

Christenson, A. L.
1979 On the Virtues of Simplicity: Some Comments on Statistical Analysis in Anthropology. *Plains Anthropologist* 24(83):35-38.

Clark, G.
1966 Prehistory and Human Behavior. *Proceedings of the American Philosophical Society. Archaeology: Horizons New and Old* 110(2):91-99.

Clarkson, C.
2008 Changing Reduction Intensity, Settlement, and Subsistence in Wardaman Country, Northern Australia. In *Lithic Technology : Measures of Production, Use and Curation*, edited by William Andrefsky, pp. 286-316. Cambridge University Press, New York.

Collins, J. M., and B. L. Molyneaux
2003 *Archaeological Survey, Vol.2: Archaeologist's Toolkit*. AltaMira Press, Walnut Creek.

Crabtree, D.
1972 *An Introduction to Flintworking. Occasional Papers of the Idaho State University Museum, No. 28.* Idaho Museum of Natural History, Pocatello.

Crabtree, D.
1982 *An Introduction to Flintworking: Second Edition. Occasional Papers of the Idaho State University Museum, No. 28.* Idaho Museum of Natural History, Pocatello.

Daniels, S. G. H.
1978 Implications of Error: Research Design and the Structure of Archaeology. *World Archaeology* 10(1):29-35

Dibble, H. L., U. A. Schurmans, R. P. Iovita, and M. V. McLaughlin
2005 The Measurement and Interpretation of Cortex in Lithic Assemblages *American Antiquity* 70(3):545-560.

Digital Atlas of Idaho
2010 Archaeology. Electronic document, http://imnh.isu.edu/digitalatlas/, Accessed May 1, 2010.

Drennan, R. D.
1996 *Statistics for Archaeologists: A Commonsense Approach*. Plenum Press, New York.

Dretzke, B. J.
2005 *Statistics with Microsoft® Excel, Third Edition.* Pearson Prentice Hall, New Jersey.

Ewan, C. R.
2003 *Artifacts, Vol. 4: Archaeologist's Toolkit*. AltaMira Press, Walnut Creek.

Friedman, I., and W. Long
1976 Hydration Rate of Obsidian. *Science*, 191, 347-352.

Friedman, I., and F. Trembour
1983 Obsidian Hydration Dating Update. *American Antiquity* 48:544-547.

Goldberg, P., and R. I. Macphail
2006 Practical and Theoretical Geoarchaeology. Blackwell Publishing, Malden.

Goodale, N. B., I. Kuijt, S. J. Macfarlan, C. Osterhoudt, and B. Finlayson
2008 Lithic Core Reduction Techniques: Modeling Expected Diversity. In *Lithic Technology : Measures of Production, Use and Curation*, edited by William Andrefsky, pp. 317-336. Cambridge University Press, New York.

Griffin, J. B., A. A. Gordus, and G. A. Wright
1969 Identification of the Sources of Hopewell Obsidian in the Middle West. *American Antiquity* 34(1):1-14.

Harris, E. C.
1979 The Laws of Archaeological Stratigraphy. *World Archaeology* 11(1):111-117.

Hatch, J. W., J. W. Michels, C. M. Stevenson, Christopher, B. E. Scheetz, and R. A. Geidel
1990 Hopewell Obsidian Studies: Behavioral Implications of Recent Sourcing and Data Research. *American Antiquity* 55(3):461-479.

Hegmon, M.
2003 Setting Theoretical Egos Aside: Issues and Theory in North American Archaeology. *American Antiquity* 68:213-243.

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

Holmes, W. H.
1894 Natural History of Flaked Stone Implements. In *Memoirs of the International Congress of Anthropology*, edited by C.S. Wake, pp. 120-139. Schulte, Chicago.

Hughes, R. E., and F. W. Nelson
1987 New Findings on Obsidian Source Utilization in Iowa. *Plains Anthropologist* 32:313-316.

Hughes, R. E.
1992 Another Look at Hopewell Obsidian Studies. *American Antiquity* 57(3):515-523.

Hughes, R. E., and A. C. Fortier
2007 Trace Element Analysis of Obsidian Artifacts from Six Archaeological Sites in Illinois. *Illinois Archaeology* 19:144–157.

Hull, K. L.
1987 Identification of Cultural Site Formation Processes through Microdebitage Analysis. *American Antiquity* 52:4(772-783).

Jeske, R. J.
1992 Energetic Efficiency and Lithic Technology: An Upper Mississippian Example. *American Antiquity* 57(3):467-481.

Kardulias, N. P., and R. W. Yerkes (editors).
2003 *Written in Stone: The Multiple Dimensions of Lithic Analysis*. Lanham, Maryland: Lexington Books.

Kelly, R. L.
1992 Mobility/Sedentism: Concepts, Archaeological Measures, and Effects. *Annual Review of Anthropology* 21:43-66

Kuhn, S. L.
1994 A Formal Approach to the Design and Assembly of Mobile Toolkits. *American Antiquity* 59(3):426-442.

Leroi-Gourhan, A.
1964 *Le geste et la parole* [Gesture and Speech]. Albin Michel, Paris.

Lohse, E. S.

1994 The Southeastern Idaho Prehistoric Sequence. *Northwest Anthropological Research Notes* 28(2):135-156.

Lutus, P.

2009 Polynomial Regression: A matrix-based data analysis method. Electronic Document, http://www.arachnoid.com/sage/polynomial.html. Accessed 11-15-2010, Accessed May 1, 2010.

