More Than Toolstone:
Differential Utilization of Glass Mountain Obsidian

by

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B.A. (University of Pennsylvania) 1996
M.S. (University of Pennsylvania) 1996

A dissertation submitted in partial satisfaction of the

requirements for the degree of

Doctor of Philosophy
in

Anthropology

in the

GRADUATE DIVISION

of the

UNIVERSITY OF CALIFORNIA, BERKELEY

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Spring 2002

The dissertation of Carolyn Dean Dillian is approved:

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Co-Chair Date

Date

University of California, Berkeley

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Abstract

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Archaeological studies of lithic material procurement and use have traditionally focused on raw material quality and proximity to source as sole indicators for selection of particular materials for stone tool manufacture. Yet this effectively denies the role of human action and belief in the choice of lithic materials. The Glass Mountain obsidian quarry provides evidence of the integration of prehistoric belief systems into toolstone procurement patterns as visible through differential toolstone use in prehistory and the selection of specific raw material types for particular categories of objects.

Large obsidian bifaces from northern California have long been known as non-utilitarian ceremonial and wealth objects. Despite their uniform and stylized shape, bifaces were manufactured from several different obsidian sources. Glass Mountain in Siskiyou County, California was one source for black obsidian bifaces. The lithic assemblage at Glass Mountain and X-ray fluorescence data from the surrounding region indicate that this obsidian was used almost entirely for biface production, and was

neglected as a source for utilitarian objects. Just as obsidian objects fulfilled utilitarian or non-utilitarian functions, obsidian sources retained special roles within the context of prehistoric culture and belief systems.

Ultimately, differential use of Glass Mountain obsidian lies in the context of cultural beliefs, which hold it as a special source to be used exclusively for the production of valued objects. Certainly Glass Mountain is not the only obsidian utilized for value objects, but it is unique in that it was used almost entirely for non-utilitarian purposes, while other nearby obsidian was exploited for utilitarian objects. The cultural context of Glass Mountain obsidian utilization varied across and within territorial and geographic boundaries, yet despite cultural differences, the concept of value is intricately linked with Glass Mountain obsidian and the large bifaces made from it. In this sense, the quarry was in itself also an active agent, which gave value to things. It provides evidence for integration of prehistoric belief systems into toolstone procurement and use patterns through the selective use of Glass Mountain obsidian for ceremonial and value objects.

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ACKNOWLEDGEMENTS

This dissertation would not have been completed if not for the help of the following individuals and organizations. By generously providing their time, hard work, resources, and funding, they have made this dissertation possible.

First and foremost, Gerry Gates, Forest Archaeologist for Modoc National Forest has assisted in many ways, from the initial brainstorming that created the research plan, to funding, crew, equipment, and encouragement. Gerry has been instrumental in helping me see this project through to completion.

Second, Dr. M. Steven Shackley has given time, energy, and encouragement over the years. As both a mentor and a friend, Steve deserves a great deal of credit for helping me formulate my research ideas and being rightfully critical of the dumb ones. Dr. Kent Lightfoot has similarly helped steer my graduate career towards its final goal, through his suggestions and support. Finally, Dr. Ian Carmichael has taken the time to offer words of advice and encouragement, as well as his opinions regarding the best bars in Alturas, California.

The dedicated field crew of the Glass Mountain Archaeological Project must also be acknowledged for their hard work and relentless enthusiasm in the face of less-than-ideal housing conditions. The field crew consisted of: Elly Lopez, Adrian Lopez, Mike Bortner, Danielle Sullivan, Brandon Patterson, Diana Stern, Bridget Mosley, Chip Hackett, Rip Hackett, Corinna Lefkowitz, Juanita Huerta, Kristen Molmen, Eri Kanno, Matt Carney, Susan Huster, and Erin Wood.

A number of organizations provided funding for this research: the Lowie and Olson Endowments, Department of Anthropology, University of California, Berkeley; the

Stahl Endowment, Archaeological Research Facility, University of California, Berkeley; the Archaeological Division of the Geological Society of America; the International Association for Obsidian Studies; the Modoc National Forest Heritage Resource Management Research Support Fund; and the George Franklin Dales Foundation. Without their help, this dissertation would not have been possible.

Material, academic, and emotional support was also provided by the following individuals: Tom Origer, Marty Yamagiwa, Neneekah Forrest, Allison Sanger, Michelle Licha, Tim Teague, Junko Habu, Meg Conkey, Steve Silliman, Julie Donnelly-Nolan, Peter Primavera, and all the others who have put up with my questions during the course of this research.

Finally, I cannot forget the role of Jared Dillian in the completion of this work: for distracting the cat, paying the bills, and taking care of everything else. Thank you for helping me follow my dream.

CHAPTER 1

INTRODUCTION

Archaeological investigations of prehistoric quarries have come a long way from the early descriptive work of William Henry Holmes (1919). New methods and analytic techniques allow for the reconstruction, with greater degrees of certainty, of the production and exchange of lithic materials. New ways of analyzing and integrating lithic debitage in archaeological research have revealed even more information about the use and production of stone objects in the past. Yet despite these new archaeological tools, research questions have lagged behind available methods. Though there are notable exceptions, many archaeological studies of prehistoric quarries still focus on descriptive goals: documenting procurement and production, and tracing exchange (Ericson 1982: 129-148, Gilreath and Hildebrandt 1997, Sappington 1984: 23-34, Luedtke 1984: 65-76). Explanations for lithic resource exploitation and procurement often revolve around raw material suitability and distance to source. Yet this effectively denies the role of human action and belief in the selection of lithic materials. There is an outstanding need to go beyond these issues and consider both economic and non-economic factors in stone tool production. Quarries are potential sources of this kind of information. Innovative approaches to quarry analysis have been used to address questions of settlement patterns, territory, control of lithic resources, and ritual and meaning (Roth 1998, Tankersley 1995, Stothers 1996: 173-216, Torrence 1986, Spence et al. 1984: 97-106, Peterson et al. 1997: 231-259, Taçon 1991, McCoy 1999, Bettinger

1982: 103-128); and as will be demonstrated here, more of this kind of work can and should be done.

In this dissertation, I propose that the ceremonial and cultural value of a lithic material and the objects made from it cannot be separated from the cultures within which it was produced, used, and ultimately destroyed. I emphasize a shift from a focus on "here's-what-they-made and here's-where-it-came-from" to a more holistic view of how lithic materials connect people, cultures, and beliefs. Without this cultural context all that remains are analyses of things. In 1986 Robin Torrence wrote, "the weaknesses of quarry and mine studies have been directly caused by the overemphasis on description for its own sake", and I argue that this is still the case. Archaeologists must formulate questions that address the whole range of prehistoric cultural behavior, and quarry studies have been notably lacking in this regard. This dissertation is a first step in this direction, and will illustrate the breadth of knowledge obtainable through the study of prehistoric quarries.

RESEARCH PLAN

This research is a two-stage process. First, I document the prehistoric use of the Glass Mountain obsidian quarry. This archaeological fieldwork, performed as part of the Glass Mountain Archaeological Project (GMAP), includes a complete archaeological survey of the Glass Mountain obsidian flow and recording of archaeological sites. Surface sampling and in-situ analysis of quarry debitage provides data on the production techniques and final products produced at the quarry site. Finally, as part of the archaeological study, chemical characterization and obsidian hydration are used to document spatial and temporal patterns of obsidian utilization. In particular, X-ray fluorescence data compiled by Cultural Resource Management projects will be employed as a way to increase the sample size of analyzed material. These data are rarely synthesized on a regional level, and this project will demonstrate the utility of gray-literature data for broader research questions.

In the second stage of this research, I propose alternative questions for prehistoric lithic material sources. Rather than conclude this study with a summary of the findings at Glass Mountain and a description of where Glass Mountain obsidian appears in the archaeological record, my objective is to take this work a step further and attempt to construct prehistoric value and belief systems as they may apply to the utilization of lithic materials. I demonstrate that differential use of lithic materials in prehistory was linked not only to utilitarian factors such as raw material quality and proximity to source, but *also and even overwhelmingly* connected to cultural beliefs about the suitability of particular raw materials for specific types of objects.

GLASS MOUNTAIN

Glass Mountain is an ideal location for this type of study. It is a large, tool quality obsidian source located in the Medicine Lake Highland in Siskiyou County, California. The Glass Mountain eruption occurred approximately 900 years ago (Donnelly-Nolan et al. 1990: 19,693), and since that time, the obsidian was used almost exclusively for the production of large bifaces. Multiple lines of evidence can be used in support of this research, facilitating a very thorough investigation of all aspects of Glass Mountain obsidian use in prehistory. First, obsidian from Glass Mountain is chemically

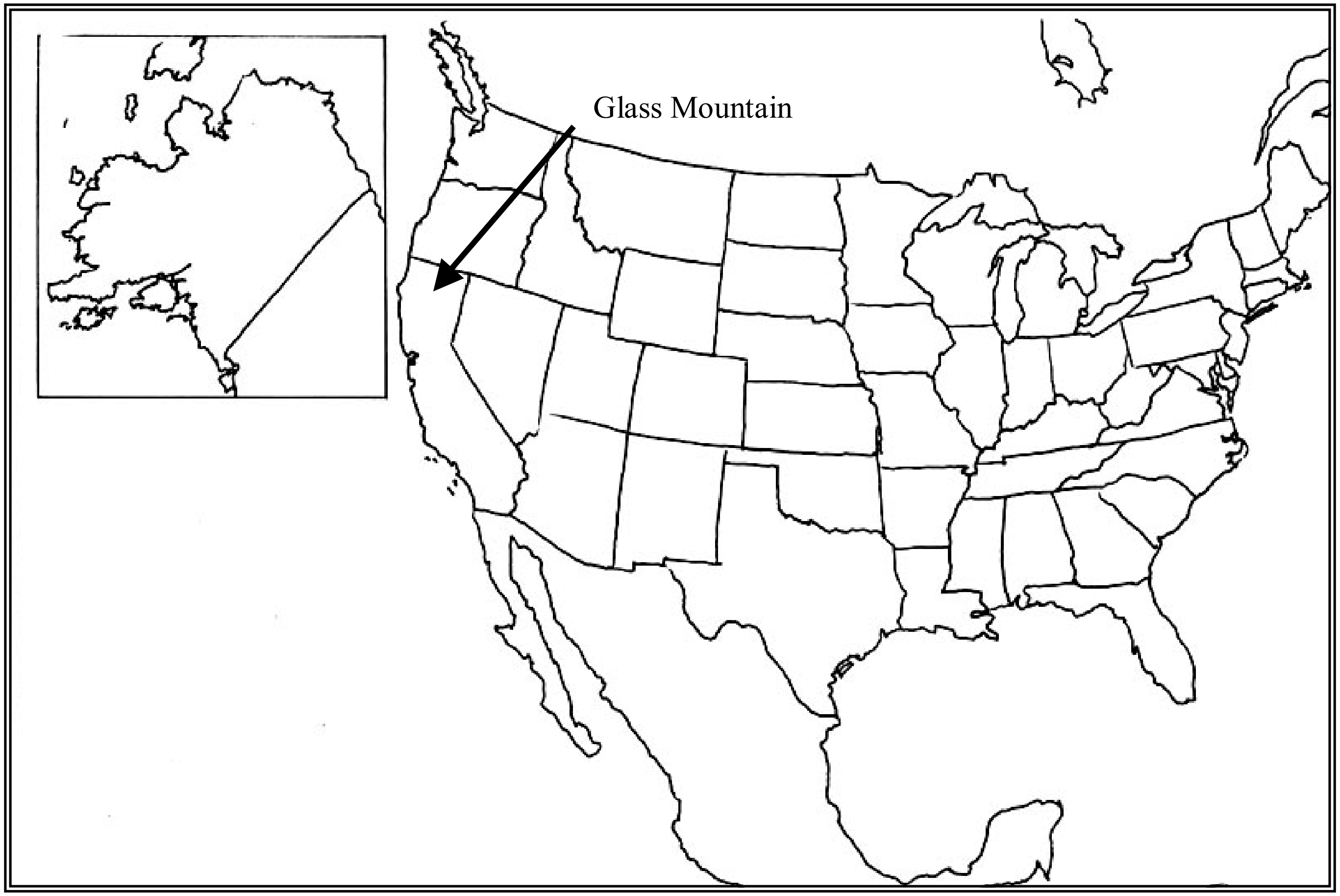


Figure 1.1: Glass Mountain location map.

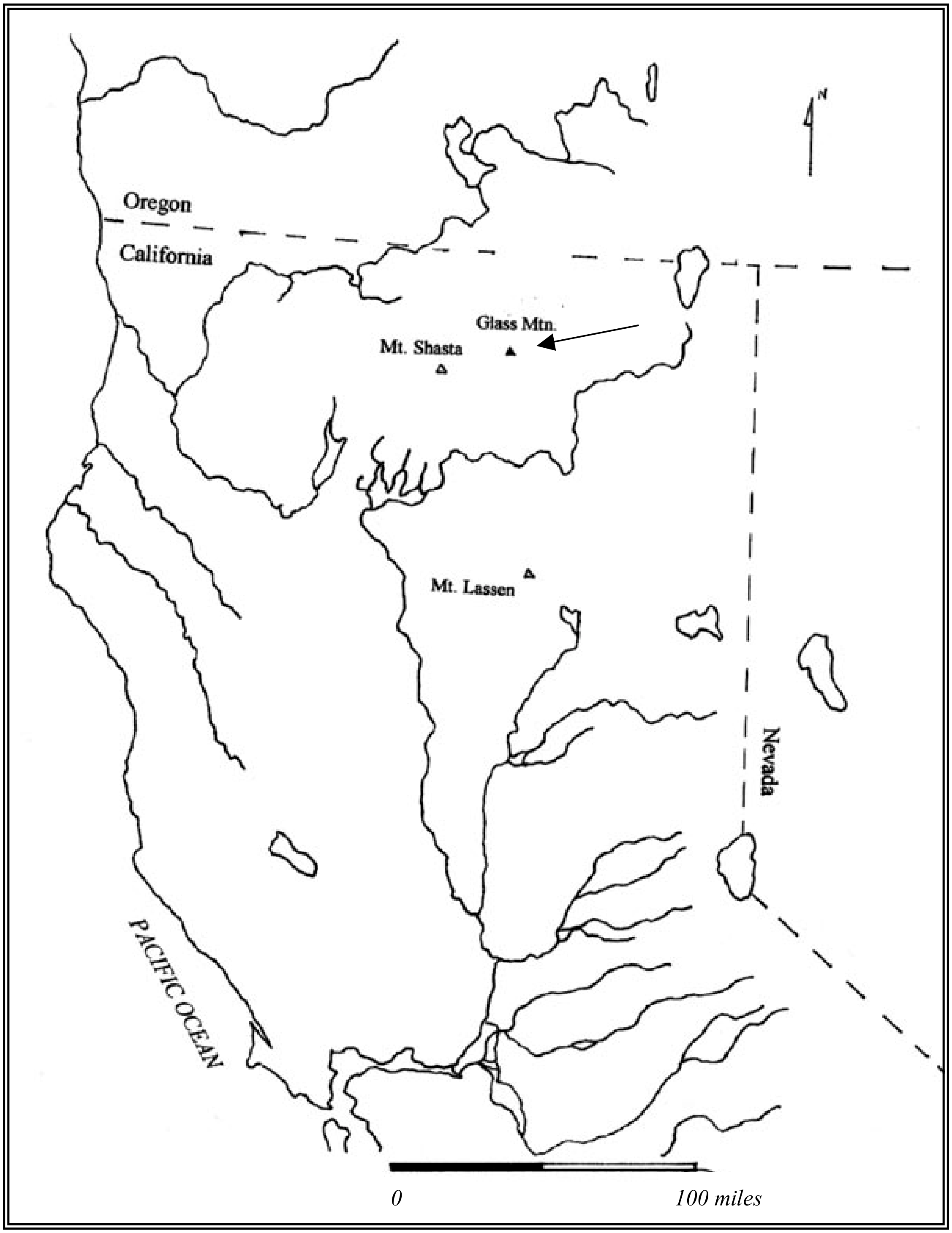


Figure 1.2: Glass Mountain Location Map, Northern California.

traceable using X-ray fluorescence, and is easily distinguishable from other obsidian sources in the region. A large database exists of prior X-ray fluorescence analyses of Medicine Lake Highland obsidian (Hughes 1986). Second, ethnographic data are available on large obsidian bifaces and their use in wealth and ceremonial contexts, due to extensive anthropological studies of northwestern California Native Americans (Kroeber 1925, 1957, Goldschmidt and Driver 1940, Rust 1905). Third, archaeological studies compiled from Cultural Resource Management projects provide extensive information on the patterns of obsidian use in the region and contribute additional X-ray fluorescence analyses. Widespread archaeological research along California's north coast has also resulted in published reports of large obsidian bifaces found in burial contexts from late prehistory (Hughes 1978, Loud 1918). Fourth, the Medicine Lake Highland volcano has been the subject of geologic research for many years, resulting in an in-depth understanding of the geologic processes involved in the formation of Glass Mountain (Donnelly-Nolan et al. 1990). Finally, Glass Mountain and the associated large obsidian bifaces are well known in the archaeological literature (Heflin 1982, Hughes 1978). Consequently, it serves as an ideal example for discussing one of the driving cultural forces behind raw material procurement and use.

INTEGRAL ISSUES IN LITHIC MATERIAL UTILIZATION

The unique patterns of lithic material utilization that will be demonstrated for Glass Mountain obsidian do not occur within a cultural vacuum. A variety of factors contribute to the transformation and translation of value and belief across cultural, temporal, and geographic boundaries. In northern California, exchange, territoriality, and culture contact all profoundly influenced the creation, transport, and continuation of value and value items in the past. Furthermore, the experiential element of recent geologic phenomena that created the Glass Mountain obsidian flow may have influenced the status of this obsidian source for prehistoric peoples. By designating the Glass Mountain quarry as a significant quarry, to be used exclusively for the manufacture of value objects, people actively created and reinforced a continuing belief system that upheld appropriate behaviors and uses for the Glass Mountain obsidian source. As such, the Glass Mountain source was imbued with a special status, which it bestowed on the objects created from this material. In this sense, the quarry was in itself also an active agent, which gave value to things.