McDonald, J. H.

2009 *Handbook of Biological Statistics (2nd ed.)*. Sparky House Publishing, Baltimore.

MacArthur, R. H., and E. R. Pianka

1966 On Optimal Use of a Patchy Environment. *American Naturalist* 100:603-9.

Michels, J. W.

1986 Obsidian Hydration Dating. *Endeavour* 10(2):97-100.

Morrison, D. M.

1994 Validity in Lithic Debitage Analysis: An Experimental Assessment Comparing Quartzite to Obsidian. Unpublished M.A. thesis, Faculty of Archaeology, Simon Frazier University.

National Climatic Data Center

2010 Storm Events, Clark County, Idaho. Electronic Document. http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms, Accessed November, 3, 2010.

Odell, G. H.

2001 Research Problems R Us. *American Antiquity* 66(4):679-685.

Odell, G. H.

2003 *Lithic Analysis*. Springer Science+Business Media, New York.

Origer's Obsidian Laboratory

2010 *Results of Obsidian Hydration Band Analysis. Report number OOL-545*. Origer's Obsidian Laboratory, Rohnert Park.

Prentiss, W. C.

1998 The Reliability and Validity of a Lithic Debitage Typology: Implications for Archaeological Interpretation. *American Antiquity* 63(4):635-650.

Rapp, G., and C. Hill
2006 *Geoarchaeology: The Earth Science Approach to Archaeological Interpretation. 2nd ed.* Yale University Press.

Reed, W. G., J. W. Ross, B. L. Ringe, and R. N. Holmer
1986 *Archaeological investigations on the Idaho National Engineering Laboratory, 1984-1985. Report to EG&G, Idaho, Earth and Life Sciences Division, Idaho Falls, Idaho. Swanson/Crabtree Anthropological Research Laboratory, Report of Investigations 86.* Idaho State University, Pocatello.

Reid, J. J., M. B. Schiffer, and W. L. Rathje
1975 Behavioral Archaeology: Four Strategies. *American Anthropologist* 77:864-869.

Reid, J. J.
1985 Formation Processes for the Practical Prehistorian. In *Structure and Process in Southeastern Archaeology,* edited by R. S. Dickens, Jr., and H. T. Ward, pp. 11-33. University of Alabama Press, Tuscaloosa.

Rogers, A. K.
2010 Accuracy of obsidian hydration dating based on obsidian-radiocarbon association and optical microscopy. *Journal of Archaeological Science* 37:3239-3246.

Rolland, N., and H. L. Dibble
1990 A New Synthesis of Middle Paleolithic Variability. *American Antiquity* 55(3):480-499.

Roth, B. J., and H. L. Dibble
1998 Production and Transport of Blanks and Tools at the French Middle Paleolithic Site of Combe-Capelle Bas. *American Antiquity* 63(1):47-62.

Sadek-Kooros, H.
1972 Primitive Bone Fracturing: A Method of Research. *American Antiquity* 37(3):369-382.

Schiffer, M. B.
1972 Archaeological Context and Systemic Context. *American Antiquity* 37:156-165.

Schiffer, M. B.
1976 *Behavioral Archaeology*. Academic Press, New York.

Schiffer, M. B.
1979 A preliminary consideration of behavioral change. In *Transformations: Mathematical Approaches to Cultural Change,* edited by C. R. Renfrew, and K. Cooke. Academic Press, New York.

Schiffer, M. B.
1983 Toward the Identification of Formation Processes. *American Antiquity* 48(4):675-706

Schiffer, M. B.
1987 *Formation Processes of the Archaeological Record.* University of Utah Press, Salt Lake City.

Schiffer, M. B.
1995 *Behavioral Archaeology: First Principle.* University of Utah Press, Salt Lake City

Schiffer, M. B.
1999 Behavioral Archaeology: Some Clarifications. *American Antiquity* 64(1):166-168.

Schweger, C.
1985 Geoarchaeology of northern regions: lessons from cryoturbation at Onion Portage, Alaska. In *Archaeological Sediments in Context*, edited by J. K. Stein, and W. R. Farrand, pp.127-141. Center for the Study of Early Man, Institute for Quaternary Studies, University of Maine, Orono.

Shott, M. J.
1994 Size and Form in the Analysis of Flake Debris: Review and Recent Approaches. *Journal of Archaeological Method and Theory* 1(1):69-110.

Shott, M. J.
2003 Chaîne Opératoire and Reduction Sequence. *Lithic Technology* 28, 95-105.

Stein, J. K.
1983 Earthworm Activity: A Source of Potential Disturbance of Archaeological Sediments. *American Antiquity* 48(2):277-289.

Steward, J. H.
1997 [1938] *Basin-Plateau Aboriginal Sociopolitical Groups. Smithsonian Institution Bureau of American Ethnology Bulletin 120.* University of Utah Press, Salt Lake City.

Strauss, A. E.
1978 Nature's Transformations and Other Pitfalls: Toward a Better Understanding of Post-Occupational Changes in Archaeological Site Morphology in the Northeast. Part I: Vegetation. *Bulletin of the Massachusetts Archaeological Society* 39:47-64.

Sullivan, A. P., and K. C. Rozen
1985 Debitage Analysis and Archaeological Interpretation. *American Antiquity* 50(4):755-779.

Swanson, E. H.
1965 Archaeological Explorations in Southwestern Idaho. *American Antiquity* 31(1):24-37.