The theoretical background for value, territoriality, exchange, and culture contact will be discussed in detail in the following chapters and is used to situate research methods within a specific theoretical context. Value, territoriality, exchange, and culture contact are all interrelated issues in the prehistoric exploitation of the Glass Mountain obsidian source.

Value:

The ways in which objects achieved value and status within prehistoric and modern societies were complex and inextricably interconnected. Multiple economic, social, and cultural factors played important roles in the mechanisms of value creation and maintenance. Furthermore, value was a variable, and in some cases tenuous, condition. What may have constituted value for one society, group, or individual, did not necessarily translate to value for other groups or individuals. In other words, value was not a universal concept or construct. How objects became valued and valuable therefore differed within and between cultures and groups. Objects necessarily reinvented their valued status in each new context throughout their use life and throughout the tenure of their remembrance.

In archaeology, artifacts made from exotic materials are often viewed as containing a great deal of value for the peoples who owned them. It is argued that since a large amount of labor and energy was expended to procure exotic objects, their value must certainly be extremely high. As a result, a strong correlation is assumed between distance to source and value (Hughes 1978, Renfrew 1984). However, the mechanisms through which objects gain reputations as status items are sometimes neglected in the study of the past.

Value is linked to a number of cultural and economic factors including, but certainly not limited to: the labor investment in an object (Marx 1867), desire (Simmel 1978), social context (Appadurai 1986), relationships between individuals (Munn 1986), and ceremony or ritual. Value objects also have important roles in status differentiation and social hierarchy. The social context of the circulation of valuables may help to define social standing and by extension, serve to illuminate the value of an object. Therefore, exchange plays an important part in the creation of value as well as in the creation of status. Through exchange, value is objectified and maintained, and value items gain a reputation, or pedigree, as they pass from person to person.

In this dissertation, I suggest means by which Glass Mountain obsidian and the objects made from it, gain value within the social and cultural contexts of late prehistory. This discussion is largely theoretical, but will hopefully offer some insight into value and value creation as it applies to obsidian objects. Specifically, this dissertation will examine how objects such as bifaces become valuable within a ceremonial and cultural context, and will ask why Glass Mountain was specially targeted for value objects.

Territoriality:

Making territoriality explicit in archaeology allows us to incorporate this aspect of the past into research questions and project design. One of the goals of this dissertation is to investigate how territories and territorial boundaries affected the procurement and exchange of obsidian and obsidian bifaces, and how this information may identify the prehistoric knappers who worked at Glass Mountain.

Hunter-gatherer territoriality in the anthropological literature is defined in two distinct, yet interrelated ways. It is a social relationship, defined as "the attempt by an individual or group to affect, influence, or control people, phenomena, and relationships, by delimiting and asserting control over a geographic area" (Sack 1986: 19). And it is an economic relationship, defined as a "cognitive and behaviorally flexible system which aims at optimizing the individual's and hence often also a group's access to temporarily or permanently localized resources, which satisfy either basic and universal or culture-specific needs and wants, or both, while simultaneously minimizing the probability of conflicts over them" (Casimir 1992: 20).

These are not mutually exclusive definitions of territoriality. As a social relationship, territoriality provides the infrastructure that may ensure access to localized resources. It is a cognitive construct that serves as a way to distinguish 'us' and 'them' (Dyson-Hudson and Smith 1978-21-41). In this way, territoriality defines a group and dictates who is entitled to the rights and privileges associated with group membership. The inverse of this statement is also true: territoriality defines who may be considered a foreigner, imposing restrictions on those who fall within this category.

This dissertation explores territoriality as a mechanism for controlling access to the Glass Mountain obsidian quarry, and as a form of spatial and social boundaries, which were crossed by exchange and interaction. Specifically, I address questions of who used Glass Mountain for biface production; how territorial behaviors restricted and controlled access to this raw material source; and how territoriality, as a means to control access to the Glass Mountain obsidian source, may have influenced the valued status of Glass Mountain obsidian.

Exchange:

Exchange served economic functions, but also occurred within a specific social and cultural context. As a result, investigations of prehistoric exchange networks must look at the big picture and move beyond merely tracing patterns of things across the landscape. Obsidian bifaces consistently represented value and status through exchange across cultural and geographic boundaries. Nevertheless, the value inherent in these obsidian objects varied in different contexts and different cultures. Bifaces may have been valuable as products from a culturally significant obsidian source, as large caches of raw material, as wealth, as exotic items, and as ceremonial objects. However, what is central to this argument is the position of obsidian bifaces as valued items across northern California. As such, they served as regionally valued objects, which were a uniting force through the contact and interaction resulting from exchange. Exchange linked northeastern California obsidian production to northwestern California obsidian consumption, yet the obsidian bifaces that were one subject of this exchange maintained a valued status across cultures and territorial boundaries. However, this is not to say that bifaces retained the same kind of value. Instead, obsidian biface value was transformed through interaction and exchange across diverse cultural and geographic settings.

Exchange commanded both economic and social roles within and between prehistoric societies. It was a form of resource redistribution (Torrence 1986), provided a buffer against resource fluctuations (Cohen 1981: 290, Arnold 1992: 77), introduced and circulated prestige items (Appadurai 1986, Hughes 1978: 53, Bennyhoff and Hughes 1987: 161, Munn 1986), created communication and information networks, and served as a social tie between spatially and culturally distant peoples (Sahlins 1972: 186).

In this dissertation, exchange is examined as the mechanism through which Glass Mountain obsidian bifaces were transported to the California coast. Specifically, I will discuss what form of biface exchange appears to be indicated by the archaeological patterning; how biface exchange was incorporated into the greater cultural and ideological realm surrounding the Glass Mountain quarry; and how biface exchange was integrated with other issues of territory, culture contact, and value.

Culture Contact:

Culture contact studies investigate the effects of contact between disparate groups of people, specifically emphasizing the biological, environmental, cultural, and demographic changes that occurred as direct or indirect effects of contact. In this dissertation, I look at the initial contact between Europeans and Native Americans in northern California, which spans the breach between historic and prehistoric periods.

Culture contact studies in North American archaeology utilize a variety of sources to reconstruct and interpret the changes and impacts of contact on both Native peoples and Europeans. Historic documentation such as explorers' journals, mission records, settlers' diaries, and other written documents provide part of the database for contact studies in northern California. However, other sources of information including oral histories, archaeology, linguistics, and ethnography also serve as valuable elements necessary for reconstructing the past.

Most importantly, the contact period in North America was a period of rapid change, both from a biological and a cultural standpoint. Archaeologists studying culture contact examine the impacts of disease (Dobyns 1983, Erlandson and Bartoy 1995, Johnson 1989, Lightfoot and Simmons 1998, Preston 1996, Walker and Johnson 1992), environmental changes (Allison 1994, Dobyns 1983, Eidsness 1988, Moratto 1973), and introduced European goods (Crosby 1972, Davis 1961) on Native American cultures as a way of determining the effects of contact and the types of adaptations that occurred during this dynamic period. Additionally, archaeologists and historians are beginning to investigate ways in which Native Americans resisted the effects of contact, often through warfare and raiding (Johnson 1998, Murray 1959, Cook 1976). Each of these issues will be discussed further within the context of the lifeways of Native Americans of northern California.

In this dissertation, I investigate the ways in which European and Anglo-American contact affected obsidian procurement at Glass Mountain and changes in the use of bifaces in northwestern California cultures. Several specific questions discussed in this dissertation include how contact changed obsidian procurement strategies in northern California and at Glass Mountain in particular; and how the role of bifaces in northwestern California cultures changed with contact.

ORGANIZATION

This dissertation is organized into four main sections: a review of prior Glass Mountain and obsidian biface research; a discussion of the theoretical context for the work conducted at Glass Mountain; an explanation of the methods employed and the results of this research; and the conclusions of this research with a discussion of Glass Mountain within the established theoretical and historical context. Each section is further divided into topically specific chapters.

Part 1: Review of Glass Mountain Literature

Chapter 2 consists of a review of significant quarry research in archaeology, with a particular emphasis on those studies that have attempted to address alternative questions regarding settlement patterns, territoriality, control of lithic resources, and ritual and meaning. In addition, this chapter contains a discussion of methodological approaches used for studying prehistoric quarries such as mass analysis, sampling, replication, refitting, and ethnographic analogy.

Chapter 3 provides a review of northern California obsidian bifaces, including a summary of ethnographic and archaeological research that has been conducted on these objects and their use. There appears little doubt that obsidian bifaces were value and status objects, and they have long been of interest to archaeologists, anthropologists, and antiquarians. Large bifaces were the main product of the Glass Mountain quarries and are central to the argument for a unique, value-laden status for the Glass Mountain obsidian source.

Chapter 4 is a synthesis of Glass Mountain geology, with a particular emphasis on the mechanisms of obsidian formation and eruption. This chapter is designed to provide a background for obsidian source characterization analyses, and also to illustrate the eruptive phenomena witnessed by northern California peoples 900 years ago. A large and explosive eruption could contribute to the special significance of the Glass Mountain obsidian source.

Part 2: Theoretical Context for Glass Mountain Research

Chapter 5 is a discussion of current theory dealing with value and value creation. Traditionally, archaeologists assume a strong correlation between distance to source and value. However, it is important to investigate alternative ways through which objects gain value, and the ways in which value is transformed as objects pass between individuals and groups. This chapter will investigate value within the context of lithic raw material sources and stone tool production, and includes both ethnographic and archaeological examples.

Chapter 6 outlines current theory on hunter-gatherer territoriality, with a particular emphasis on ethnographic and archaeological fingerprints of territorial behaviors. For the sake of this dissertation, territoriality was important in shaping exchange and interaction across and within geographic and social boundaries. The use of northern California obsidian will be further examined within this context.

Chapter 7 contains a discussion of exchange theory and research, with a goal towards understanding the mechanisms and function of prehistoric exchange. Broad theoretical and methodological approaches used in the study of prehistoric exchange are presented, including a discussion of economic and social models, for it is impossible to separate the economic from the social contexts for exchange. This chapter specifically aims to develop a theoretical base for the study of obsidian exchange in northern California.

Chapter 8 reviews culture contact research with a particular emphasis on northern California. I present a summary of the late prehistoric and early historic periods surrounding contact in this region, as a way to illustrate the changes that occurred during this time period. This section will examine the broad impacts of disease, environmental changes, and introduced European goods, which occurred as a result of contact.

Part 3: Methods and Results

Chapter 9 outlines the procedures and results of the Glass Mountain Archaeological Project. This fieldwork included extensive archaeological survey and sampling at Glass Mountain, and was designed to investigate quarrying and production behaviors with a goal of determining the types of objects produced at Glass Mountain and the knapping stages represented. Fieldwork for the Glass Mountain Archaeological Project was conducted with three main purposes in mind: first, to identify and record archaeological sites along the glass flow margins; second, to document lithic production or retooling at Glass Mountain; and third, to collect archaeological and geological samples for geochemical characterization and obsidian hydration dating.

Chapter 10 documents biface production at the Glass Mountain quarry. Production debitage at the Glass Mountain quarry, in combination with archaeological and ethnographic data from other parts of northern California were examined to look for a pattern of biface manufacture and specialized use. In order to more fully understand these mechanisms of procurement and production at Glass Mountain, the stages of biface manufacture present at the quarry were recorded and quantified for each reduction locus, and will be summarized in this chapter.

Chapter 11 is a discussion of the X-ray fluorescence analyses carried out on Glass Mountain geological samples and analyses from Cultural Resource Management projects conducted in northern California. Research investigating the chemical homogeneity of obsidian sources has revealed that individual flows within a single rhyolite dome sometimes possess trace element chemical differentiations vast enough to warrant false assignment to distant sources (Shackley 2000: 1-4, Tykot 1998: 67-82, Hughes 1994, Hughes and Smith 1993: 79-91). As a result, despite prior studies of the composition of the Glass Mountain obsidian source (Hughes 1986, Grove et al. 1997: 205-223), additional geologic specimens were collected for chemical characterization using X-ray fluorescence as part of the research conducted for this dissertation. X-ray fluorescence studies performed in conjunction with Cultural Resource Management projects in northern California have revealed an interesting pattern of Medicine Lake Highland obsidian procurement and use during late prehistoric times. This chapter will synthesize these findings, and explore the possible explanations for minimal Glass Mountain obsidian use in the past.

Chapter 12 presents the results of obsidian hydration analyses conducted on archaeological samples collected at the Glass Mountain quarry. Obsidian hydration offers one means for calculating chronological estimates in obsidian quarry situations such as that at Glass Mountain. Obsidian hydration directly dates an obsidian artifact, and therefore does not rely on stratigraphic association with other materials for chronologies. However, due to inherent problems with this technique, which will be discussed in further detail in Chapter 12, obsidian hydration is often not the preferred method for achieving temporal control. Despite this, because associated organic materials were not observed at Glass Mountain, and temporally diagnostic formed tools were not recovered, obsidian hydration provided the most appropriate available method to determine the time period when Glass Mountain sites were created.

Part 3: Conclusions and Discussion

Chapter 13 presents the conclusions of this research with a discussion of Glass Mountain within the context of the already established theoretical framework. Procurement and use of the Glass Mountain obsidian quarry was centrally situated within cultural and ideological systems of northern California. I summarize why the Glass Mountain obsidian quarry provides evidence for integration of prehistoric belief systems into toolstone procurement and use patterns, and the selective use of Glass Mountain obsidian for ceremonial and value objects.

Chapter 14 contains a brief suggestion for directions for future research in addressing the role of cultural and ideological systems in the prehistoric procurement and use of lithic raw material sources. Preconceived ideas about the utilitarian function of quarries in the past have blinded us to the cultural context of these important sites, future research integrating questions of individual and cultural belief provide a new line of inquiry for archaeological investigations of lithic material procurement and use.

CONCLUSION

As I will attempt to demonstrate in this dissertation, the root of differential use of the Glass Mountain obsidian quarry was situated in the associated cultural beliefs. The cultural context of Glass Mountain obsidian utilization varies across and within territorial and geographic boundaries, yet despite cultural differences, the concept of value is intricately linked with Glass Mountain obsidian and the large bifaces made from it. Prehistoric people actively created and reinforced a continuing ideology, which upheld appropriate behaviors and uses for the Glass Mountain obsidian source. As such, the Glass Mountain source was imbued with a special status, which it bestowed on the objects created from this material.

Descriptive studies of prehistoric quarries provide a useful background for further research into the role of quarry locales in past cultures. Yet the archaeological studies of lithic material procurement and use have traditionally focused on raw material quality and proximity to source as sole indicators for selection of particular materials for stone tool manufacture. As will be illustrated here, there is room for a new research focus, which will investigate the role of human actions and ideology in the choice of lithic materials.

CHAPTER 2

QUARRIES AND QUARRY RESEARCH

INTRODUCTION

Archaeological investigations of prehistoric quarries have traditionally emphasized analyses of lithic procurement and production techniques, and the ways in which these techniques intersect with subsistence rounds and exchange networks (Ericson 1982: 129-148, Gilreath and Hildebrandt 1997, Sappington 1984: 23-34, Luedtke 1984: 65-76). However, quarries have the potential to reveal much more about individual actions, cultures, beliefs, and economy. Alternative ways of looking at quarries have prompted the development of hypotheses about territory, resource control, and belief systems (Roth 1998, Tankersley 1995, Stothers 1996: 173-216, Torrence 1986, Spence et al. 1984: 97-106, Peterson et al. 1997: 231-259, Taçon 1991, McCoy 1999, Bettinger 1982: 103-128), which enhance our understanding of how these sites intersect with a larger cultural system.

This chapter presents a discussion of recent and significant research in archaeological quarry studies. Some of the topics commonly addressed through quarry analyses are detailed, such as procurement, production, and exchange. However, in my opinion, research incorporating questions such as territoriality, resource control, and belief systems offer a refreshing new way of studying prehistoric quarries. This chapter also provides a brief overview of methodological approaches such as mass analysis (Ahler 1989), sampling (Torrence 1986), replication (Bloomer 1991), refitting (Leach

1984), and ethnographic analogy (Binford and O'Connell 1984, Taçon 1991) used in the analysis of the Glass Mountain quarry.

PROCUREMENT

Studies of raw material procurement dominate much of the quarry literature, but should certainly not be considered the *only* subject relevant to quarry analysis. Procurement was integrated within a larger system of raw material exchange and production. It was balanced with other subsistence and settlement requirements, and thus was inextricably linked with the entire prehistoric system. Raw material was obtained either directly from the quarry site or indirectly through extensive exchange networks. In this section, procurement through quarrying and mining will be discussed, rather than procurement through exchange.

Both quarrying and mining technologies were used to obtain raw materials. In some ideal situations, tool-quality stone was picked up from the ground surface with little or no digging activity. Obsidian flows such as Newberry Crater in Oregon (Ozbun 1991) and Glass Mountain in California contained easily accessible, large blocks of material. These places are known as "quarries" and were "open sites where material was procured directly from outcrops located on the surface or from relatively shallow pits or trenches" (Torrence 1986: 165). Other sources required extensive tunneling and excavation for procurement (Gramly 1984, Shackley et al. 1996). These are called "mines" and were "sites where impressive shafts of up to ten meters deep were sunk in order to obtain high quality subsurface rocks" (Torrence 1986: 165).

At the Sta Nychia and Demenegaki quarries of Melos, Greece for example, tool-quality obsidian nodules were quarried from the surrounding geologic matrix through shallow hollows excavated in the rock outcrops (Torrence 1986: 172-176). In this instance, obsidian nodules were preferentially extracted from kaolinized rhyolite deposits, and to a lesser degree, lahars. Both soft matrices contained easily removable nodules and large unfractured cobbles of obsidian. Harder rhyolites/rhyodacites and calcareous ash were less popular sources of raw material. Digging into the softer deposits and pulling large nodules from the surrounding matrix created archaeologically visible, shallow pits and trenches. Quarrying in this example appeared to involve neither highly organized specialists, nor formalized mine construction.