Swanson, E. H.
1972 *Birch Creek: Human Ecology in the Cool Desert of the Northern Rocky Mountains 9,000 B.C.-A.D. 1850.* Idaho State University Press, Pocatello.

Taylor, W. W.
1948 A Study of Archaeology (Mem. 69). *American Anthropology* 50 (No. 3, Part 2).

Trigger, B.
2007 [1996] *A History of Archaeological Thought: Second Edition.* Cambridge University Press, New York.

Tschauner, H.
1996 Middle-Range Theory, Behavioral Archaeology, and Post-Empiricist Philosophy of Science in Archaeology. *Journal of Archaeological Method and Theory* 3:1-30.

USGS Geographical Names Information System
2011 Feature Detail Report for: Centennial Mountains. Electronic Document, http://geonames.usgs.gov/pls/gnispublic/f?p=154:3:979948376242368::NO:3:P3_FID,P3_TITLE:398998%2CCentennial%20Mountains, Accessed February 2, 2011.

Western Regional Climate Center
2010 Kilgore, Idaho (104908) Period of Record Monthly Climate Summary. Electronic Document, http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?idkilg, Accessed November 15, 2010.

Willey, G. R., and P. Phillips.
1958 Method and Theory in American Archaeology. University of Chicago Press, Chicago.

Willingham, C. G.
1995 Big Table Mountain: An Obsidian Source in the Centennial Mountains of Eastern Idaho. *Idaho Archaeologist* 18(1):3-7.

Wright, G. A., and H. J. Chaya
1985 Obsidian Source Analysis in Northwestern Wyoming: Problems and Prospects. *Plains Anthropologist* 30:237-242.

APPENDIX A

MATERIAL DATA SHEETS

Site Bear Gulch Recorder. P. Raley. Date 1-29-10
Unit 1 Level_ surface Artifact Category debitage Date Excavated. 08-2009 Sheet # 1, all obsidian

	Weight	**Max Length**	**Max Width**	**Max Thickness**	**Term**	**Bulb**	**Platform Width**	**Platform Thickness**	**Cortex %**	**Flake Type**	**Ratio C:NC /Comments**
	4	2.72	2.54	0.54	WF	Y	1.65	0.24	5	SD	
	0.3	1.3	1.25	0.2	WF	N			0	SD	
	534	11.89	8.05	4.5	Core	Y	(5.01)(5.21)	11.89	90	CORE	WHOLE
	271	8.26	6.05	4.1	Core	Y	(4.24)(7.7)	(4.29)(3.76)	65	CORE	NEAR COMPLETE
	36.1	6.27	3.49	2.1	WF	Y	2.56	0.81	50	PD	
	13	4.73	4.25	0.68	FF	N			50	PD	
	7	3.12	2.68	0.81	FF	N			50	PD	
	1.9	1.9	1.9	0.62	WF	Y	0.56	0.61	10	SD	
	2.8	3	2.5	0.68	WF	Y	2	0.65	10	SD	
	2.3	2.82	1.78	0.66	FF	N			0	SIP	
	1.6	2.2	1.76	0.62	WF	N			10	SD	
	1.7	1.7	1.38	0.53	FF	N			0	SIP	
6 count	0.1	? 1			WF				0	SH	
17 count	0.5	1			FF				0	CIP	
7 count	1	2			WF				0	CIP	
	9.4	6	2.5	0.59	FF	Y			0	CIP	
	6.6	3.69	1.48	1.48	FF	N			75	SH	
	0.5	1.79	1.18	0.21	FF	N			0	CIP	
	0.3	2	1.5	0.1	WF	N			0	CIP	BANDED
3 count	0.1	? .1			WF	N			0	pf	ROUNDED
	894.2								10:39		49:3

PF=percussion fragment C=cortical SH=shatter *All weights in grams. All distance in cm.
PD=primary decortication pf=pressure flake SIP=simple interior percussion C:NC=cultural:non-cultural
SD=secondary decortication WF=whole flake CIP=complex interior percussion LBT=late biface thinning
SF=step fracture FF=flake fragment EBT=early biface thinning AP=angular percussion

Site: Bear Gulch Recorder. P. Raley. Date: 2-5-10
Unit: fall Level: 1 Artifact Category_debitage Date Excavated. 08-2009 Sheet # 2, all obsidian

	Weight	Max Length	Max Width	Max Thickness	Term	Bulb	Platform Width	Platform Thickness	Cortex %	Flake Type	Ratio C:NC /Comments
	28.9	6.15	4.12	1.75	FF	N			10	SD	STEP FRACTURE
	15	3.8	3.55	1.39	FF	N			70	PD	
	14	4.63	3.17	1.1	WF	Y	2.35	0.76	10	SD	
	1.8	3.7	1.79	0.37	WF	N			0	SIP	
	5.3	3.66	2.06	0.74	WF	N			90	PD	SIMPLE FLAKE TOOL
	6.6	2.45	2.09	1.33	WF	N			70	PD	
	3.4	2.77	2.03	0.81	WF	N			50	PD	
	1.1	2.67	1.53	0.3	FF	N			0	EBT	
	1.8	2.05	1.75	0.49	FF	Y	1.14	0.4	10	SD	
	2.4	1.84	1.77	1.06	WF	N			70	PD	
	5.1	1.74	1.7	1.66	WF	N			70	PD	
	2.5	2.16	1.23	1.1	WF	N			10	SH	
6 count	3.3	2			FF	N				3SH/3EBT	3 CORTEX/3 NONE
24 count	2.9	?1			FF	N				9SH/15EBT	7 CORTEX/17 NONE
	681.4	13.48	6.19	6.19	CORE	Y	1.64 (3.92) (2.67)	(6.59) (7.18) 11.52	90	CORE	DISCARDED
	775.5										
									21:22		43:94