In contrast, the obsidian mines of Pico de Orizaba in Veracruz, Mexico were highly organized, specialized operations (Stocker and Cobean 1984). Extensive tunnel systems measuring as long as 70 meters were recorded at Valle del Ixtetal, one of several obsidian sources at Pico de Orizaba. Wooden levers were used to follow natural fractures in the obsidian and remove large blocks, which were then manufactured into uniform blade cores. The sheer size of the obsidian mines at Valle del Ixtetal, the regular size and shape of blade cores and blade fragments, and its distribution across a wide geographic region, suggests standardization and centralized control of this raw material source (Stocker and Cobean 1984: 92-93).

Direct procurement also included recovery of lithic material from alluvial deposits. Alluvial sediments often required little or no digging, were rarely geographically centralized, and access was difficult, if not impossible, to control. This type of exploitation was a form of direct access to the source, yet the source does not represent the geologic genesis of the material. Instead secondary deposition by water and gravity moved and extended the potential procurement zone. For example, the primary Cow Canyon obsidian source located in eastern Arizona completely weathered away, so that marekenites of Cow Canyon obsidian were potentially collected from the area of the original outcrop into the Gila River system up to 100km away. Useable nodules from the Mule Creek obsidian source of western New Mexico also eroded over 100km into the Gila River (Shackley 1998b: 86-89, 1992: 315-326), and as a result, both types of obsidian were available across this 100km overlapping geographic region. Mule Creek and Cow Canyon obsidians were procured – or quarried – from any location where it occurred in the alluvium. As such, a quarry location does not necessarily have to be a single point in space, or a single geologic context. Secondary deposition is therefore an important consideration in the discussion of prehistoric procurement and exchange patterns (Shackley 1998b).

It is often assumed that procurement strategies concentrated on high-quality raw material, but such assumptions may be problematic. For example, at the site of Franchthi Cave in Greece, Upper Paleolithic consumers instead modified their stone tool technology to adapt to locally abundant, low-quality raw material. "The time saved in the acquisition of raw materials thus can be put forward as the determining factor of the whole strategy" (Perles 1993: 229). Only later in time did peoples of Franchthi Cave import exotic, high-quality raw materials such as obsidian.

In Eastern Europe on the Russian Plain, however, seasonal ranges of Upper Paleolithic Kostenki-Borschevo hunter-gatherers covered distances of 130 to 300km to include direct procurement of high-quality stone. Unlike the contemporaneous Upper

Paleolithic peoples of Franchthi Cave, cited above, the Kostenki-Borschevo hunter-gatherer lithic procurement and production strategy placed a higher value on quality raw material, enough to incorporate its long-distance acquisition into their seasonal subsistence rounds (Soffer 1991: 233).

Because quarrying was an extractive technology, assessing volumes of quarried material can be problematic. Non-quarry archaeological sites may also offer little quantitative data to answer questions of procurement amounts, since stone tools were often curated, retouched, and discarded elsewhere. To address this issue, Luedtke devised a formula for quantifying lithic demand and calculating the amount of raw material used from quarry sites in prehistory (1984: 65-76). The formula is a function of three aspects of lithic technology: the number and frequency of activities requiring stone tools, stone-tool-production techniques, and stone tool efficiency. "Demand will reflect technological complexity in part, and will also be influenced by the presence or absence of functional alternatives for stone" (Luedtke 1984: 66). The following formula calculates the amount of lithic material needed per household:

$$L=\sum_{i=1}^{n} T_i / D_i(S_i + M_i + R_i)$$

Where L is lithic demand, T_i is the number of times a stone tool-using task is performed during a single year, D_i is the discard rate of a tool, M_i is the amount of unused manufacturing debris produced in a year, S_i is the weight of the object at discard, and R_i is the amount of unused resharpening debris produced in a year. The following example illustrates how the formula works: "if the average scraper made in the hypothetical culture weighs 5g at the time of discard, has lost 0.5g through resharpening, and 'costs'

7g of waste flakes to produce, then S+M+R =12.5g. If 10 hides were processed at 2 hides per scraper then $T_i/D_i=5$. Therefore 62.5g of stone were required to produce the scrapers needed for deer hide processing in a single household" (1984:66). However, to complicate this model, the formula must be applied to all possible tasks and all stone tools used by a household within a year. The formula is designed to yield an estimate of the total required lithic material for a prehistoric household.

There are a great many problems unaddressed in this lithic demand formula, including a lack of consideration for individual variation in knapping ability, stone tools serving multiple functions, raw material availability, tool loss or breakage, and cultural norms of tool replacement and discard. Yet Leudtke concluded that "consideration of the factor of lithic demand can provide a useful means for understanding lithic procurement strategies, quarrying practices, and other aspects of prehistoric economic and social adaptations" (1984: 75), and that the formula has a demonstrated utility for prehistory.

The usefulness of this lithic demand formula is highly debatable, for the use of lithic materials is intricately linked to cultural norms, practices, traditions, and beliefs. A great deal of variation occurred in the way people procured, made, used, recycled, and discarded stone objects. Reducing lithic use to a simple formula ignores this variation. From a pragmatic viewpoint, when magnified by time and space, individual variation can result in altered lithic demand quantities measured in tons of raw material. But what is even more problematic about this formula is that it disregards the potential aspects of quarrying that are the most revealing about peoples in the past: traditions, beliefs, practices, and individual actions. These characteristics of prehistoric quarrying practices are at the crux of the research for this dissertation at Glass Mountain.

PRODUCTION

Production studies emphasize the types of objects manufactured and the associated behaviors and decision-making processes at prehistoric quarries. Production was closely tied to other issues such as procurement, exchange, technology, and social organization (Ericson 1984:3). It is commonly investigated through the analysis of debitage, and broken, discarded, and exhausted tools found at quarry sites. Production studies address questions about the kinds of objects made from a raw material, what behaviors these objects represent, and in what form the raw material was leaving the quarry location. Production thus is "the total of synchronous activities and locations involved in the utilization and modification of a single source-specific lithic material for stone-tool manufacture and use in a larger social system" (Ericson 1984: 3).

Sequential modeling is used to ascertain the stages of production in the manufacture of stone tools. These models deal with the human processes used to bring artifacts from the unmodified raw material through the production steps and into a useable form. Sequential models do not address taphonomic and post-depositional factors affecting artifacts after they have entered the archaeological record. Such models generally fall into two categories: linear models and branching models. Both deal with the human actions and decisions used in the sequential process of stone tool production. Chaîne opératoire, one of the more common sequential models of stone tool production (Bleed 2001: 101), is largely used for European assemblages and is rarely employed in its pristine form in North America, as a result, chaîne opératoire will not be discussed in detail in this dissertation.

Teleological models of production emphasize the results of the production process. These models are emic, in that they look at the internally determined actions that comprise the sequence of production stages. They are based on the idea that the stages of production lead to a predetermined goal (Bleed 2001: 121). As a result, teleological models of production are *linear models,* in that each stage is part of a set sequence that is performed in a specific order.

Evolutionary models of production emphasize the situational qualities of the steps in the production process. These models are etic, and describe the results produced by interactions between conditions and variables (Bleed 2001: 201). Evolutionary models of production are *branching models,* because each stage of production can have different outcomes based on the conditions or context of its manufacture and use.

Production research at Newberry Crater, Oregon is one example of production modeling at an obsidian quarry. Newberry Crater contains extensive obsidian flows, of which extremely large boulders of obsidian make up much of the available material. The volcano erupted numerous times over the past 700,000 years, but the Big Obsidian Flow is only approximately 1350 years old, limiting its use to late prehistoric times. This source was extensively used for large bifacial cores. Production at Newberry Crater was documented through debitage, biface fragments, and discarded tools on site. Newberry Crater obsidian was knapped into large bifaces at the flow, and then further reduced at outlying sites into useable tools and projectile points (Ozbun 1991: 149). The work at Newberry Crater also illustrates that the analysis of production is not an end unto itself. Instead, in this instance, an economic focus for demonstrated production methodologies was used to reveal the decision-making processes operating in prehistory.

> Large initial size is proposed as a planned design concept intended to compensate for expected use-life reductions in size through attrition, breakage, and rejuvenation processes. Since long use-life is a desired attribute of the technology, and since the users expect attrition and breakage to occur, it would not be surprising that they also would insure a longer functional utility through manufacture of larger artifacts (Ozbun 1991: 157).

Quarries are unique for their sheer mass of debitage and broken objects. Broken or discarded tools at quarry locales were less likely to be recycled, due to the plentiful raw material nearby. As a result, these sites provide insight into stages of production and knapping technologies, which may be otherwise difficult to discern from the finished and discarded object. However, this view of quarries may be misleading. "Items found at quarries are largely rejected items and unfinished pieces. Consequently, those assemblages present a quite biased impression of the quantity and kinds of items successfully produced and transported from an area" (Gilreath and Hildebrandt 1997: 20). Furthermore, production often occurred on a hierarchical level of reduction at sites far from the raw material source, and initial reduction at a quarry might not accurately represent the final product. Ericson calls this *sequential production* (1984: 4). Debitage analysis may offer a more accurate assessment of production at a quarry site. However, production must be studied within the context of a regional complex of sites and reduction locations.

Off-quarry sites can sometimes elucidate patterns not apparent at quarry locales. For example, the Rose Spring site in Inyo County, California contained deposits spanning the transition between dart and arrow point production. Yohe (1998) proposed that a decrease in large biface thinning flakes would represent an increase in arrow point production, since biface thinning flakes were easily manufactured into small projectile points. Dart points, alternatively, were largely a core technology, rather than a flake technology. Unfortunately, an expected decrease in large biface thinning flakes over time, as measured by stratigraphic positioning, was not apparent. Instead, it was proposed that prehistoric peoples may have been mining earlier deposits for biface thinning flakes as a raw material for arrow point manufacture (Yohe 1998: 49). By extension, it appeared that lithic quarries may show little evidence of the technological change to arrow point production. Specifically, these patterns of lithic consumption at non-quarry sites may, in some cases, reveal more about production methodologies and raw material utilization than do studies of production at quarry locales.

Production techniques and outcomes varied due to a whole range of cultural, social, political, economic, geographic, geological, and technological factors, so no single quarry analysis methodology can be applied universally. Instead, contextually situated analyses are necessary for a coherent and holistic view of prehistoric lithic production.

RESOURCE CONTROL AND RESTRICTED ACCESS

One innovative research question for quarry studies is that of resource control and restricted access to raw material sources. In the absence of restrictive structures such as walls, it is decidedly difficult to document how prehistoric peoples may have maintained control of a resource and prevented other groups from obtaining raw material (Torrence 1986: 169). A monopoly over raw materials potentially created advantages in commercial trade. However, the archaeological signature for resource control or restricted access may be undetectable, as walls or enclosures are not the only available method for limiting access to a resource. Interestingly, models of hunter-gatherer territoriality contribute alternatives to physical barriers as effective means for maintaining resource control and restricted access, and will be discussed further in chapter 6.

At the Melos quarries of Sta Nychia and Demenegaki, there were few, if any, restrictions on resource use or access, suggesting a lack of ownership or control by a single individual or group. A notable absence of any restrictive structures supports this assertion, however, as already mentioned, lack of built structures does not automatically imply free access. However, further evidence in the form of a remarkable variability in debitage and core preparation implies that knappers of varying skill maintained access to the quarries, and suggests minimal restrictions on quarry use (Torrence 1986: 170).

In contrast, evidence from obsidian workshops at Teotihuac·n appears to indicate that green obsidian sources *were* controlled by the state. Analysis of debitage at Teotihuac·n and geochemical studies of green obsidian distribution suggests that quarrying was conducted by either local specialists or state-organized mining expeditions, and the quarry region may have been under full control by the Teotihuacán state. Geochemical studies of green obsidian document distribution to workshops under state jurisdiction. All aspects of obsidian procurement and production were thus under centralized control, and only a restricted group of individuals were permitted to use and manufacture obsidian implements (Spence et al. 1984: 102).

However, restrictions on access do not necessarily require such formalized institutions. Models of perimeter defense and social boundary defense among hunter-gatherers illustrate mechanisms used to control access without state intervention or built structures.

Perimeter defense entailed marking the perimeter of the territory boundary and controlling access, and often occurred in areas of dense and predictable resources (Casimir 1992: 11). In this model, territories were relatively small and boundaries actively defended. However, communication and aggressive threats may have limited the instances in which conflict actually occurred, and non-aggressive means served to effectively maintain geographic boundaries (Wilmsen 1973: 5). Monitoring territory perimeters may have been the most costly aspect of boundary defense (Cashdan 1983: 49). Such territory control may leave few archaeological signatures, yet potentially limited access to quarries and lithic material sources.

Social boundary defense entailed defending the boundaries of the social group rather than the perimeter of the territory itself (Cashdan 1983: 49). In this model, groups maintained geographic boundaries by concocting elaborate greeting and trespass rules for outsiders who wished to enter a given territory, though territories were often large and difficult to defend. Instead, groups relied on communication, kin and trading networks, and reciprocal behavior to maintain territorial order. Societies that depended on social boundary defense may have granted outsiders permission to use local resources, but expected to receive the same type of leniency in the future when they trespass on another's property (Cashdan 1983: 49-50). Again, archaeological evidence of this type of territorial control would be very limited, but could have affected the procurement and exchange of lithic materials by increasing the number of groups that potentially had direct access to a specific quarry location.

Archaeological studies of prehistoric quarries have found evidence for state control and restrictions on access in some cases. However, except in rare instances, this can be notably difficult to document. Other types of territorial control, such as hunter-gatherer practices of boundary defense commonly left few traces, yet may have been much more common and have had significant effects on raw material procurement, use, and exchange.

RITUAL AND BELIEF SYSTEMS

Quarry studies are seriously lacking in analyses focused on ritual and belief systems in the past. These types of questions are largely ignored in favor of economic and production studies. However, a few archaeologists are presenting ideas which begin to address issues of ritual and meaning in the study of prehistoric quarries.

For example, the Mauna Kea adze quarry in Hawai'i (McCoy 1999: 11-34) contains several enclosures near the quarry that appear similar in style and structure to shrines constructed elsewhere in Hawai'i. A phenomenological perspective, ethnographic analogy, and archaeological data, were used to propose that these enclosures represented the location of initiation rites for apprentice adze makers.

> The lack of evidence for actual habitation suggested that they might have been 'occupied' in the process of undergoing ordeals typical of initiation rites and that the structures themselves may have symbolized birth and death (McCoy 1999: 28).

Crude adzes may indicate samples of work presented to the gods by apprentice adze makers. Such evidence of apprentice workers and ritualized process indicates a highly organized group of specialists responsible for adze production in Hawai'i, and also suggests a system of privileged access condoned by supernatural beings.

In a second example, Taçon (1991) looked at the meaning of stone tools in Arnhem Land, Australia. Relying extensively on ethnographic analogy, he suggested that stone sources contained significant power and meaning, and that this meaning influenced the decision to adopt particular sources of raw material for specific tasks.

> When a local stone source was found, it was often given heightened significance by associating it with powerful, dangerous forces. This not only helped control access to and use of the site, but also reinforced the power and prestige of both the managers of the quarry site and the owners of the tools made from it (Taçon 1991: 199).

Aboriginal peoples considered quartzite to be the petrified bones of Ancestral Beings, and for this reason quartzite was the preferred material for spear points. "By making tools from the petrified remains of these Ancestral Beings, especially powerful and effective pieces would result" (Taçon 1991: 205). Cultural meaning strongly influenced stone selection, though many places and chronological periods do not offer the same potential for ethnographic analogy as is possible in Australia. Such evidence mandates consideration of alternative reasons for the adoption and use of various materials in prehistory.

Cultural meaning is also apparent in toolstone selection in the preference for particular colors of raw material for specific objects, such as black and red obsidian bifaces, which will be covered in further detail later in this dissertation. A matched pair of black and red obsidian bifaces was a necessary part of the White Deerskin Dance (Goldschmidt and Driver 1940:109), and burial contexts also showed a preference for a pair of black and red bifaces. Red obsidian was obtained from distant sources in the Warner Mountains of eastern California, and black obsidian from sources such as Glass

Mountain (Hughes 1978). The cultural context dictated the raw material sources that were used for these specific ceremonial and value objects, and this idea will be discussed extensively throughout this dissertation.

At Gilman Falls in central Maine, value objects were quarried and manufactured. These objects were found in high-status burials, which date to between 6000 and 7500 BP. Groundstone rods were produced at this quarry, but the quarry was abandoned after 6000 BP, when groundstone rods ceased to be used in high-status burials (Sanger et al. 2001: 662). The cultural and ideological context during this time period prompted the quarrying and manufacture of these objects for specific uses, however, changes in the ideological system had ramifications for quarrying and groundstone production as seen archaeologically in the abandonment of the Gilman Falls quarry.

The economic focus of much of the quarry analysis performed today is limited by a narrow view of the role of stone tools in prehistoric life. Though not universally applicable, the examples cited here suggest that there are other questions archaeologists can ask of quarry material. "As researchers become frustrated by the limited amount of information obtained from typological and functional studies of lithics perhaps future work elsewhere should shift its focus more to the social, symbolic and aesthetic realms" (Taçon 1991: 206).

METHODOLOGY

A number of different techniques have been used to study quarries, including mass analysis (Ahler 1989), sampling (Torrence 1986), replication (Bloomer 1991), refitting (Leach 1984), and ethnographic analogy (Binford and O'Connell 1984, Taçon

1991). Elements of these techniques are all utilized in the research conducted at Glass Mountain, so the methods discussed here maintain a direct applicability to this dissertation. A complete discussion of how these methodologies are employed at Glass Mountain is provided later.

Because quarries contain such large amounts of lithic debitage, techniques employed in their analysis must deal with large sample sizes. Mass analysis is one way to analyze large numbers of lithic debitage with minimal time investment. In some situations, it may even be superior to the study of individual flakes for its ability to incorporate all flakes and debitage fragments, rather than only flakes with diagnostic attributes. In mass analysis, debitage fragments are sorted by size grades and counted, weighed, or examined within each size category. Useful measurements and counts obtained in mass analysis include distributions across size grades, expressed both by count and weight, mean flake weight within a size grade or grouped size grades, and the relative frequency of cortex on flakes in particular size classes (Ahler 1989: 112). Differences in sizes and characteristics of lithic debitage are related to stage of manufacture, and can be used in aggregate to assess reduction stages and flaking methodology. This technique is particularly applicable to quarry studies for its ability to handle large amounts of lithic debitage. Quarry locations usually contain a high number of large, cortical flakes, indicative of the primary stages of nodule reduction, however, mass analysis may reveal deviations from the expected pattern, which may correlate with specific technological processes used by prehistoric knappers. Mixed-component sites or repeated use of quarry locales can hinder the effectiveness of mass analysis in recognizing stages of manufacture and core reduction, because mass analysis is based on the calculation of proportions of particular quantities of flake types in the debitage assemblage. However, its utility in quarry situations is unsurpassed, and like all forms of debitage analysis, it must be employed with a thorough understanding of the archaeological context and taphonomic processes.

Sampling is also important in all types of quarry analyses for the same reason that mass analysis is particularly useful, namely that quarry sites contain huge quantities of lithic debitage. At Glass Mountain, for example, a random sampling methodology was employed for the analysis of surface debitage within reduction loci at sites along the base of the Glass Mountain Glass Flow. As will be discussed in more detail later, this probabilistic sampling strategy permitted the collection of statistically valid data without necessitating the analysis of tremendous numbers of artifacts. Due to the sheer mass of lithic debitage on quarry sites, sampling is essential to any quarry analysis. When using probabilistic sampling, it is necessary to gather enough material to be representative of the population, yet minimize collection so that analysis is not overwhelming.

Replication, in conjunction with the methods presented above, also offers a way to analyze quarry debitage. Replication studies have been used to model the debitage types expected from production of a specific tool types. In bifacial reduction experiments, debitage has been collected from the production of experimental bifaces and compared to debitage from archaeological sites, notably in the vicinity of the Tosawihi quarries in Nevada. Through these comparisons, evidence for the stages of production were defined based on debitage assemblages, and were also documented at archaeological sites. Researchers documented multiple stages of production, including initial biface reduction as well as heat treatment and final bifacial retouch (Bloomer

1991). Unfortunately, mixed archaeological assemblages can also complicate this type of analysis. However, replication experiments offer utility for revealing differences between the expected debitage and the archaeological data.

Lithic refits are yet another way to glean information from quarry debitage, though unfortunately refits are time consuming and often unproductive. However, when successful, refits contribute data on knapping techniques and final products made at a quarry. Most importantly however, are the flakes and cores that are not present on a site, for they may indicate pieces that were taken away or made into finished tools for consumption or trade. For example, Leach (1984) refit New Zealand blade knives and adzes to determine the technologies used to manufacture both artifact types, and found that the knapping procedures used to make blade knives and adzes were similar. It is suggested that the blade knife technology, which appears to be an earlier stone tool form, was "presumably in response to economic pressures, as yet not fully documented. It amounts to a local return to the ancient art of making blade artifacts using adze-production methods" (1984: 117). When successful, refitting can provide a great deal of information on production methodologies and final products, as illustrated in this example. However refitting can be difficult to impossible in areas of homogenous raw material, where color, texture, or cortex cannot serve as a guide.

Finally, ethnographic analogy can be useful as a way to understand how people might have made and used stone tools. In a classic example, Binford and O'Connell visited an Alyawara stone quarry in Australia to view the procurement, reduction, and shaping of cores, flakes and blades (1984: 406). Like replicative experiments, ethnographic analogy presents one way in which people made and used stone tools, and can be useful for forming and testing hypotheses. Unfortunately, as Binford and O'Connell acknowledge, "the traditional Alyawara technological system was extinct at the time of our observations" (1984: 428) so many of the techniques observed and recorded might not accurately reflect the way things were done in the past. Nevertheless, it offers new ideas and for the interpretation of archaeological assemblages.

As discussed in this section, a variety of techniques are appropriate for the study of lithic quarries, and there are certainly more than are presented here. Due to the large quantities of lithic debitage present on quarry sites, the most important aspect of these methodological approaches is how to wade through all the data to form some useful hypotheses and conclusions. Sampling and mass analysis are particularly helpful in this regard, and a combination of different methodologies can perhaps offer the most reasonable approach to quarry analysis. In this study, sampling, mass analysis, ethnographic analogy, and replication are all important elements.

CONCLUSION

The approaches and methodologies discussed in this chapter represent much of what are, in my opinion, some of the most relevant quarry research that has been done recently in archaeology. Aspects of each of these studies are incorporated in the work conducted for this dissertation at Glass Mountain. However, I also believe that it is the somewhat non-traditional quarry analyses that will set the stage for the future of quarry research, and that Glass Mountain will serve as an example. This is not to say that studies of production, procurement, and exchange will become obsolete, for these are still vital elements of any quarry research. Instead, I maintain that it is necessary to build on more traditional questions about quarry use, and then go one step beyond. Studies that incorporate elements of territoriality, resource control, and most importantly, belief systems, provide a new and exciting frontier in lithic studies, as illustrated in several of the examples cited in this chapter. This dissertation will stretch the limits of current quarry research, as I propose that raw material selection was linked not only to raw material availability and quality, but also overwhelmingly intertwined with prehistoric belief and value systems.

CHAPTER 3

BIFACES: BACKGROUND AND REVIEW OF PREVIOUS RESEARCH

INTRODUCTION

Large obsidian bifaces from ethnographic and archaeological contexts in northern California and coastal Oregon have long been objects of interest for archaeologists and antiquarians. Their unique beauty and superlative craftsmanship makes them a desirable commodity for museums and collectors. However, these objects are much more than merely beautiful things. Bifaces have and continue to serve essential functions in the ceremonial and wealth traditions of the northwest California coast. These artifacts are also important family heirlooms, whose ownership lineage is traceable far back into the past. Their value in a ceremonial, economic, and sentimental realm is undisputable. In order to understand the role of bifaces more fully, this chapter presents archaeological and ethnographic contexts for biface use in northwestern California.

The morphology of northern California ceremonial obsidian bifaces varies somewhat, perhaps as a result of raw material quality, nodule size, and knapping ability. Hughes notes that bifaces "varied markedly in length and shape, but were usually either bipointed or straight based" (1978: 53). Length was one reflection of value, and some biface specimens were up to thirty inches long. In fact, one historic specimen measured 48.5 inches (118 cm) in length (Heflin 1982: 124). Most of the obsidian bifaces recorded archaeologically and ethnographically are bipointed with parallel or slightly concave margins, otherwise known as "waisted" types (Heflin 1982: 126). However, some

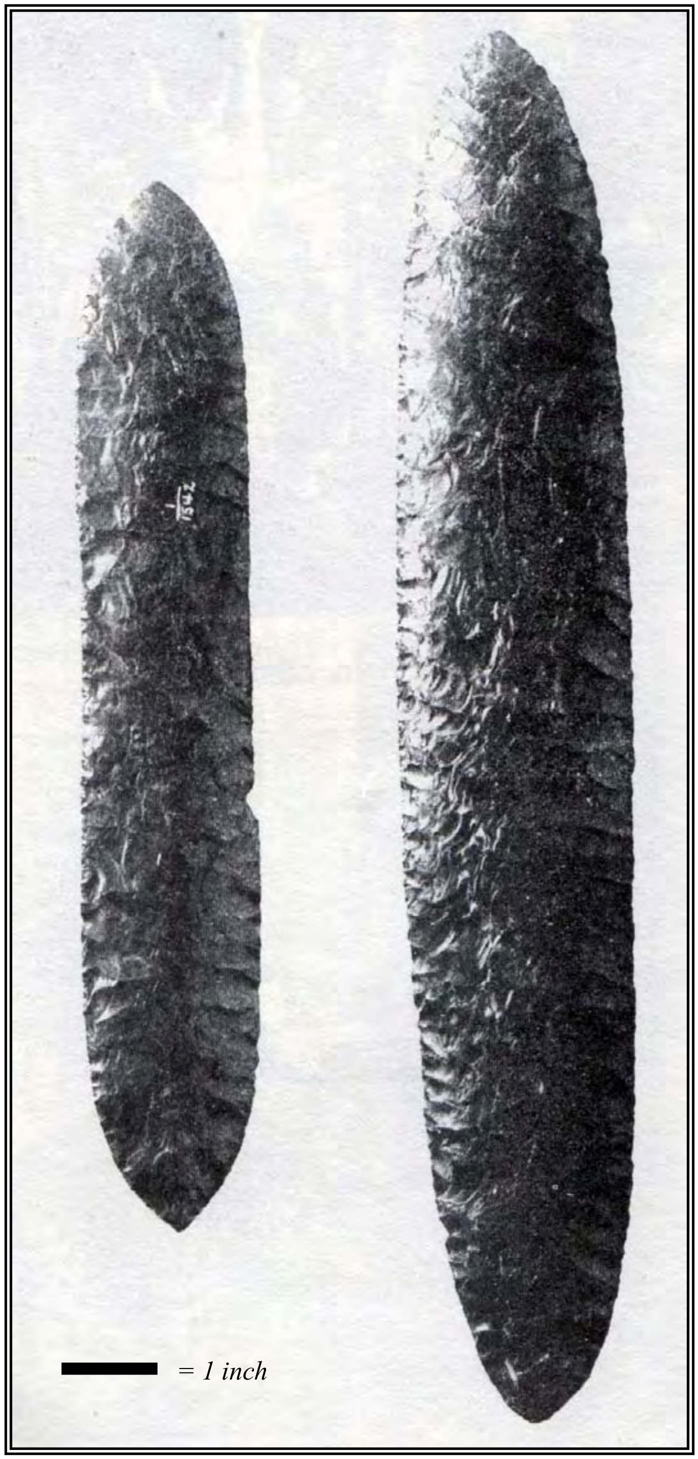


Figure 3.1: Bipointed Obsidian Bifaces (Kroeber 1925).

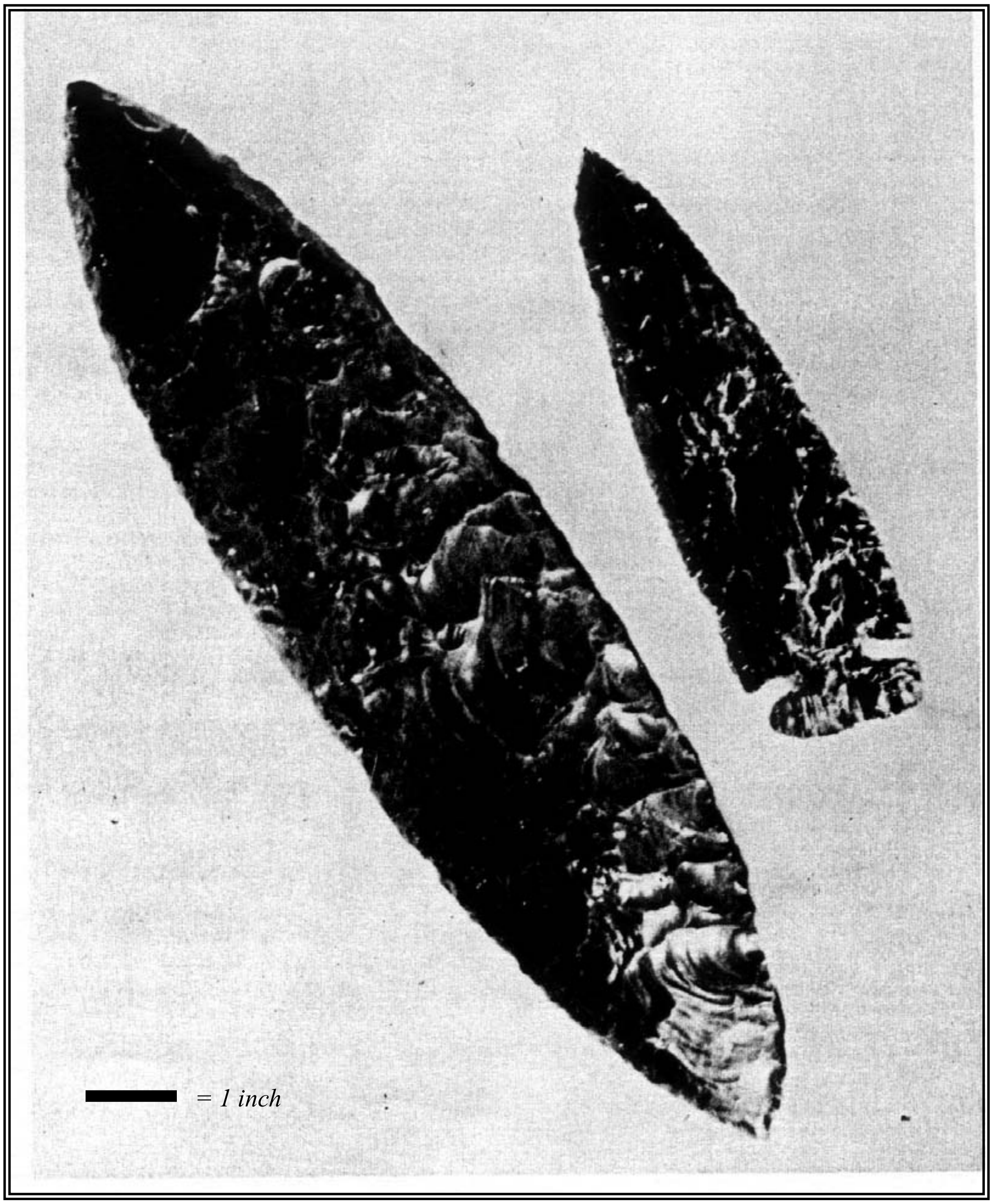


Figure 3.2: Bipointed and Straight Based Obsidian Bifaces (Heflin 1982).

straight-based bifaces have also been found, and probably represent regalia reserved for the Brush Dance (Rust 1905: 694).

Obsidian bifaces were traditionally part of a matched pair of one black and one red biface. Red obsidian was often mined from sources in the Warner Mountains of northeastern California, where nodules of red obsidian are large enough to be made into sizeable obsidian bifaces. Black obsidian was obtained from a variety of sources, including Glass Mountain, Glass Buttes, Vya, Spodue Mountain, and Silver Lake/Sycan Marsh, among others (Hughes 1990: 51). The presence of nodules large enough to be manufactured into ceremonial bifaces limited potential obsidian sources. Hughes suggests that increased distance to the obsidian source is also a factor in the inherent value of the biface (1978: 60), which will be discussed further in later chapters.

ETHNOGRAPHY

Ethnographically, anthropologists noted the use of obsidian bifaces among tribes of the northwestern California coast. Obsidian bifaces were recorded as important regalia displayed during the White Deerskin Dance among the Yurok, Hupa, Tolowa, and Karok. Additionally, ethnographic references mention the use of bifaces by the Shasta, Chimariko, Wiyot, and Wintu, though for these tribes, bifaces were not part of the White Deerskin Dance (Kroeber 1925).

The White Deerskin Dance was an opportunity for tribal members to display their wealth, including obsidian bifaces, white deerskins, and woodpecker scalps (Kroeber 1925: 54). However, this dance was more than just a chance to exhibit valuables, for it functioned as an important ceremony for world renewal and maintenance (Heflin 1982:

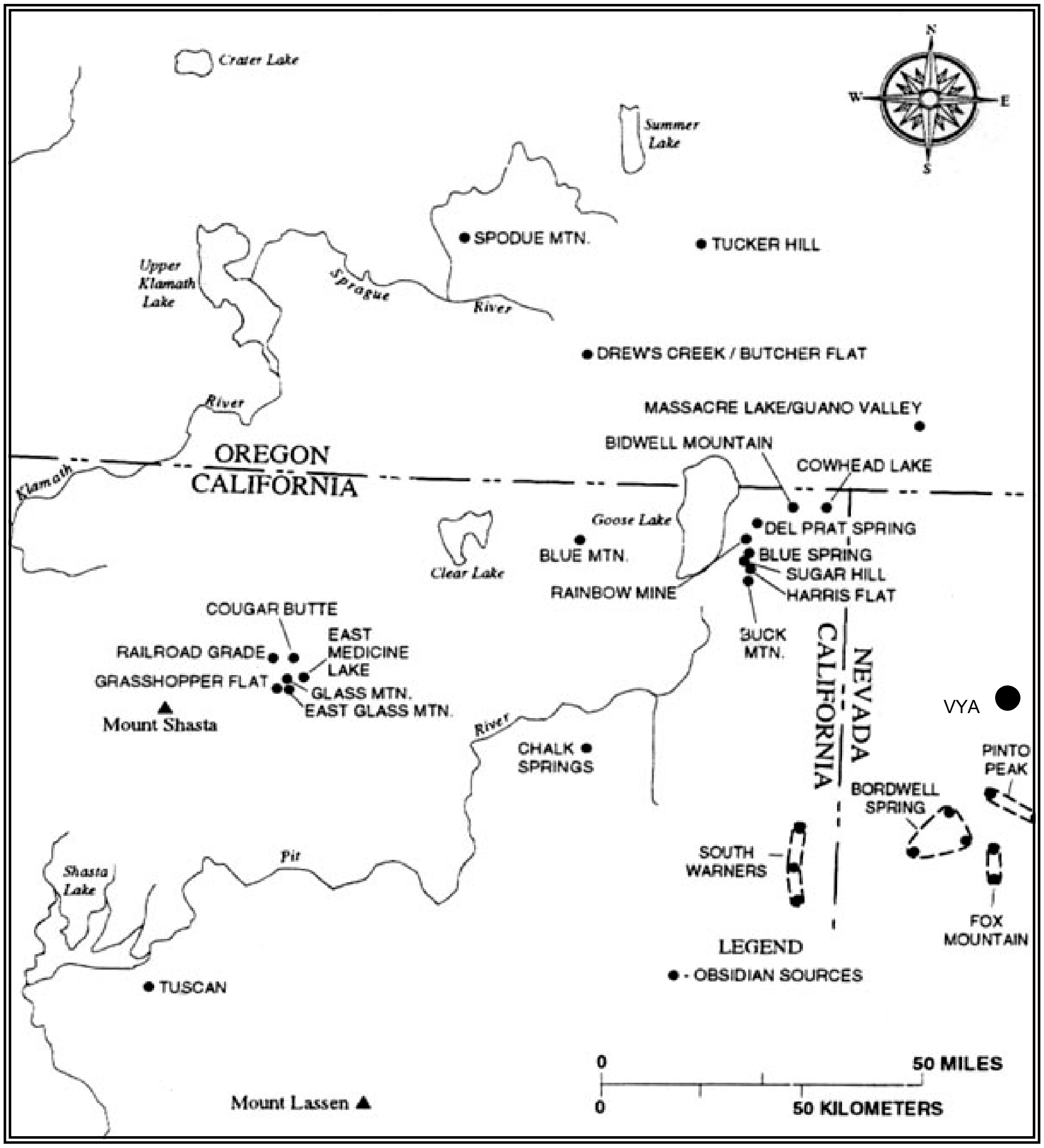


Figure 3.3: Northern California, Western Nevada, and Southern Oregon Obsidian Sources (Schalk 1995).