PF=percussion fragment C=cortical SH=shatter *All weights in grams. All distance in cm.
PD=primary decortication pf=pressure flake SIP=simple interior percussion C:NC=cultural:non-cultural
SD=secondary decortication WF=whole flake CIP=complex interior percussion LBT=late biface thinning
SF=step fracture FF=flake fragment EBT=early biface thinning AP=angular percussion

Site: Bear Gulch Recorder. P. Raley. Date: 2-5-10
Unit: root wad Level: 0-10 Artifact Category: Debitage Date Excavated. 08-2009 Sheet # 3, all obsidian

	Weight	Max Length	Max Width	Max Thickness	Term	Bulb	Platform Width	Platform Thickness	Cortex %	Flake Type	Ratio C:NC /Comments
	21.5	5.29	2.61	1.94	WF	N			90	PD	SIMPLE FLAKE TOOL
	4	3.25	1.61	0.67	WF	Y	1.62	0.59	50	SD	
	2.9	2.58	1.28	0.75	WF	Y	1.8	0.38	50	SD	
22 count	3.7	? 1			FF	N				SH/CIP	15 CORTEX/7 NONE
	0.7	2			FF	N			90	SH	
											26:?
											Several artifacts have flake
											Morphology but display
											Cortex.
											TOTAL 26
	32.8								19:07		

PF=percussion fragment C=cortical SH=shatter *All weights in grams. All distance in cm.
PD=primary decortication PF=pressure flake SIP=simple interior percussion C:NC=cultural:non-cultural
SD=secondary decortication WF=whole flake CIP=complex interior percussion LBT=late biface thinning
SF=step fracture FF=flake fragment EBT=early biface thinning AP=angular percussion

Site: Bear Gulch Recorder. P. Raley. Date: 2-19-10
Unit: root wad Level: 10-20 Artifact Category: Debitage Date Excavated. 08-2009 Sheet # 4, all obsidian

	Weight	Max Length	Max Width	Max Thickness	Term	Bulb	Platform Width	Platform Thickness	Cortex %	Flake Type	Ratio C:NC /Comments
	2.6	2.43	1.61	0.53	WF	Y	1.41	0.54	50	PD	
	3	2.81	2.11	0.68	FF	N			90	PD	Distal end mod. Bi-face
	1.6	2.3	1.25	0.59	FF	N			50	SD	
	1.2	2.09	1.43	0.5	FF	N			50	SD	
	1.1	1.86	1.25	0.5	WF	Y	No plat	No plat	50	SD	
7 count	4.3	2			WF					SH	W/CORTEX
8 count	0.9	? 1			WF					SH	W/CORTEX
3 count	0.4	? 1			WF					CIP	1 LBT
2 count	0.1	? 1			WF					pf	LINEAR PF
2 count	0.1	? 1			WF					pf	ROUNDED
											27:99
	15.3								20:07		Possible weathered flakes(nc)

PF=percussion fragment C=cortical SH=shatter *All weights in grams. All distance in cm.
PD=primary decortication pf=pressure flake SIP=simple interior percussion C:NC=cultural:non-cultural
SD=secondary decortication WF=whole flake CIP=complex interior percussion LBT=late biface thinning
SF=step fracture FF=flake fragment EBT=early biface thinning AP=angular percussion

Site: Bear Gulch Recorder. P. Raley. Date: 2-19-10
Unit: root wad Level: 20-30 Artifact Category: Debitage Date Excavated. 08-2009 Sheet # 5 , all obsidian

	Weight	Max Length	Max Width	Max Thickness	Term	Bulb	Platform Width	Platform Thickness	Cortex %	Flake Type	Ratio C:NC /Comments
	201.2	7.53	7.38	5.2	CORE	Y	No plat	No plat	25	CORE	CONCAVE BULB/spent
	87.6	6.46	5.1	2.39	COBBLE	Y	1.74	2.63	90	ASSAYED	1 FLAKE REMOVAL
	185.3	10.3	4.65	3.23	COBBLE	Y	(2.84) (2.49) 2.17	(4.22) (5.0) (3.65)	90	ASSAYED	3 FLAKE REMOVALS
	95.6	6.48	5.28	2.43	COBBLE	Y	5.11	6.46	95	ASSAYED	5 FLAKE REMOVALS
	147.5	7.87	4.11	3.33	COBBLE	Y	2.67	2.82	95	ASSAYED	1 FLAKE REMOVAL
	83.3	7.73	4.37	2.28	COBBLE	Y	1.54	2.76	95	ASSAYED	4 FLAKE REMOVALS
	96.7	9.48	4.26	2.59	WF	Y	(1.69)(1.55)	6.23 both	95	SD	Simple flake tool. 4 perc.
	34.3	7.04	3.84	2.21	WF	Y	2.85	2.11	15	SD	
	6.1	3.09	2.4	1.06	FF	Y	1.14	0.76	5	SH	CORTEX
	3.6	2.83	2.04	0.79	WF	N			70	PD	
	1.4	2.96	0.76	0.57	WF	N			70	PD	
2 count	5.7	2			WF					SH	1 CORTEX
22 count	3.1	1			WF					SH	13 CORTEX
5 count	0.6	1			WF					pf	ROUNDED
1 count	0.1	? 1			FF					PF	*PERCUSSION FRAG
											41:51:00
	952.1								25-16		