123). During the dance, bifaces were displayed by special “flint-carriers”, who held a matched pair of red and black obsidian bifaces. The bifaces were sometimes tied to the carrier’s wrist, to prevent them from falling and breaking if dropped. The flint-carriers danced back and forth in front of a line of men carrying white deerskins and held the matched bifaces out in front so as to be readily visible (Goldschmidt and Driver 1940: 109). Kroeber states that a main function of the dance was to serve as “the one occasion on which the wealthy can make public display of the property on which their position in the world depends; while the entertainment of visitors from far and near is a burden they are reluctant and yet proud to bear” (1925: 54). Indeed, this was important as a means to reinforce the social hierarchy of the tribe; however, the spiritual nature of the White Deerskin ceremony should not be neglected. It was part of a system of world renewal, and with the Jump Dance, was the most important dance for the cohesion and continuation of the community. Its purpose included reestablishment and firming of the earth, prevention of disease or disaster, and continuation of a way of life for another year (Kroeber 1957: 405).

Obsidian bifaces also played a lesser role in other dances and ceremonies such as the Brush Dance and were symbolically represented by flat pebbles in the Boat Dance (Goldschmidt and Driver 1940: 117). However, the obsidian bifaces used in these other dances sometimes varied from the large, elaborate objects exhibited during the White Deerskin Dance. Usually only the largest and most ostentatious obsidian bifaces were displayed during the White Deerskin Dance; smaller bifaces were reserved for other dances.

Figure 3.4: The White Deerskin Dance (Kroeber 1925).

In the Brush Dance, obsidian bifaces were hafted on long poles decorated with feathers and cloth. Smaller bifaces were not always bipointed, and in fact, often possessed squared bases (see figure 3.2), perhaps to facilitate hafting (Rust 1905: 694). In the Hupa Boat Dance, flat pebbles were picked up from the beach and displayed by the flint-carriers in an imitation of the White Deerskin Dance (Goldschmidt and Driver 1940:116). A similar dance has been described for the Yurok, in which a mock White Deerskin Dance was held upon completion of a fish weir. This dance also involved flint-carriers holding flat beach pebbles in imitation of the White Deerskin Dance (Kroeber 1925: 58).

According to Kroeber, dances served as an opportunity to display personal wealth and property:

> The dances are performed by two or more parties, which aim to outdo one another in the display of wealth. At a dance held at a certain village a certain man is usually recognized as the principal person or organizer of a party; but generally only a small part of the valuables displayed by his party are actually his property, the remainder being contributed by his wealthy friends living in other villages. In return, when a dance is held at a village where one of his friends is looked upon as the principal man of a dancing party, he is expected by the latter to bring or send his property, and failure to do so is deeply resented (Kroeber 1905: 691).

In this way, obsidian bifaces, and other wealth, created and maintained ties between individuals and communities. By establishing a sense of mutual obligation between powerful families, links were created which extended beyond constrained geographic areas. Such ties were probably not limited to exchange and loan of wealth, but also resulted in marriage partners, political alliances, and trade. Bifaces thus played an important role in maintaining regional networks and facilitating exchange.

Obsidian bifaces were treated with a great deal of care and caution. In many cases, they were wrapped with leather or redwood bark and cached away, either within the house or in a secret place outside. This behavior occasionally resulted in the loss of a biface. According to Rust, in one instance "the owner having died or forgotten where he hid an object, it was lost until chance brought it to light again. It was learned from one family that an obsidian blade belonging to them had in this way been lost beyond recovery" (1905: 688).

The monetary value of obsidian bifaces was also an important part of their function in northern California cultures. Obsidian bifaces have been documented as payment in bride price and dowries. In one example, a large obsidian was given as a dowry in the marriage of a Wiyot girl to a Yurok man. The young man's family paid "ten pairs of strings of shell money, a woodpecker headband of the highest value, and a red obsidian reaching up to the elbow" for her hand in marriage (Spott and Kroeber 1942: 210). In return, the girl's family gave a very large black obsidian biface, an object worth a great deal, but stipulated that it should remain in the family and be displayed in the White Deerskin Dance. This biface was passed down through several generations, and at the time of ethnographic research, remained with the descendants of the original couple (Spott and Kroeber 1942: 210). Loud states that marriage between the Yurok and Wiyot was known, but not common. "Intermarriage… was somewhat hindered by the social customs common to the northwest coast, which made one person belong to the wealthy aristocracy, and another to the poor class" (1918: 250). Ownership of an obsidian biface was one measure of the aristocracy, and Loud points out that "it will be readily understood that Yurok wives of the better class were entirely beyond the means of most

Figure 3.5: Ethnographic territories (after Kroeber 1925)

Wiyot men, and the Wiyot being poorer than the Yurok, the export of women was greater than the import" (1918: 250).

A second example of the exchange of obsidian bifaces as a monetary unit is a story regarding the payment of an obsidian biface as a fine for murder between the Hupa and a man from the village of Weitspus. This man killed a person from Hupa and was required to make payment of a large black obsidian biface in return for his misdeed. However, many years later, there was an incident in which a Hupa man accidentally shot a Weitspus woman. The Weitspus people demanded that the original black obsidian be returned to settle the crime, but it was believed to be missing and a different obsidian biface was accepted in payment (Spott and Kroeber 1942: 212).

These two examples illustrate how obsidian bifaces were used as a unit of money in the payment of dowry and bride price, and in the settlement of fines. Rust also presents a general value, in 1905 U.S. dollars, in which obsidian bifaces were generally valued at one dollar per inch. However, larger bifaces were worth much more: a twenty inch biface was worth at least fifty dollars, and bifaces in excess of this length probably would not be sold at any price (Rust 1905: 695).

Bifaces also were important heirlooms among northern California tribes, and still continue in this role today. As described in the example of the Wiyot obsidian dowry, obsidian bifaces were passed down within families, and often were immediately recognized, and to some degree claimed by members of the community (Rust 1905: 688). Kroeber suggests that "strictly the ownership of these blades is purely personal; but a certain claim of lien of persons possessing no title to them is recognized" (1905: 691). Rust and Kroeber both indicated that bifaces were generally not buried with the owner, but instead were passed down within the family as a way of transmitting wealth and rank to the next generation. Kroeber states,

> Like most of the more valuable property of these Indians, the obsidian blades are not destroyed at the owner's death or buried with him, but transmitted to the heirs. Social rank, which is dependent almost entirely on wealth, passes from father to son only if property is inherited (Kroeber 1905: 691).

However, this ethnographic data contradicts archaeological evidence in which obsidian bifaces were directly associated with funerary remains, and may be a result of the demographic and social upheaval associated with European contact.

Rust outlined one instance where a man was persuaded to sell an obsidian biface, but swore Rust to secrecy lest his reputation suffer. Rust tells the story thus: "one old Indian, living alone in abject poverty, exacted a promise that I would not tell his neighbors that I had bought his blade. He said: 'Now they call me rich. If they know I sell him, they say 'He poor Indian – no account.'' The promise was given and his reputation for wealth and honor saved" (1905: 689). The act of selling such a valuable heirloom would have tarnished the old man's standing in the community.

However, in another example, a man was not willing to sell the biface he inherited from his father, but sold the biface inherited through his wife's family instead. Rust states that "he showed me a fine blade and said: 'my father he big chief. He have this one; I no sell him. My wife her father he big chief too; she got him sword; I sell you hers.'" (1905: 689). Needless to say, neither Rust nor the seller bothered to ask his wife if she objected to the sale of her father's biface. Kroeber indicates elsewhere that wealth can indeed be the personal property of a woman and that "it is not uncommon that a woman personally inherits obsidian blades… her ownership seems to be clearly established" (1905: 692). Despite ethnographic evidence documenting ownership of obsidian bifaces by women, modern Yurok peoples strongly prohibit women from touching these artifacts (Yurok Nation NAGPRA Committee 1998: personal communication). There is little in the ethnographic writings suggesting that this restriction was enforced in the past; however, Kroeber and Rust do not go into detail regarding women handling obsidian bifaces.

Ethnographic evidence also indicates that obsidian bifaces were important trade items within northern California. Documented instances of obsidian exchange from northeastern California and southern Oregon are present in historical and ethnographic records. Goldschmidt and Driver note that for the Hupa, the obsidian used in bifaces for the White Deerskin Dance came from outside the region: "red obsidian that presumably comes from the south, and a black obsidian that comes from the Shasta region in northeastern California" (1940: 120). In this instance, they were probably referring to the Medicine Lake Highland or Glass Mountain as the source for black obsidian, based on this geographic description. Additionally, they state, "no Hupa remembers seeing any other Hupa make these flints, though some have seen a Karok man make them" (Goldschmidt and Driver 1940: 120). It is assumed from this statement that, at least in historic times, these artifacts were being exchanged as finished bifaces, rather than as nodules or preforms. Finally, Hughes quotes Voegelin as also saying that bifaces were manufactured by interior tribes, in this case the Eastern Shasta and the Karok, and traded to the west (Hughes 1978:54).

> There is abundant documentation for the Glass Mountain area (Medicine Lake Highland) of northeast California as the chief contributor of obsidian to groups of northwest California. The

> principal route seems to have been down the Klamath River, with the Shasta and Achumawi often mentioned as middlemen or direct suppliers; the Shasta appeared to have been pivotal to he northwest groups (Hupa, Karok, Yurok, Wiyot), while the Achumawi were central to the obsidian acquisitions of the Wintu, Maidu, Yana, and Atsugewi (Hughes 1978: 54).

Documentation of prehistoric and historic period exchange networks in northern California also indicated that northeastern California tribes were indeed instrumental in providing obsidian, both in nodule and finished form, to coastal peoples. The Achumawi and Shasta served as major suppliers of obsidian to others in northern California. In particular, exchange of finished obsidian bifaces from the Shasta, in north-central California, west to the Karok was documented (Davis 1961: 15).

Finally, Hughes notes that northeastern California has been recorded ethnographically as the main source of obsidian for the Tolowa. However, Glass Buttes in south-central Oregon was also a significant obsidian source in historic times. He quotes Gould as stating "Mr. Sam Lopez, aged seventy-nine, recalled how his father had been engaged in a regular overland trade for obsidian from the vicinity of Bend, Oregon. Much of this material was brought down the Klamath River, too, mainly by Hupa, Karok, and Yurok traders" (Gould 1966: 79 in Hughes 1978: 54).

ARCHAEOLOGY

Archaeological evidence of biface production and use in northern California and some areas of southwestern Oregon generally agree with the ethnographic documentation. However, there are several points of contention, and it has not been possible to mitigate these discrepancies. The most blatant disagreement between the archaeological and ethnographic records is the occurrence of bifaces in archaeological funerary contexts. Ethnographic data indicates that this should not occur, since bifaces were passed down in the family rather than remaining with the deceased. This contradiction will be discussed in further detail later in this dissertation. Archaeologically, obsidian bifaces conforming to the general size and shape discussed in the ethnographic records are found throughout northern California and in some sites along the western Oregon coast (Hughes 1990, 1978; Heflin 1982, Sampson 1985).

At CA-Hum-67, obsidian bifaces were found in direct association with human remains. The site was excavated in 1913 by Llewellyn Loud, and is located within the ethnographic territory of Wiyot peoples along the coast of northern California, near the present city of Eureka (Hughes 1978: 56). It contained twenty-two burials, with thirteen associated obsidian bifaces (Loud 1918: 357-358). Five black obsidian bifaces were found and ranged in length from 27.2 cm to 41.0 cm (Loud 1918: 357). All of the black obsidian bifaces were bipointed, and all were associated with burned human remains. Loud refers to these as cremations, but Hughes specifies that this actually represented grave-pit burning (1978: 56). Hughes geochemically characterized many of the obsidian bifaces recovered in Loud's excavations. The results for the black bifaces indicated that two were made of obsidian from the Medicine Lake Highland region, two of Vya obsidian, and one of Glass Buttes obsidian (1978: 58). In terms of distance, the obsidian sources are far from CA-Hum-67. Medicine Lake is the closest, at about 175 miles from the site, Glass Buttes is about 300 miles distant, and Vya is about 250 miles away (Hughes 1978: 60-61).

Loud also excavated eight red obsidian bifaces found in direct association with human remains. Hughes also geochemically characterized the red bifaces, and determined that all eight originated from the Warner Mountains, located 220 miles from the site (1978: 58). The bifaces range in length from 17.1 cm to 30.5 cm (Loud 1918: 358). All exhibited the same bipointed morphology as the black bifaces, though neither Loud nor Hughes discusses the presence or absence of paired specimens.

The bifaces from this site have not been dated directly using obsidian hydration. However, radiocarbon dates from a basal peat layer at the site yield a date of 1050±200 years B. P. (Hughes 1978: 56), which provides an earliest date for the site. Hughes further speculates that the burials themselves and the associated bifaces are approximately 600 years old based on stratigraphic associations.

Another site that contained obsidian bifaces is the Nightfire Island site, located in northcentral California, about five miles south of the Oregon border. This site contained fragments of five large obsidian bifaces. Two were of red obsidian, and three were of black obsidian. Unfortunately, not all were collected during excavation. Mr. C. B. Howe collected the three black bifaces, and their provenience is somewhat uncertain. Of the five bifaces, two exhibited distinctive signs of burning, including heat spalls and crazing (Sampson 1985: 357). This is interpreted as the association of the bifaces with cremations, or grave pit burning, similar to that seen on coastal sites (Sampson 1985: 357). This site is within the ethnographic territory of the Modoc, which is unique in that they were not known to have performed the White Deerskin Dance. Instead, the bifaces may have represented another form of wealth and prestige among the Modoc. The obsidian bifaces have been dated using obsidian hydration, and all date to the late prehistoric/early historic period (Sampson 1985: 112).

At the Karlo Site (Las-7), four large obsidian bifaces were recovered in direct association with cremation remains. Interestingly, Riddell speculates that these burials may represent shamans, since the Wadátkut Paiute burned malevolent shamans, but buried members of the general population (Riddell 1960: 29). This region was not known for a ceremonial or wealth complex like that of the California coast, and bifaces may have retained alternate meanings as shamanistic tools or exchange items.

Finally, several obsidian bifaces excavated at the Gold Hill Site in southwestern Oregon illustrate the wide geographic distribution of this artifact type. Twenty obsidian bifaces were recovered. These artifacts are identical to those from CA-Hum-67 and Nightfire Island. Similarly, eighteen of the twenty bifaces were found in direct association with human remains. Hughes geochemically characterized all the excavated bifaces and found that 30 percent were from Buck Mountain (Warner Mountains), 40 percent from Silver Lake/Sycan Marsh, 20 percent from Spodue Mountain, and one biface each from Glass Buttes, Horse Mountain, and Quartz Mountain (1990: 51). Additionally, the bifaces were either found in paired sets or as single specimens. According to ethnographic information, bifaces are part of a matched pair, which was documented in the archaeological record at Gold Hill.

The Gold Hill data, and statements by Kroeber (1920: 157) to the effect that a ceremonial complex similar to that of northwestern California may have existed in earlier prehistory further north, have prompted the hypothesis that the obsidian bifaces in southern Oregon may represent a somewhat older tradition than that found in northern

California. Dating the specimens from Gold Hill and northern California sites may shed some additional light on this issue. Evidence suggests that this socioceremonial sphere may have extended even further into the upper Willamette Valley, since one obsidian biface was recovered at the Fuller Mound on the Yamhill River, about 15 miles (25km) northwest of Salem. This biface was sourced to Silver Lake/Sycan Marsh in south-central Oregon (Hughes 1990: 55).

The archaeological evidence indicates that obsidian bifaces occur in similar contexts throughout northern California and southern Oregon. The bifaces that have been dated indicate that they are a relatively recent phenomenon, and bifaces were still in use in historic times, as wealth and an important part of ceremonies. It may be safe to assume that this is a late prehistoric ceremonial system, which perhaps may have older antecedents to the north (Hughes 1990: 55). Bifaces are generally associated with burials, and often with burned human remains. Interestingly, obsidian sources, particularly the obsidian sources preferred for ceremonial bifaces, were far from the archaeological sites where they have been found. Therefore it is important to consider the exchange networks that must have occurred prehistorically to transport obsidian long distances from interior sources to coastal sites.

The archaeological contexts in which obsidian bifaces have been found do not always agree with the ethnographic data. Ethnographic documentation strongly emphasizes the importance of obsidian bifaces as family heirlooms. In general, they were not mentioned as funerary items, though other wealth objects, such as dentalium shells, were discussed as important grave goods (Kroeber 1925:42). This contradiction between the archaeological and ethnographic evidence poses a problem for discussion of obsidian bifaces. Cressman recognized this problem in 1933. He suggested that burying obsidian bifaces with the deceased was perhaps an older practice. Later, due to influence by the "property-emphasis complex of British Columbia" (Hughes 1978:63), "property, instead of being something that might readily be buried with its owner, came to be a means of establishing status" (Cressman 1933:19).

Hughes proposes another hypothesis to explain the contradiction between archaeological and ethnographic evidence.

> It is also conceivable that social boundaries were beginning to consolidate in northern California and southwestern Oregon, resulting in restriction or attenuation of the flow of material through existing exchange networks. If this had been so, the cost of these items would have encouraged hoarding (Hughes 1978: 63).

Little evidence has been found to support or refute this statement, however, ethnographic documentation of extensive exchange networks indicates that at least during historic times, coastal tribes were able to obtain obsidian nodules and bifaces from interior groups (Davis 1961).