PF=percussion fragment C=cortical SH=shatter *All weights in grams. All distance in cm.
PD=primary decortication pf=pressure flake SIP=simple interior percussion C:NC=cultural:non-cultural
SD=secondary decortication WF=whole flake CIP=complex interior percussion LBT=late biface thinning
SF=step fracture FF=flake fragment EBT=early biface thinning AP=angular percussion

Site: Bear Gulch Recorder. P. Raley. Date: 2-19-10
Unit: root wad Level: 30-40/ 40-50 (top) Artifact Category: Debitage Date Excavated. 08-2009 Sheet # 6, all obsidian

	Weight	Max Length	Max Width	Max Thickness	Term	Bulb	Platform Width	Platform Thickness	Cortex %	Flake Type	Ratio C:NC /Comments
	195.8	9.01	5.5	4.07	WF	Y	3.8	0	95	ASSAYED	
	59.3	11.76	3.52	1.87	WF	N			20	SD	
	58.8	7.64	5.1	1.64	WF	N			5	SIP	
	10	5.11	2.11	0.95	WF	Y	1.36	0.62	70	PD	
	23.2	3.38	2.71	1.83	WF	N			30	SH	CORTEX
	21.5	4.82	2.78	1.93	WF	Y	1.78	2.03	90	ASSAYED	
	1.6	2.64	2.28	0.29	WF	Y	? 1	? 1	1	PF	CORTEX
	2.2	2.68	1.59	0.65	FF	N			70	SH	CORTEX
	0.5	2.9	0.58	0.34	FF	N			40	SD	
	5.4	2.24	1.91	1.12	WF	N			90	SH	
	4.2	3.16	1.21	1.28	WF	N			10	SH	
	2.4	2.46	1.28	0.69	WF	N			50	SH	
11 count	13.1	2			WF					SH	CORTEX
22 count	5.5	? 1			WF					SH	CORTEX
9 count	3	2			FF				0	SIP	
28 count	1.4	? 1			FF				0	pf	
											82:47:00
	407.9								45-37		

PF=percussion fragment C=cortical SH=shatter *All weights in grams. All distance in cm.
PD=primary decortication pf=pressure flake SIP=simple interior percussion C:NC=cultural:non-cultural
SD=secondary decortication WF=whole flake CIP=complex interior percussion LBT=late biface thinning
SF=step fracture FF=flake fragment EBT=early biface thinning AP=angular percussion

Site: Bear Gulch Recorder. P. Raley. Date: 2-19=10
Unit: tree throw pit Level: 0-10 Artifact Category: Debitage Date Excavated. 08-2009 Sheet # 7, all obsidian

	Weight	Max Length	Max Width	Max Thickness	Term	Bulb	Platform Width	Platform Thickness	Cortex %	Flake Type	Ratio C:NC /Comments
	300.5	11.09	6.26	4.85	WF	Y	1.73	2.06	90	ASSAYED	
	10.9	3.36	1.95	1.47	WF	N			80	SH	
	3	2.5	2.48	0.68	FF	N			0	SIP	Formed flake tool. Dist. prep
2 count	7.2	2			WF	N				SH	CORTEX
25 count	5	? 1			WF	N				SH	CORTEX
	0.1	2			FF	N			0	SIP	
7 count	0.2	? 1			WF	N			0	PF	
											38:06:00
	326.9								29-9		

PF=percussion fragment C=cortical SH=shatter *All weights in grams. All distance in cm.
PD=primary decortication pf=pressure flake SIP=simple interior percussion C:NC=cultural:non-cultural
SD=secondary decortication WF=whole flake CIP=complex interior percussion LBT=late biface thinning
SF=step fracture FF=flake fragment EBT=early biface thinning AP=angular percussion

Site: Bear Gulch Recorder. P. Raley. Date: 3-5-10
Unit: tree throw pit Level: 10-20 cm Artifact Category: Debitage Date Excavated. 08-2009 Sheet # 8, all obsidian

	Weight	Max Length	Max Width	Max Thickness	Term	Bulb	Platform Width	Platform Thickness	Cortex %	Flake Type	Ratio C:NC /Comments
	335.2	9.4	8.17	4.8	TOOL	Y	1.74, 1.45	6.04, 6.04	90	Core tool	whole, ang. 7 flk removal bi-f
	33.7	4.5	4.17	1.85	TOOL	Y	2.81	3.46	90	Flake tool	Mod. Flk. 6 flk removals. bi-f
	3.6	2.25	1.66	1	WF	N			90	SH	
	7.6	2.8	2.19	1.26	WF	N			90	SH	
	0.8	2.1	1.22	0.4	WF	Y	2	0.4	70	PD	
	1	1.56	1.42	0.44	FF	N			0	CIP	
2 count	0.6	2			FF	N			0	PD/CIP	1 each
2 count	0.6	2			FF	N			50	SH	cortex
8 count	0.2	? 1			WF	N			50	SH	
											18:30
	383.3								15-3		

PF=percussion fragment C=cortical SH=shatter *All weights in grams. All distance in cm.
PD=primary decortication pf=pressure flake SIP=simple interior percussion C:NC=cultural:non-cultural
SD=secondary decortication WF=whole flake CIP=complex interior percussion LBT=late biface thinning
SF=step fracture FF=flake fragment EBT=early biface thinning AP=angular percussion

Site: Bear Gulch Recorder. P. Raley. Date: 3-5-10
Unit: tree throw pit Level: 20-30 Artifact Category: Debitage Date Excavated. 08-2009 Sheet # 9, all obsidian

	Weight	Max Length	Max Width	Max Thickness	Term	Bulb	Platform Width	Platform Thickness	Cortex %	Flake Type	Ratio C:NC /Comments
	304.6	10.54	8.7	3.69	assayed	Y	3.35	7	90	ASSAYED	Whole, tabular, 2 removals
	42.7	4.32	4.29	1.67	FF	Y	3.67	3.57	90	PD	
	25.8	6.58	2.53	1.89	WF	Y	2.29	1.77	75	TOOL	Formed, uni-face, str. vent.
	17.9	5.51	4.58	0.68	WF	Y	0	3.36	0	CIP	
	15.9	4.07	2.52	1.76	WF	N			50	SH	
	5.6	4.17	1.85	0.88	WF	N			90	TOOL	Simple, 1 edge, dorsal, bi-f
	7.5	2.46	2.05	1.09	FF	N			20	SH	
	3.3	2.79	1.58	0.71	FF	N			90	PD	
5 count	2.5	2			FF	N			0	SIP	
2 count	3.6	2			WF	N			50	SH	
4 count	0.7	? 1			WF	N			0	CIP	
21 count	5.3	? 1			WF	N			50	SH	ALL CORTEX
											40:89
	435.4								30-10		

PF=percussion fragment C=cortical SH=shatter *All weights in grams. All distance in cm.
PD=primary decortication pf=pressure flake SIP=simple interior percussion C:NC=cultural:non-cultural
SD=secondary decortication WF=whole flake CIP=complex interior percussion LBT=late biface thinning
SF=step fracture FF=flake fragment EBT=early biface thinning AP=angular percussion

Site: Bear Gulch Recorder. P. Raley. Date: 3-5-10
Unit: tree throw pit Level: 30-60 Artifact Category: Debitage Date Excavated. 08-2009 Sheet # 10, all obsidian

	Weight	Max Length	Max Width	Max Thickness	Term	Bulb	Platform Width	Platform Thickness	Cortex %	Flake Type	Ratio C:NC /Comments
	330.3	9.51	7.24	4.69	Assayed	Y	4.71	5.16	90	ASSAYED	wh, ang, 3 flk removals
	164.2	7.08	5.34	4.31	Assayed	Y	3.71	3.75	90	ASSAYED	wh, ang, 1 flake removal
	28	4	3.37	2.11	WF	Y	3.38	2.71	75	PD	
	8.6	5.22	2.53	0.58	FF	N			90	PD	*weathered flake?
	2.2	2.29	1.28	0.63	FF	N			50	SIP	
	1.8	2.9	1.2	0.49	WF	N			0	CIP	
	0.9	1.73	1.57	0.23	FF	N			50	PD	
9 count	15.3	2			WF	N			50	SH	ALL CORTEX
6 count	0.7	? 1			FF	N			0	SIP	
44 count	9.2	? 1			WF	N			50	SH	ALL CORTEX
											66:424
											Boulders in the bottom of the
											Unit caused the 30 cm level
	561.2								59-7		Depth.

PF=percussion fragment C=cortical SH=shatter *All weights in grams. All distance in cm.
PD=primary decortication pf=pressure flake SIP=simple interior percussion C:NC=cultural:non-cultural
SD=secondary decortication WF=whole flake CIP=complex interior percussion LBT=late biface thinning
SF=step fracture FF=flake fragment EBT=early biface thinning AP=angular percussion

APPENDIX B

OBSIDIAN HYDRATION BAND ANALYSIS REPORT

ORIGER'S OBSIDIAN LABORATORY
P.O. BOX 1531
ROHNERT PARK, CALIFORNIA 94927
(707) 584-8200, FAX 584-8300
ORIGER@ORIGER.COM

November 8, 2010

Patrick Raley
1257 ½ Warner Street
Chico, California 95926

Dear Patrick:

I write to report the results of obsidian hydration band analysis of six specimens from Bear Gulch in eastern Clark County, Idaho. This work was completed as requested in your letter dated October 29, 2010.

Procedures typically used by our lab for preparation of thin sections and measurement of hydration bands are described here. Specimens are examined to find two or more surfaces that will yield edges that will be perpendicular to the microslides when preparation of each thin section is done. Generally, two parallel cuts are made at an appropriate location along the edge of each specimen with a four-inch diameter circular saw blade mounted on a lapidary trimsaw. The cuts result in the isolation of small samples with a thickness of about one millimeter. The samples are removed from the specimens and mounted with Lakeside Cement onto etched glass micro-slides.

The thickness of each sample was reduced by manual grinding with a slurry of #600 silicon carbide abrasive on plate glass. Grinding was completed in two steps. The first grinding is stopped when each sample's thickness is reduced by approximately one-half. This eliminates micro-flake scars created by the saw blade during the cutting process. Each slide is then reheated, which liquefies the Lakeside Cement, and the samples are inverted. The newly exposed surfaces are then ground until proper thickness is attained.