It is difficult to say why the pattern of burying bifaces ceased and they began to be passed down as heirlooms. Perhaps obsidian was in short supply. Or perhaps with the drastic population declines associated with white contact, group coherence was shattered and there was no guarantee that status of an ancestor would be remembered. If this were the case, it may have been beneficial for descendants to keep the bifaces, rather than bury them, as proof of the high status of their family line. This scenario will be discussed in further detail later within the context of the effects of culture contact on northern California peoples.

CONCLUSION

Kroeber states, "these obsidian blades of the Indians of northwestern California have been called, and in a measure are, sacred. Nevertheless, the term can be applied to them only qualifiedly. They are primarily objects of wealth" (1905: 695). He did not perceive the bifaces as possessing any sort of sacredness in and of themselves. He clarified that:

> Like the white deerskins and woodpecker-scalp ornaments, the obsidian blades are not used directly in connection with any of the sacred formulas around which the deeper religious life of these Indians clusters. There seems also to be very little and probably no sense of their being charms or objects with a fetish or medicine or animistic power (Kroeber 1905: 695).

Despite Kroeber's assessment to the contrary, modern Native American peoples feel very strongly about the ceremonial and sacred significance of obsidian bifaces. Yurok tribal members have emphasized that these items are vital to their ceremonial system, particularly as part of the White Deerskin Dance (Yurok Nation NAGPRA Committee 1998: personal communication).

These obsidian bifaces obviously held a special place in the wealth and ceremonial spheres of northern California societies. As will be discussed further in later chapters, Glass Mountain was one of the sources for black obsidian used in these bifaces, and archaeological reconnaissance reveals that the Glass Mountain source was used almost exclusively for their production. Bifaces maintained a special significance for northern California peoples, and the use of Glass Mountain obsidian for their manufacture was an important part of the inherent value of ceremonial bifaces.

CHAPTER 4

THE GEOLOGY OF GLASS MOUNTAIN OBSIDIAN

INTRODUCTION

Obsidian is a natural volcanic glass that was extensively utilized prehistorically and historically for the manufacture of flaked-stone tools. In areas where high quality obsidian was available, it was often the preferred prehistoric toolstone for its glassy texture and predictable flaking properties. It was so highly desired that in locales where obsidian was not a naturally occurring material, it was sometimes traded over hundreds of miles (Hatch et al. 1990: 461-479).

In the United States, obsidian is readily available throughout a large portion of the west, including California, Oregon, Nevada, New Mexico, Arizona, Alaska, Idaho, Wyoming, Colorado, and Utah (Hughes 1986, Shackley 1990). No obsidian sources have been found in the eastern U.S., nor will they, since this region lacks Cenozoic volcanism. Yet obsidian from Obsidian Cliff in Yellowstone has been recovered from Hopewell sites in Ohio, illustrating its far-reaching importance in prehistory (Hatch et al. 1990: 461-479).

Obsidian is a glass with the physical properties of a liquid in all respects except for the ability to flow easily (Cann 1983: 227). As a result, obsidian fractures conchoidally, making it an ideal material for stone tool manufacture. However, most obsidian is not of tool quality. Many flows contain phenocrysts, inclusions, or vesicles, which hinder conchoidal fracture. In addition, natural glass rapidly decomposes into perlite, so only relatively recent obsidian flows usually contain glassy nodules large enough for tool manufacture.

Obsidian forms in a variety of different colors, including black, red, gray, green, and brown. Translucency may vary from clear to opaque, and banded or “mossy” color arrangements are common. Differences in obsidian appearance can be attributed to diverse factors such as microlites, gas bubbles, chemical variation, oxidation, or incorporation of foreign material into still liquid lava. Color, in some cases, was an important factor in the selection and use of particular obsidian sources in prehistory (for an example, see Hughes 1978).

OBSIDIAN FORMATION

Obsidian is a natural volcanic glass, which commonly forms in two ways: first, it occurs when high silica lavas cool so rapidly that crystal formation is minimal or non-existent. Second, it can be the product of welding and compaction of silica-rich pumice and ash (Blatt and Tracy 1996: 29). In both scenarios, the original magma is rhyolitic in composition, containing concentrations of silica (SiO_2) as high as 70%-75% and aluminum (Al_2O_3) concentrations between 10%-15% (Glascock et al. 1998: 18). Rhyolite lava is extremely viscous, and as a result, obsidian flows generally appear as steep-sided domes. Other types of volcanic glass, which can form during rapid cooling of lower-silica basalt or andesite lavas are generally not of tool quality or workable size, and thus are outside the scope of this chapter.

When melted, the Earth’s mantle and much of the crust is basaltic in composition. Basaltic magma is relatively low in silica, so in order to erupt as rhyolitic lava some processes must take place to increase the silica composition of the magma. Rhyolitic lavas may be the result of a combination of two distinct processes, which will be discussed specifically with regards to Glass Mountain later in this section.

The first process, which can increase silica content in magma is fractional crystallization. Fractional crystallization is defined as "processes that produce modifications in the bulk chemical compositions of magmas through physical removal of early-crystallizing minerals. These processes thus provide a mechanism that allows magmas to evolve chemically from the eutectic or batch melt compositions" (Blatt and Tracy 1996: 119). Liquid magma is originally at equilibrium such that for a given temperature and pressure, minerals are dissolved within the melt and the liquid is saturated with these minerals. When the magma begins to rise within the crust and slowly starts decreasing in pressure and losing heat to the surrounding matrix, the minerals that were formerly in solution are no longer in equilibrium and begin to crystallize from the liquid. If the crystals are heavier than the parent magma, they will sink to the bottom of the chamber. Other minerals, such as plagioclase, which are less dense than basaltic melts, may float to the top of the magma chamber. Eventually, the magma will again reach equilibrium for a given temperature and pressure. However, temperature and pressure are continuously changing, and as a result the magma will continue to evolve until the temperature reaches the eutectic and the magma begins to solidify or the magma erupts, effectively halting the system. As magma crystallizes, the remaining liquid changes composition. It becomes richer in SiO_2, Na_2O, and K_2O, and poorer in MgO, FeO, and CaO (Blatt and Tracy 1996, DePaolo 2000: personal communication).

The second process, which can chemically change the composition of magma is contamination with or assimilation of surrounding rocks. Contamination in this context is defined as "modification of magmas through addition of extraneous material. The most commonly proposed mechanisms for contamination are the melting of wall rocks in situ or disaggregation and melting of wall rock xenoliths by ascending magma" (Blatt and Tracy 1996: 119). Thus addition of foreign material from the surrounding matrix can alter the chemical composition of basaltic (and other) magmas. Contamination generally occurs in situations where magma achieves a maximum of surface contact with surrounding rocks. As a result, low-viscosity basaltic magmas, which commonly travel through narrow cracks and dikes, may be more susceptible to contamination by surrounding rocks. High-viscosity rhyolitic magmas are more likely to pool into rounded magma chambers and have minimal surface contact and thus less contamination.

Contamination and assimilation occur in three main ways: chemical, physical, and thermal. In chemical contamination, compounds that are highly concentrated in the surrounding rock may dissipate or dissolve into magmas that have a lower concentration of these compounds. Chemical contamination can occur with or without complete melting of the surrounding matrix, since leaching is possible between solid rock and liquid magma at temperatures below that necessary for melting.

Physical contamination occurs through the assimilation and melting of xenoliths and mineral crystals. Sometimes this is evident in the retention of partially dissolved xenoliths in erupted lavas, or crystal growth surrounding a xenocryst core. Xenoliths may be dislodged due to thermal shock, which creates fissures along crystal boundaries, and then carried along with flow of magma. Eventually they may melt and become completely assimilated into the magma.

Thermal processes also facilitate contamination and assimilation in that higher temperature basaltic magmas are more conducive to assimilation than lower temperature rhyolitic magmas, due to the increased heat available for melting country rocks. An additional aspect of thermal processes however, is that heat given off through crystallization may play a role in increasing and maintaining high magma temperatures. And as a result, higher temperatures increase contamination and assimilation by raising magma temperatures high enough to melt wall rocks and xenoliths. However, it is speculated that this energy is more important in the composition of magmas while pooled in the magma chamber, rather than during transport to the chamber (Blatt and Tracy 1996: 134).

Once magma has achieved a rhyolitic composition, with increased concentrations of silica, it will behave differently than lower-silica magmas. Rhyolitic magma is highly viscous because it contains a three-dimensional network of silica (SiO_4) tetrahedra (Carmichael et al. 1974: 133). This polymerization of silica and oxygen makes the rhyolite very stiff, unlike lower-silica magmas, which contain much less cross-linking between silica tetrahedra, and as a result are much less viscous. The addition of dissolved water to a rhyolitic magma depolymerizes the silicate melt by adding a hydroxyl and breaking the oxygen links in the tetrahedra (Si-O-Si + H_2O forms 2Si-OH). Therefore, rhyolitic magmas that contain higher concentrations of water are much less viscous (Carmichael et al. 1974: 144).

The viscosity of rhyolitic lava is linked to its ability to form a glass, specifically obsidian. In order to grow crystals, the mineral particles must diffuse through the magma to the crystal surface. In high-viscosity magmas, diffusion rates are much lower, so crystals will grow more slowly. Rhyolitic melts that erupt and cool before crystals have time to form, result in an aphyric glass. Low-viscosity magmas form crystals more readily because particles diffuse through the liquid at a faster rate (Carmichael et al. 1974: 156). As a result, extremely rapid quenching is necessary to form a glass from basaltic or andesitic lavas, and these types of glasses are rarely found in large nodules.

GLASS MOUNTAIN

Glass Mountain represents the most recent eruption of the Medicine Lake volcano, a large shield volcano exhibiting seventeen different eruptive events throughout the Holocene (Donnelly-Nolan et al. 1990: 19,693). The Medicine Lake volcano is located at the eastern edge of the Cascade Range in northern California, and like other parts of the Cascades, remains seismically and volcanically active (USGS 2000). Glass Mountain sits along the eastern rim of the Medicine Lake caldera, and the obsidian flow extends down the steep eastern flank. The Glass Mountain eruption formed multiple rhyolite and rhyodacite domes on a fissure trending N30°W (Anderson 1933). Ten small domes extend to the north of the main flow, and one small dome lies to the south (Grove et al. 1997: 206). Tool-quality obsidian, largely free of phenocrysts and inclusions is available around much of the perimeter of the main flow, as well as on parts of the surface of the flow. Tool-quality obsidian is also available at many of the smaller domes. However, some domes and some parts of the main flow are dominated by lower-silica

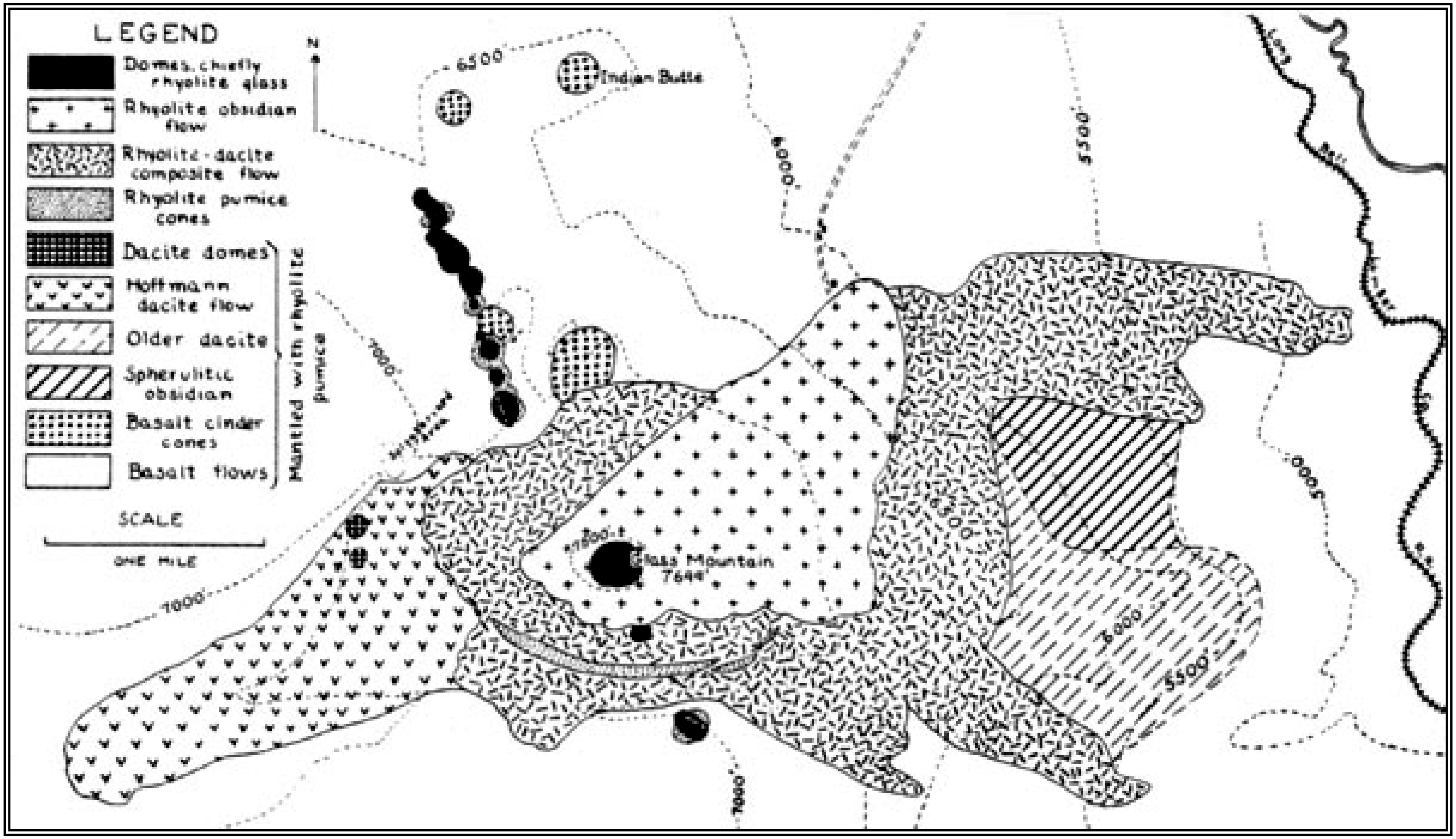


Figure 4.1: Geologic Map of Glass Mountain (Anderson 1933: 489).

Figure 4.2: Glass Mountain obsidian.

compositions, by inclusion-bearing or porphyritic glass, and by pumiceous or vesicular facies.

The Glass Mountain eruption formed two arms of an extensive dacite/rhyodacite flow and a massive, steep-sided obsidian flow at the higher elevations (Anderson 1933, Eichelberger 1981: 183). In addition, there are extensive pumice deposits associated with Glass Mountain, which may have preceded the lava flows by only a few hours or by as much as 150 years based on stratigraphic associations with other Medicine Lake Highland tephras (Donnelly-Nolan et al. 1990: 19,699, Chesterman 1955). These pumice deposits contain pronounced banding, indicating a vulcanian-type eruption (Anderson 1941: 375), which are traditionally characterized by "discrete explosions at intervals varying from minutes to hours, caused by repeated build-up of pressure beneath a plug" (Fisher and Schmincke 1984: 82). Also, Anderson observed that deposition of pumice is lightest southwest of Glass Mountain, probably indicating that the wind was blowing from that direction when it erupted (1941: 375).

Anderson argues that the eruptive sequence at Glass Mountain began when vents opened along a N30°W fissure and erupted pumiceous ejecta, which formed a heavy mantle over much of the surrounding area. Seven distinct pumice cones developed, including the largest, which was later obscured by Glass Mountain lava. In the small cones, extremely viscous domes of vesicular glass rose and apparently marked the end of eruptive activity for the smaller vents (Anderson 1933: 489-490).

At Glass Mountain proper, large quantities of dacite and rhyodacite flowed approximately three and one-half kilometers down the eastern slope of the Medicine Lake Highlands. The lava formed two arms, separated by an older complex of dacite and

Figure 4.3: Aerial Image of Glass Mountain Dome (USGS 2000).

rhyolite. Large volumes of rhyolite lava followed eruption of the dacite, forming the major northern tongue of obsidian. The eruption obscured a pre-existing pumice cone at Glass Mountain. Remnants are visible as linear zones of breccia, which support the only significant tree growth within the flow. Finally, a large dome of vesiculated rhyolite plugged the main vent and formed the rounded summit of Glass Mountain (Anderson 1933: 491-493).

The Glass Mountain eruption has been radiocarbon dated to 885 $\pm$ 40 years B.P. from a wood sample obtained from a dead cedar tree preserved in the distal margin of the dacite flow. This date may actually be several years too old, since some of the exterior of the tree was missing at the time when the sample was collected. An early date of 1050 B.P. is also available based on radiocarbon samples, paleomagnetic dates, and geomorphological data from tephra originating from Little Glass Mountain located eight miles to the west of Glass Mountain. Little Glass Mountain tephra directly underlies the Glass Mountain tephra (Donnelly-Nolan et al. 1990: 19,699).

Interestingly, Donnelly-Nolan et al. (1990: 19,700 from Finch 1928) recount a local rancher's allegations from 1910, which tell of earthquakes, flames, ground breakage, and 'blue mud' on vegetation at Glass Mountain. If true, such information would be valuable in understanding the continued volcanic activity of the Medicine Lake Highlands (Donnelly-Nolan 2001: personal communication), but geologic evidence of later eruptions at Glass Mountain has not been verified.