Correct thin section thickness is determined by the "touch" technique. A finger is rubbed across the slide, onto the sample, and the difference (sample thickness) is "felt." The second technique used to arrive at proper thin section thickness is the "transparency" test where the micro-slide is held up to a strong source of light and the translucency of each sample is observed. The samples are reduced enough when it readily allows the passage of light. A cover glass is affixed over each sample when grinding is completed. The slides and paperwork are on file under File No. OOL-545.

The hydration bands are measured with a strainfree 60-power objective and a Bausch and Lomb 12.5-power filar micrometer eyepiece mounted on a Nikon Labophot-Pol polarizing microscope. Hydration band measurements have a range of +/- 0.2 microns due to normal equipment limitations.

Six measurements are taken at several locations along the edge of each thin section, and the mean of the measurements is calculated and listed on the enclosed data page.

All six specimens were marked by measurable hydration bands. We used the hydration band measurements to calculate dates as described below.

We calculated dates by determining the rate of hydration through comparison to an obsidian with a well-established rate, and then calculating the EHT for the specimens' location. The steps we follow allow us to essentially convert the subject obsidian specimens' hydration band widths into their control source equivalency. We establish what we term "comparison constants." This is done in most cases by using data from laboratory induced hydration. Joseph Michels published a series of reports on the results of induced hydration for a large number of sources, and those reports are often used to establish the comparison constants.

Next, effective hydration temperatures (EHT) differences are taken into account between the control source's EHT and the subject specimens' EHT. EHT values are calculated using temperature data from the website, www.wrcc.dri.edu/summary/climsmut.html. We are able to adjust the subject specimens' hydration band measurements and use them in the standard diffuse formula (Time = kx^2) to arrive at dates. "K" is the hydration rate constant and "x" is the hydration band measurement.

In this case, all six specimens probably derived from the Bear Gulch source. Induced hydration data indicate that the development of hydration on this source varies relative to Napa Valley obsidian, the control obsidian for which a good hydration rate has been determined (see Table 1). Thus, rate adjustments are necessary (see Table 2, Column 3).

Table 1. Ratio of hydration development relative to the control obsidian source

Source	Ratio NV:BG	References
Bear Gulch	1:1.06	Michels 1983, 1986

* NV signifies Napa Valley, the control obsidian source

The EHT of the control obsidian source (Napa Valley) is 16.4, and the nearest weather station to Bear Gulch is Kilgore, but Kilgore it is situated approximately 900 feet lower in elevation. The EHT where the specimens were collected is probably slightly lower (cooler) because of the higher elevation. Other weather sites were analyzed, and based on that analysis, it is estimated that the Bear Gulch locality has an EHT of 6.8 degrees. Therefore, the Bear Gulch EHT is 9.6 degrees lower (cooler) than the control locality. This means that obsidian at the Bear Gulch specimens hydrated more slowly than the same source of obsidian would have at the (warmer) control locality.

Because the EHT for the Bear Gulch locality is cooler we adjust the subject specimens' hydration band measurements upward by 6% per degree difference. Six percent has been found to be an appropriate adjustment based on several studies (Basgall 1990; Origer 1989).

Patrick Raley
November 8, 2010
Page 3

Table 2 shows dates derived after making required hydration band measurement adjustments for differences in hydration rate and EHT.

Table 2. Hydration band adjustments and dates

Specimen Number	Hydration Band (in microns)	Rate Adjusted Hydration Band	EHT Adjusted Hydration Band	Date (in years before present)
1.S	1.0	0.9	1.6	393
1.R	1.9	1.8	3.1	1,474
1.P	2.4	2.3	4.0	2,454
2.S	1.2	1.1	1.9	554
2.R	1.5	1.4	2.4	884
2.P	3.2	3.0	5.2	4,148

Please don't hesitate to contact me if you have questions regarding this hydration work.

Sincerely,

Thomas M. Origer
Director

References

Basgall, M
1990 Hydration Dating of Coso Obsidian: Problems and Prospects. Paper presented at the 24th annual meeting of the Society for California Archaeology, Foster City, California.

Michels, J.
1983 Hydration Rate Constants for Camas-Dry Creek Obsidian, Clark County, Idaho. Mohlab Technical Report No. 26. State College, Pennsylvania.

1986 Hydration Rate Constants for Napa Glass Mountain Obsidian, Napa County, California. Mohlab Technical Report No. 14. State College, Pennsylvania.

Origer, T.
1989 Hydration Analysis of Obsidian Flakes Produced by Ishi During the Historic Period. Current Directions in California Obsidian Studies. Contributions of the University of California Archaeological Research Facility. Number 48. Berkeley, California.

Submitter: P. Raley - Chico State University November 2010

	Lab#	Sample#	Description	Unit	Depth	Remarks	Measurements	Mean	Source*
Bear Gulch, ID									
	1	1.S	Debitage	1	Surface	None	0.9 0.9 0.9 1.0 1.0 1.0	1.0	BG
	2	1.R	Debitage	1	20-30	None	1.8 1.9 1.9 1.9 1.9 1.9	1.9	BG
	3	1.P	Debitage	1	20-30	None	2.3 2.4 2.4 2.5 2.5 2.5	2.4	BG
	4	2.S	Debitage	2	Surface	None	1.1 1.1 1.1 1.2 1.2 1.3	1.2	BG
	5	2.R	Debitage	2	60-70	None	1.4 1.4 1.4 1.4 1.6 1.6	1.5	BG
	6	2.P	Debitage	2	40-50	None	3.0 3.1 3.2 3.2 3.2 3.3	3.2	BG

Lab Accession No: OOL-545 Technician: Thomas M. Origer

BG = Bear Gulch

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November 22, 2010

Patrick Raley
1257 ½ Warner Street
Chico, California 95926

Dear Patrick:

I write to report the results of obsidian hydration band analysis of two additional specimens from Bear Gulch in eastern Clark County, Idaho. This work was completed as requested in your letter dated November 15, 2010.

Both specimens were marked by measurable hydration bands from which we calculated dates in the same fashion as described in my letter report dated November 8, 2010.

Table 1. Hydration band adjustments and dates

Specimen Number	Hydration Band (in microns)	Rate Adjusted Hydration Band	EHT Adjusted Hydration Band	Date (in years before present)
2.R-1	3.9	3.7	6.4	6,283
2.R-2	7.8	7.3	12.6	24,354

Both specimens yielded significantly older dates than did the other six specimens we analyzed, and both exhibited signs of weathering in the form of corrosion on the external portion of the hydration bands (specimen surfaces). These two specimens have rough (possibly crazed) surfaces when viewed under a binocular microscope. Perhaps they had been exposed to fire sometime in the past.

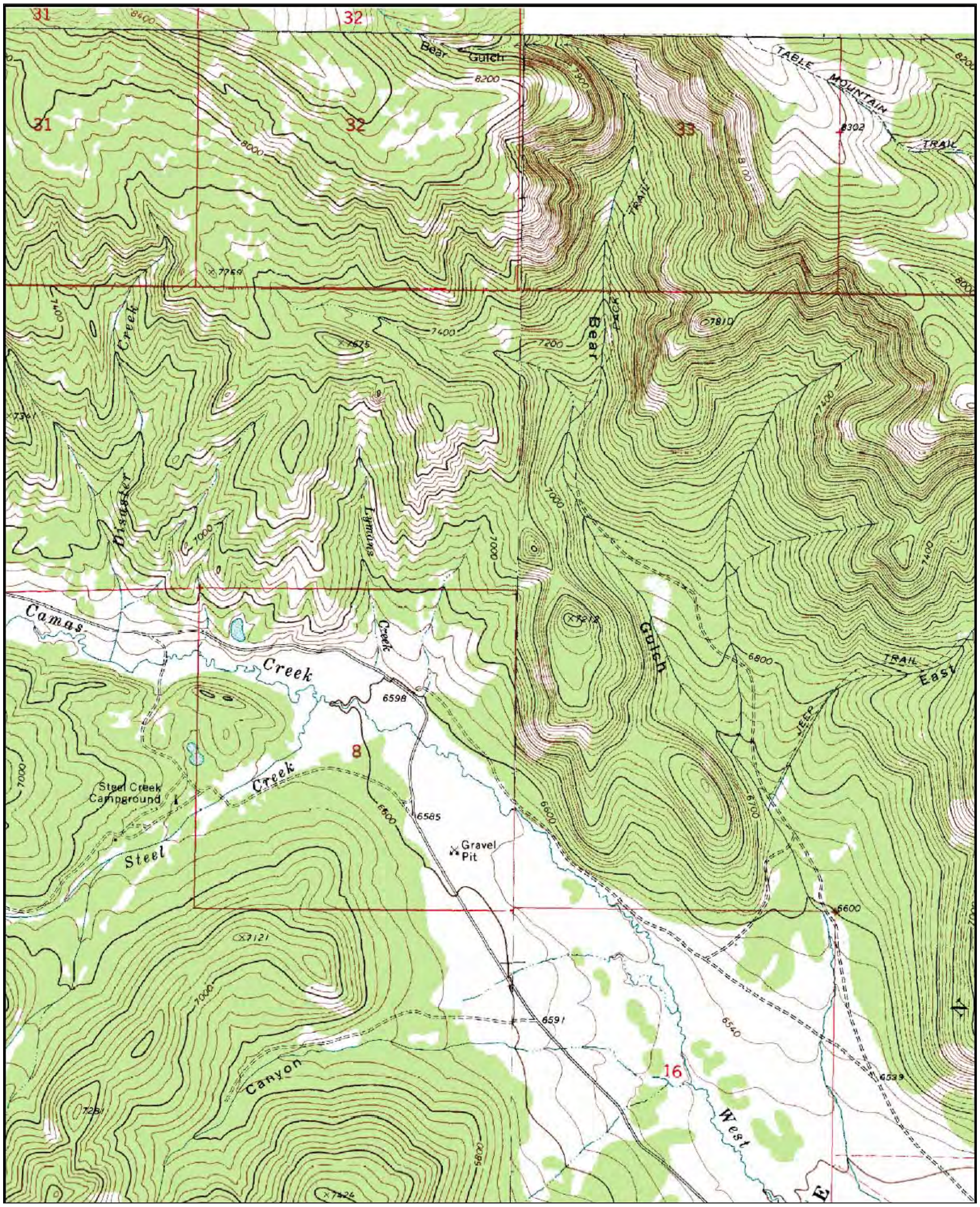
Please don't hesitate to contact me if you have questions regarding this hydration work.

Sincerely,

Thomas M. Origer
Director

APPENDIX C

MAP



Source: United States Geological Survey Kilgore, 1990, Idaho-Clark County 1:24,000 topographic quadrangle map. United States Geological Survey, Reston, VA.