The formation processes for the rhyolitic magma of Glass Mountain are currently disputed, but popular models fall on a continuum of fractional crystallization of mafic magma on one extreme, to melting of granite crustal material on the other (Donnelly-

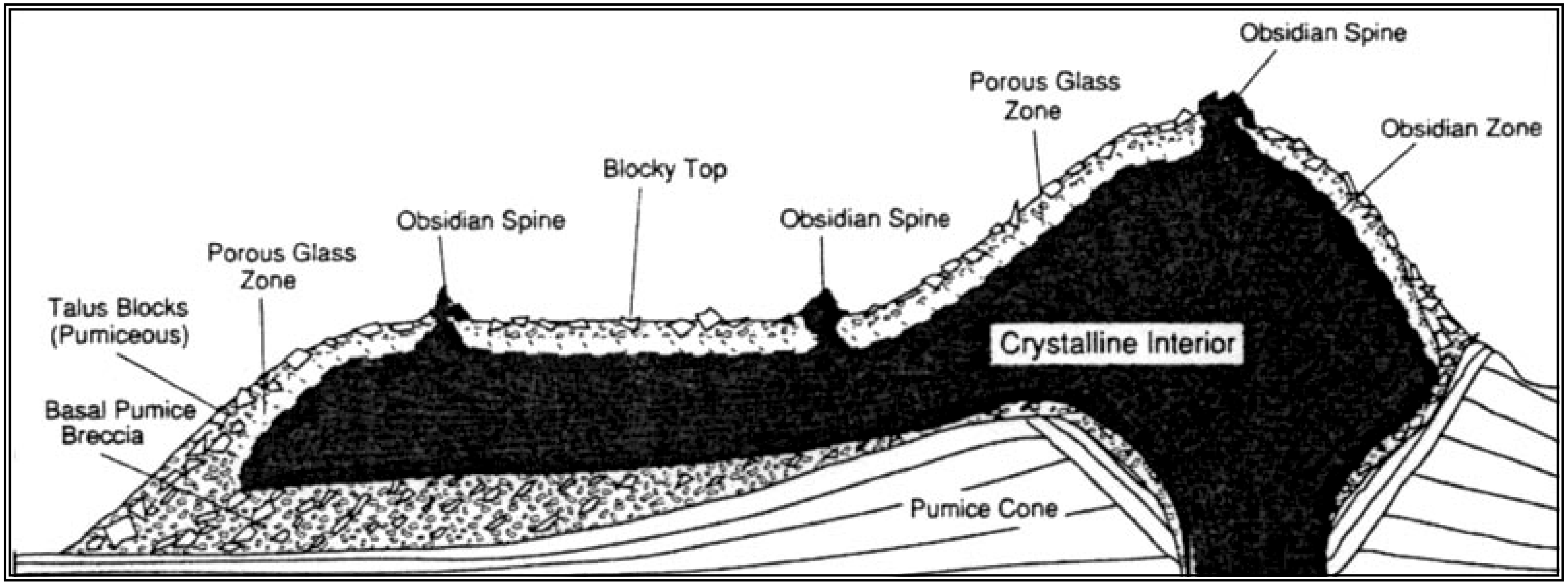


Figure 4.4: Cross-Section of Rhyolite Dome Containing Obsidian (Hughes and Smith 1993: 82).

Nolan 2001). Grove et al. (1997) argue for a model midway between the two extremes. They suggest that mafic melt under Glass Mountain underwent fractional crystallization, thus creating a differentiated high-silica melt. Meanwhile, heat from the original andesite magma caused melting of crustal granite. Both the differentiated melt and the granite floated to the top of the magma chamber forming a rhyolitic magma, while heavier mafic magma and crystallized minerals sank to the bottom. An injection of additional mafic andesite magma into the chamber increased pressure and ultimately led to the eruption of Glass Mountain. This model is based on extensive geochemical analyses and field observations of partially melted granite xenoliths embedded in Glass Mountain rhyolite and dacite.

Eichelberger (1981: 183-189) suggests instead that a rhyolitic magma chamber existed beneath Glass Mountain. Mafic magma was injected into the chamber and chilled quickly to form quenched inclusions within the low-temperature rhyolite. The combination of rapid cooling and decreased pressure caused water vapor to exsolve from the melt. This process created a mafic foam, which floated to the top of the chamber and carried a mixture of basaltic and rhyolitic magma with it. This foam and lava erupted from the chamber first, and was followed later by rhyolite. Eichelberger argues that the dense mafic magma that initiated the eruptive process would remain at the base of the magma chamber. He bases this model on the presence of vesiculation in mafic inclusions embedded in the rhyodacite lava at Glass Mountain. As a comparative example, he argues for a similar occurrence at Crater Lake prior to the explosive eruption of Mt. Mazama.

GLASS MOUNTAIN IN PREHISTORY

The experiential aspect of the Glass Mountain eruption of 885 B.P. merits consideration as an important element in the placement of this obsidian source in the world cosmology and belief systems of prehistoric peoples in northern California. The archaeological record of the region documents Native American habitation both before and after the Glass Mountain eruption (Baker et al. 1990, Bevill and Nilsson 1996, Busby et al. 1990, Delacorte et al. 1995, Gates 1991, Gates et al. 2000, Hughes 1986, McAlister 1988, Mikkelsen and Bryson 1997, Moratto 1995, Sampson 1985) indicating minimal population dislocation as a result of volcanic activity. Therefore, the assertion that ancestors of ethnographically documented Native American populations witnessed the Glass Mountain eruption bears some validity. Furthermore, a large pyroclastic eruption such as that which occurred at Glass Mountain was a rare and spectacular event, which directly influenced the ideological significance of Glass Mountain obsidian. Stories of the eruption of Little Glass Mountain, located approximately eight miles west of Glass Mountain, in 1050 B.P. may have already been part of the local oral histories, but it is highly unlikely that any individuals alive during the Glass Mountain eruption of 885 B.P. had witnessed such an event before.

Current knowledge of vulcanian-type eruptions permits the reconstruction of phenomenological events during the Glass Mountain eruption of 885 B.P. First and foremost, earthquakes of varying intensity may have preceded the eruption. Earthquakes may not have been new to inhabitants of the region, though they were probably rare enough to arouse some excitement. Then, days or weeks later, bursts of pumice and ash erupted from Glass Mountain, darkening the sky and raining down heavily to the northeast and east, including a large portion of ethnographically recorded Modoc territory (Kroeber 1925).

Following the pumice and ash fall, lava spewed forth from the main Glass Mountain vent and flowed down the eastern side of the Medicine Lake Highland. This initial lava flow cooled to form high silica dacite and rhyodacite, and thus as lava would have flowed very slowly. Fractures in the upper crust of the lava flow exposed molten material, which may have glowed a fiery-red. Meanwhile, sulfurous gasses and steam escaped through vents in the crust, creating an inhospitable environment and a turbulent atmosphere surrounding the volcano. Rapidly melting snow may also have contributed to a massive steam cloud. The eruption was accompanied by bursts of lightning over Glass Mountain and extensive burning of adjacent forests. People living in the region had to take shelter from falling ash, and the area may have experienced a perpetual darkness throughout the day. At night, if the air was clear, molten lava glowed atop Glass Mountain and would have been visible for many miles.

During the final stage of the Glass Mountain eruption, extremely viscous rhyolitic lava plugged many of the secondary vents, yet the primary central vent created a significant obsidian flow. Rhyolitic lava squeezed upwards from the central vent and slowly inched down the eastern slope of the Medicine Lake Highland. Because it was so viscous, the lava cooled into an extremely steep sided flow, with a central dome capping the top of the mountain. As the top of the flow cooled, it fractured into angular fragments while the interior of the lava flow continued to move. The lava cooled rapidly, preventing crystallization within the lava matrix, and formed a high-quality, glassy black, banded obsidian.

Glass Mountain remained hot and likely contained active fumaroles for centuries after the glass-forming eruption in 885 B.P. Therefore, access to the source could have been dangerous for many years. It is also possible to speculate that prehistoric peoples were hesitant to collect and use Glass Mountain obsidian soon after the eruption, even once the danger of heat, earthquakes, and poisonous gasses dissipated. People may have been fearful of this mountain, given the impact of its massive eruption, and avoided the source for several generations. Over time, however, fear may have given rise to reverence of Glass Mountain as a special place, ultimately culminating in its use for high value and ceremonial objects. The experiential aspect of the obsidian forming Glass Mountain eruption of 885 B.P. was an important element in the placement of this obsidian source in the world cosmology and belief systems of prehistoric peoples in northern California. The large pyroclastic eruption which occurred at Glass Mountain was a rare and spectacular event and directly influenced the ideological significance of Glass Mountain obsidian. Through traditions, oral histories, and legends, the Glass Mountain obsidian source maintained a reputation as a special source, and was used for ceremonial and high-value objects as a result. Furthermore, the use of Glass Mountain obsidian for special things served to reinforce the importance of this obsidian, creating a continuing cycle of ideology and value.

CHAPTER 5

VALUE AND VALUE CREATION

INTRODUCTION

There is little doubt, based on ethnographic and archaeological data, that large obsidian bifaces made at Glass Mountain were high-value objects (Hughes 1978, Kroeber 1905, 1957). However, in order to explore value in the archaeological record, an understanding of what makes an object valuable and how value objects interconnect with other aspects of culture, economy, and belief is necessary. This chapter presents a review of theoretical discussions of value and value transformation, and includes examples from archaeological and anthropological studies. In particular, the role of bifaces as value objects is presented within the context of theoretical discourse. Value is discussed from a number of perspectives, including the creation of value (Simmel 1978, Appadurai 1986, Munn 1986), the maintenance of value and status positions (Arnold 1991, Ames 1995), and the exchange of value and status objects (Sahlins 1972, Renfrew 1984, Weiner 1992). Obsidian bifaces from northern California were intertwined with issues of value, and may also represent a form of conspicuous consumption (Veblin 1899), as objects of display and as burial goods. Furthermore, Glass Mountain, as a preferred source for black obsidian bifaces, both contributed to and was enhanced by the valued status of these things.

THE CREATION OF VALUE

The ways in which objects achieved value and status within prehistoric and modern societies were complex and inextricably interconnected. Multiple economic, social, and cultural factors played important roles in the mechanisms of value creation and maintenance. Furthermore, value was a variable, and in some cases tenuous, condition. What may have constituted value for one society, group, or individual, did not necessarily translate to value for other groups or individuals. In other words, value was not a universal concept or construct. How objects became valued and valuable therefore differed within and between cultures and groups. Objects necessarily reinvented their valued status in each new context throughout their use life and throughout the tenure of their remembrance.

In archaeology, artifacts made from exotic materials are often viewed as containing a great deal of value for the peoples who owned them. It is argued that since a large amount of labor and effort was involved in procuring exotic objects, their value must certainly be extremely high. As a result, a strong correlation is assumed between distance to source and value (Hughes 1978, Renfrew 1984). However, the mechanisms through which objects gained reputations as status items are largely neglected in the study of the past. Anthropological and philosophical approaches, alternatively, offer insight into the process of value creation and provide a starting point for examining value in prehistory.

According to Marx, the value of an object is directly proportionate to the amount of labor invested in it, and this value is objectified through exchange (1867). Furthermore, objects also retain a use-value, which can be independent of the exchange value, and this use-value becomes apparent during use or consumption of an object. This may appear most applicable to studies of the production and consumption of commodities, although prehistoric artifacts such as bifaces, which can be traced geochemically over extensive distances and which contained a large labor investment in manufacture, may be classified as objects of superior value based on the labor involved.

Obsidian bifaces were very labor-intensive objects, particularly when transportation costs were taken into consideration. Highly skilled flintknappers traveled to the obsidian source to obtain raw material and then, at least in the case of Glass Mountain, remained at the quarry long enough to produce finished bifaces, which were either carried directly to the consumer, or exchanged through multiple middlemen to the California coast. It has been argued that obsidian objects made from sources at greater distances were more highly valued than those at closer proximity to the consumer, based solely on transportation costs as a form of labor (Hughes 1978). This may indeed have been one factor in the value of obsidian bifaces, yet was certainly not the only element in their valued status.

Simmel suggests that value is subjective. It is an individual's *desire* for a thing that gives it value, rather than something objective and inherent in the thing itself (1978: 59-66). He states:

> Value is only reinstated as contrast, as an object separated from the subject… the mere withholding of a desired object often endows it with a value quite disproportionate to any possible enjoyment that it could yield… value does not originate from the unbroken unity of the moment of enjoyment, but from the separation between the subject and the content of enjoyment as an object that stands opposed to the subject as something desired and only to be attained by the conquest of distance, obstacles and difficulties (1978: 66).

Simmel's explanation for value as the result of an individual's desire for an object is problematic. Desire implies that the object has a perceived value *prior* to an individual's wanting the thing. Whether this perceived value is due to economics or sentimentality is irrelevant. It begs the question: why would an individual want an object if that individual did not perceive the thing as holding value from the outset? Admittedly, this is a circular argument, for if desire creates value, value also creates desire.

Alternatively, Bataille views value objects as an expenditure of excess energy.

> The living organism, in a situation determined by the play of energy on the surface of the globe, ordinarily receives more energy than is necessary for maintaining life; the excess energy (wealth) can be used for the growth of a system (e. g., an organism); if the system can no longer grow, or if the excess cannot be completely absorbed in its growth, it must necessarily be lost without profit; it must be spent, willingly or not, gloriously or catastrophically (1967: 21).

Value objects represent this excess energy, since they are largely perceived as superfluous to the necessities required to sustain life. Such an argument is problematic. It implies that value objects only appear in situations where all needs are met, which may be a hazardous assumption. Value objects, as exchangeable things, may eventually be traded for necessities. Since no culture truly exists in isolation, it can only be assumed that value objects take on different roles and uses in different cultures. What may be one society's expenditure of excess energy may be another's exchange item for subsistence goods. As a form of social storage, valued objects may not be truly 'superfluous' at all.

Value is contingent on the surrounding social actions. Value "is general and relational, rather than particular and substantive. It involves a deeper dimension of cultural meaning implicated in the substantive value products and acts (and their various interrelationships with each other)" (Munn 1986: 9). In other words, it is the social interaction that creates value, rather than an objective element inherent in the object itself. This explanation of value as imbedded in the surrounding cultural context embraces many of the arguments for value creation that have been presented here. Value does not exist in a cultural vacuum. Objects gain value and value is remembered only within group or societal situations. It is relations between individuals, and between people and things, which helped create and maintain value in the interaction and the object itself

Value creation has been examined from a number of different, yet linked, directions. Value objects become valuable through their intrinsic labor in production and acquisition (Marx 1867), desire for the object (Simmel 1978: 66), the social context of an object's use or exchange (Munn 1986), or as a necessary expenditure of excess energy or wealth (Bataille 1967: 21). Yet these explanations are not independent. The ways in which objects achieved value and status within prehistoric and modern societies were complex and interconnected. Multiple economic, social, and cultural factors played important roles in the mechanisms of value creation and maintenance. Value was dependent on humans, their interactions with one another, and the interactions between people and things. The creation of value and valuables cannot be separated from people, their actions, and their beliefs.

VALUE AND STATUS

Value objects also maintained a role in the creation and maintenance of social hierarchy. In simplified terms, people used valuable objects to reinforce or enhance their position within society. Value objects were essential elements of status differentiation and social hierarchy. The social context of the circulation of valuables, whether through potlatching, gifting, or exchange, defined social standing and illuminated the value of an object. Exchange within the context of gifting created reciprocal obligation systems, which have continual feedback into a system of social hierarchy and status. Furthermore, manipulations of valuable production and exchange reinforced the emblematic function of these goods as status markers and wealth.

Gifting was one form of exchange and status maintenance. Mauss's classic work on the gift revolves around the central premise that any gift requires a counter-gift or service in return. This is epitomized by the Moari idea of the "hau". The hau, according to Mauss, is the spirit of the gift that requires a repayment in kind. He states, "what imposes obligation in the present received and exchanged, is the fact that the thing received is not inactive… In reality, it is the hau that wishes to return to its birthplace, to the sanctuary of the forest and the clan, and to the owner" (1950: 11-12). Sahlins however, criticizes Mauss's elementary view of the hau, emphasizing that hau also refers to the productive spirit of the forest. The hau is rather "that one man's gift should not be another man's capital, and therefore the fruits of a gift ought to be passed back to the original holder" (1972: 160). The hau dictates that the selfish withholding of goods is immoral.

Gifts were given and reciprocated within socially defined situations. For example, within the context of the kula, gifts were given and received in accordance with a regional etiquette system. Certain situations compelled the participant to give or receive gifts, thus starting the exchange cycle. Gifts also created indebtedness between the recipient and the giver. The quality and quantity of gifts received and reciprocated served to determine, and even define, the relationship between the two parties. "Hence the artifact is not simply a valuable object of exchange or even a gift that creates relations of one sort or another but also a crucial index of the extent to which those relations are sustained or disfigured" (Thomas 1991: 19).

The Northwest Coast potlatch was another form of valuable circulation and status maintenance that occurred within a defined social context. It was a system of gift exchange, but was intrinsically linked to individual and clan prestige. The potlatch was a mechanism for the consumption and destruction of goods, which temporarily bankrupted a chief economically, but bestowed great power and honor by obligating other chiefs to reciprocate in kind. The Northwest Coast environment was ideally suited to the accumulation of wealth through concentrated occurrences of resources. Elites often owned fishing locations and productive berry patches, which were exploited by the elite and their household or kin. Through household labor, it was possible for elites to amass great quantities of food and other goods, which were then converted into status through the potlatch. The potlatch transformed these goods into a form of social storage, and redistributed resources to other households and elites. Then, other elites were morally obligated to reciprocate with potlatches and massive distributions of their own goods (Ames 1995: 155-163). In this manner, valuables served to reinforce social status through circulation and display during the ostentatious destruction and distribution of wealth.

Trade feasts were a similar phenomenon, practiced by the Pomo of central California. These events served as a form of social storage, while simultaneously boosting individual and community status. Generally, villages with temporary abundance invited other communities to participate in a large feast. Visitors often brought shell beads, as gifts for the host community, and were given food goods to take home. Hosting a feast bestowed prestige and provided insurance against future shortages. Contributing to the feast was rewarded in the form of wealth objects such as beads. This event not only was a means to increase status and get wealth objects, but also geographically and temporally redistributed resources to insure against temporary food shortages (Vayda 1967: 498-500).

Another example of value items in status maintenance was the production and exchange of shell beads among the Chumash of California. Beads were included in high status burials and were exchanged throughout the state (Bennyhoff and Hughes 1987: 79-175). Arnold argues that the exchange of shell beads was controlled by Chumash elites (1991), and this may have limited the accessibility of these objects to elites and the upper class. Control over production inflated the value of specific prestige items, for if "the production of wealth is partly or entirely in the hands of attached specialists; wealth is specifically an elite good and its circulation is restricted" (Brumfiel and Earle 1987: 7). Furthermore, elite control over the exchange and consumption of shell beads reinforced the role of beads as status markers. Elites used their control over valuable production to maintain their position as important members of the society.

The skills and abilities needed to produce wealth objects were also a form of cultural capital, which may have been exploited for power and prestige. In the Classic Maya, the creation of fine craft products had significant ideological meanings. The presentation and distribution of wealth objects was a way of gaining and maintaining power and prestige, and the act of making them was directly related to status (Inomata 2001: 333).

Obsidian, as a geographically limited resource, was used in the Early Classic Period Hohokam platform mound site of Marana to legitimize elite status within the context of ceremonial events and chiefly redistribution. Archaeologically, obsidian at Marana was found in the households of all socioeconomic classes, suggesting egalitarian access. Obsidian projectile points showed no sign of use, and may have served as ceremonial objects, based on archaeological and ethnographic evidence. Elites sponsored ceremonial events and used the opportunity for obsidian redistribution to enhance status. In this instance, “display and socially circumscribed consumption of selected resources reinforced and legitimized elite status” (Bayman 1995: 40).

Among the coastal peoples of northern California, obsidian bifaces were the mark of a wealthy individual, and were brought out and displayed during ceremonies such as the White Deerskin Dance (Kroeber 1905: 695). Unlike the potlatch, objects were not given away or destroyed. These ceremonies were an important aspect of the maintenance and creation of status, and the possession of valuables served to unite elites as sponsors of these events. Elite individuals funded and supported dances, such as the White Deerskin Dance, and took on the role of community benefactor. These dances were not only a chance to display personal wealth, but also opportunities to indulge in an informal competition for status and prestige. However, it was rare that elites possessed the quantity of valued objects, such as deerskins, woodpecker scalps, and obsidian bifaces that were necessary for a truly spectacular event. As a result, wealthy individuals from other communities loaned their valued property for display during the dance. This not only united the elite from different communities, but also served to create an obligation relationship between wealthy individuals. When dances were held at other communities, elites who had received loaned value objects sent their own wealth in return. Failure to reciprocate was greatly resented, and resulted in a loss of status and honor (Kroeber 1905: 691). In this way, obsidian bifaces, and other wealth, served to create and maintain ties between individuals and communities. In establishing a sense of mutual obligation between powerful families, links were created which extended beyond constrained geographic areas. Additionally, one can assume that such ties were not limited to the exchange and loan of wealth, but perhaps also resulted in marriage partners, political alliances, and trade.

Valuables strongly influenced and enhanced status differentiation. Elites reinforced their position as wealthy members of society through the exchange, display, and control of value items. Gifting and potlatching obligated recipients to respond in kind, thus establishing indebtedness and creating a power relationship, which could then be exploited by the giver. Access to high status goods was limited by social and economic restrictions, suggesting that valuables defined an upper class, since only qualified individuals were permitted to obtain them.

EXCHANGE

Exchange and value are forever entangled. Valuables were important variables underlying the creation of status and prestige. Furthermore, the exchange of specific things within a particular social and cultural context also created additional value for the objects. In this way, exchange and value were mutually dependant and inextricably linked. Value of a thing was objectified and enhanced through exchange, while valuables further transformed the prestige and status of the actors involved.

Value was created and transformed by social context, but exchange also played a role in the value of an item. Exchange served to commodify an object, in that once exchanged, the object's value can be correlated with that for which it was traded. According to Marx "it is only by being exchanged that the products of labor acquire a socially uniform objectivity as values" (1867). Simmel echoes this by saying that "there is a reciprocal determination of value by the objects. By being exchanged, each object acquires a practical realization and measure of its value through the other object" (1978: 78). Exchange was the method through which consumers overcome the *subjective* and personal value of an object and created an *objective* and social value.

Exchange was obviously connected with the social and cultural context. Without the social element, exchange could not and would not exist. Furthermore, exchange was both constrained by and channeled through social, cultural, and political means. Exchange could be restricted or encouraged through social relations. "Politics (in the broad sense of relations, assumptions, and contests pertaining to power) is what links value and exchange in the social life of commodities" (Appadurai 1986: 57). Exchange connected individuals and groups, but restrictions on exchange also enhanced status and created prestige items. However, the "exchangeability" of those objects was what defined value within the social context.

Exchange objectified the value of a thing, and individuals and groups manipulated this in various ways in an effort to increase social status. Weiner (1992) introduced the idea of the inalienable possession, an object that one wishes to keep for its personal and economic significance, yet which often must be given away or exchanged as dictated by cultural etiquette. The memory of ownership of such an object succeeded the owner through time, even if exchanged, and in that sense was never truly released from one's possession. Ownership of such objects imbued the possessor with status. As a result, others wished to gain access to and possession of such an inalienable object, which in turn, created additional status as the original owner is thus sought out for desirable exchanges (Weiner 1992: 37-43).

Munn also used exchange as the creation and transformation of value. In her example from Gawa, gifts and exchanges of food and other items created positive value, while consumption and witchcraft were viewed as producing negative value. This balance between exchange as positive and consumption as negative was an important part of Gawa's system of value transformation. Additionally, the path taken by items of exchange created lasting memory of the "historical memorability [of an object] as a unique artifact so that it may be remembered long after it has disappeared" (1986: 12). In this way, these value transformations were similar to the inalienability of exchanged objects. Through exchange, value was objectified and maintained, and value items gained a reputation, or pedigree, as they passed from person to person. Not only was the value of an object solidified within the social context, but also the *process* of exchange was value-creating and transformational in and of itself.

Exchange served as an important link between northeastern and northwestern California. It provided the means to obtain obsidian bifaces for coastal Nations. However, the exchange networks and associated cultural interactions were also vital elements of a thing's value. Exchange was a way to objectify the value of objects, yet the social ties created and maintained through exchange or gift-giving were perhaps even more important. Payment of bifaces as bride price was one way in which these objects were exchanged in northwestern California. For example, in one ethnographically recorded instance, a large obsidian biface was given as a dowry in the marriage of a Wiyot girl to a Yurok man. The young man's family paid "ten pairs of strings of shell money, a woodpecker headband of the highest value, and a red obsidian reaching up to the elbow" for her hand in marriage (Spott and Kroeber 1942:210). In return, the girl's family gave a very large black obsidian biface, an object of extremely high value. This exchange of valuables within a ceremonially and socially charged context enhanced the value and status of the couple while simultaneously adding to the pedigree of the valuables involved. In this instance, valuables were important actors in the creation of status and prestige for the married couple. Furthermore, the exchange of specific things within this context also created additional value for the objects. In this way, exchange and value were mutually dependant and inextricably linked. Value of a thing was objectified and enhanced through exchange, while valuables further transformed the prestige and status of the actors involved.

BIFACES AS WEALTH AND VALUE

Large obsidian bifaces were undeniably wealth and value objects in northern California during late prehistory. Many factors contributed to the valued status of these things, and the value that these objects bestowed upon their owners. Theoretical considerations of how objects gained value and how this value is transformed within and between cultures and individuals provided a starting point for additional dialogue. Bifaces were ultimately embedded within an ever-changing cultural context, and bifaces as things valued by human beings, cannot be extricated from this social web.

Bifaces were reserved for ceremonial and wealth functions, and as such were a form of conspicuous consumption. The concept of conspicuous consumption was first introduced over one hundred years ago as an explanation of excessive waste and display of non-utilitarian things among an economic elite (Veblen 1899). This non-utilitarian or minimally utilitarian consumption or use of high-cost objects enhanced and reinforced the status of the consumer. In many ways, the use and display of bifaces by northwestern California peoples may be viewed as a form of conspicuous consumption. These bifaces not only served purely ceremonial functions, but they were ultimately destroyed and buried with their owner in prehistoric times, which served to take the biface out of the circulation of exchange.

A biface represented the most efficient use of toolstone material (Kelly 1988). Bifaces offered strong, yet durable cutting and scraping edges, and could easily be resharpened. Additionally, with only minimal platform preparation, bifaces could be used as cores to produce flakes that were made into other tools or used in an expedient fashion. Bifaces were a means of conserving raw material, and were a versatile tool.

Finally, they were often small and compact enough to be carried by hunter-gatherers during seasonal forays (Kelly 1988: 717-734). However, the Native Americans of the northern California coast did not use bifaces for utilitarian functions, as evidenced through a lack of use wear on archaeological specimens. Additionally, ethnographic data and the unwieldy size and shape of these objects further support the suggestion that these were non-utilitarian objects. Instead, bifaces served exclusively as wealth, ceremonial items, and prestige objects. They represented a large quantity of labor and raw material that was not used per se, but only displayed. Bifaces were potentially an efficient tool or core, yet were not employed for this purpose, but were kept and destroyed upon death in prehistoric times. They were consumed, but not utilized as tools.

Bifaces, as large, concentrated sources of otherwise relatively rare raw material, were a type of wealth regardless of the associated ceremonial system. Obsidian, particularly that from distant sources, was a very rare and valuable commodity. It could serve utilitarian functions as an effective cutting tool. In that sense a biface could conceivably be knapped into points, knives, or flake tools. One aspect of the innate value of a biface was in some degree a measure of the *possible* other tools it could be made into. A large biface was effectively a large piece of raw material. However, these bifaces were not made into utilitarian tools. Instead they were retained as personal property and wealth, and in this way, were a type of conspicuous consumption. It was a large cache of potentially useful raw material that was, in effect, *not* used. It existed as wealth (Kroeber 1905: 691) and was incorporated into the ceremonial world renewal system, and thus took on a more important significance, verging on sacred.

Beyond the mere material aspect of bifaces as raw material, bifaces were also a vital element of the ceremonial system of northern California. Large black and red obsidian bifaces, along with other wealth objects such as white deerskins and woodpecker scalps, figured prominently in the White Deerskin Dance (Kroeber 1925: 54). This dance was more than just a chance to exhibit valuables, for it functioned as an important ceremony for world renewal and maintenance (Heflin 1982: 123). During the dance, bifaces were displayed by special "flint-carriers", who held a matched pair of red and black obsidian bifaces. The flint-carriers danced back and forth in front of a line of men carrying white deerskins and held the matched bifaces out in front so as to be readily visible (Goldschmidt and Driver 1940: 109). The White Deerskin Dance was part of a larger system of world renewal, and with the Jump Dance, was the most important dance for the cohesion and continuation of the community (Kroeber 1957: 405). Obsidian bifaces also played a lesser role in other dances and ceremonies such as the Brush Dance and were symbolically represented by flat pebbles in the Boat Dance (Goldschmidt and Driver 1940: 117). However, the obsidian bifaces used in these other dances sometimes varied from the large, elaborate objects exhibited during the White Deerskin Dance. Usually only the largest and most ostentatious obsidian bifaces were displayed during the White Deerskin Dance; smaller bifaces were reserved for other dances.

Large bifaces were ceremonial objects, which lent an aura of value and sacredness about them. Bifaces were active in the initiation of prestige and importance for both dancers and the White Deerskin Dance as a ceremony, as well as for the elites who sponsored these events. Bifaces both received and caused status within the social context of ceremony and belief.

GLASS MOUNTAIN AND VALUE

Value in this case was intertwined ultimately with both the object and the source. Large obsidian bifaces were value objects and were made from Glass Mountain obsidian, which was reserved as a 'special' obsidian source. This cycle of value between object and source only served to further reinforce the value and status of the other. Thus the cultural context of obsidian use was an essential factor in the value of both source and object.

The Glass Mountain obsidian source retained a special place in the worldview of local peoples. It was perceived as a location for the production of ceremonial and high value objects, yet cultural prohibitions prevented its use for utilitarian tools. Given the recent date for the eruption of Glass Mountain obsidian, it is highly likely that local peoples witnessed this eruption and the formation of the obsidian flow. Stories of the eruption entered into oral histories and legends, and contributed to the special status of this obsidian source in the local cosmology. The phenomenological and experiential aspect of Glass Mountain's powerful obsidian-forming eruption strongly contributed to the valued status of this obsidian source. As a result, Glass Mountain obsidian was used exclusively for ceremonial and high status objects, such as large bifaces, and neglected for utilitarian purposes. Thus the cultural context of the prehistoric belief system and oral histories about Glass Mountain underlie selective procurement and use of this obsidian source. The Glass Mountain quarry was a significant actor in the creation and transformation of value for large bifaces made from this source. Interestingly, the northwestern California cultures that used obsidian bifaces in their ceremonial and wealth practices were geographically quite removed from the experience and phenomenon of the Glass Mountain eruption. Yet this obsidian source still figured prominently in the ideological system in the form of large bifaces. Translation of value extended across both geographic and cultural boundaries through exchange and interaction of disparate groups. The significance of Glass Mountain in the belief system and worldview of peoples living in the immediate vicinity of the volcano was vastly different from that of peoples along the California coast. However, Glass Mountain and its products retained a valued status in both regions. This translation and transformation of value and ideology further illustrates how both objects and places gain value and transmit or alter that valued status between people and cultures.

CONCLUSION

Objects gained value through a wide range of different contexts, including, but certainly not limited to, exotic origins, ceremonial importance, gifting, use, economy, desire, ownership, and exchange. This chapter has only touched on issues involving the creation of value, the maintenance of value and status positions, and the exchange of value and status objects. Obsidian bifaces from northern California were important value items among the sedentary hunter-gatherer societies of California's northwest coast. Applying the theoretical and philosophical perspectives addressed in this chapter to the study of these bifaces adds an alternative dimension to the traditional archaeological interpretations of value, namely a strict correlation between value and distance to source. Most notably, bifaces may represent a form of conspicuous consumption, as objects of display and as burial goods. This chapter links anthropological and economic theories of value and status to the archaeological record. Such dialogue presents new avenues of interpretation for archaeological data. Furthermore, Glass Mountain, as a preferred source for black obsidian bifaces, both contributed to and was enhanced by the valued status of these objects.

CHAPTER 6

TERRITORIES AND TERRITORIALITY

INTRODUCTION

The ways in which territoriality affected human interactions in the past are rarely made explicit in the archaeological research undertaken in California today. As part of a renewed interest in regional syntheses, largely resulting from extensive Cultural Resource Management projects, spatial territories are often assumed when constructing prehistoric culture areas and subsistence rounds. However, the interactions across and within territory boundaries are not often explored. Territory is a term used here to indicate the geographic or social confines that a human group controls or uses more or less exclusively, and territoriality is used to mean the behaviors utilized to defend or delineate a territory.

In California, territories and territoriality influenced prehistoric interaction and exchange between groups. If it is assumed that territories played a part in the spatial and cultural organization of prehistoric peoples, then it must be assumed that territoriality affected the ways in which people communicated and interacted across these boundaries. The archaeological record is not territorially neutral. Instead, it is necessary to incorporate hypotheses involving territorial behaviors into archaeological research questions.

In regions where lithic materials were produced, exchanged, and consumed within and between the territories of spatially and culturally separated societies, such territorial behaviors are visible in the archaeological and ethnographic data. At Glass Mountain, territoriality affected access to and exchange of obsidian and obsidian bifaces. Therefore, this chapter will present a review of anthropological and archaeological theory and method for addressing territoriality among hunter-gatherer populations, and how these ideas provide a context for archaeological research at Glass Mountain.

BACKGROUND

Hunter-gatherer territoriality in the anthropological literature is defined in two distinct, yet interrelated ways. It was a social relationship, defined as:

> The attempt by an individual or group to affect, influence, or control people, phenomena, and relationships, by delimiting and asserting control over a geographic area (Sack 1986: 19).

And it was an economic relationship, defined as:

> A cognitive and behaviorally flexible system which aims at optimizing the individual's and hence often also a group's access to temporarily or permanently localized resources, which satisfy either basic and universal or culture-specific needs and wants, or both, while simultaneously minimizing the probability of conflicts over them (Casimir 1992: 20).

These are not mutually exclusive definitions of territoriality. As a social relationship, territoriality provided the infrastructure that ensured access to localized resources. Territoriality was a cognitive construct that served as a way to distinguish 'us' and 'them' (Dyson-Hudson and Smith 1978: 21-41). In this way, territoriality defined a group and dictated who was entitled to the rights and privileges associated with group membership. The inverse of this statement is also true: territoriality defined who might be considered a foreigner, imposing restrictions on those who fall within this category.

There are three main components of territoriality. First, territoriality included geographic or social boundaries. These boundaries may be flexible and changing (Tilley 1994: 54), but some form of boundary was present in all types of territoriality (Sack 1986: 21). Second, territoriality contained a form of communication. In order to distinguish boundaries, groups or individuals must have a means of communication, either through signs, signals, gestures, or language. Third, territoriality incorporated a means of boundary defense. Sack states that this included "enforcing control over access to the area and to things within it, or to things outside of it by restraining those within" (1986: 22). Boundaries were maintained through non-aggressive cultural means, or through aggressive techniques such as defensive posturing, warfare, or the threat of spiritual harm (Andrews 1994: 82-83, Williams 1982: 147, Cashdan 1983: 49).

Territoriality was a spatial concept and a cognitive construct, and distinguished those within the group from those on the outside. Ethnographic and archaeological data indicate the presence of territoriality among hunter-gatherers of the present and the past, though much of this research has focussed on territoriality as an optimal strategy for resource procurement. Archaeology can and should look beyond spatial organization and subsistence optimization, and consider how territoriality affected interaction across boundaries.

THEORETICAL APPROACHES

Some of the earliest theoretical approaches to territoriality dealt with animal ecology. Particularly, these studies focused on group spacing and resource use (Peterson 1975: 55, Carpenter and MacMillan 1976), and examined ways in which territoriality provided the holder with a reproductive advantage. This research demonstrated that while territoriality provided increased access to and availability of resources by eliminating competition, it also required additional energy expenditures for boundary maintenance and defense (Cashdan 1983: 48).

Ecological models of human territoriality are one approach to the study of hunter-gatherer territoriality and boundary defense. Traditionally, ecological theories of human territoriality were loosely based on subsistence models of the New Archaeology. Most importantly, Binford's (1982) forager/collector model and ethnographic documentation of seasonal rounds in the subsistence practices of the Nunamiut Eskimo suggested that hunter-gatherers lived and gathered resources from within a cognitively defined area, or territory. However, the presence of a defined area of exploitation does not necessarily indicate the practice of territorial behaviors.

Site catchment analysis, as presented by Vita-Finzi and Higgs (Vita-Finzi and Higgs 1970; Higgs and Vita-Finzi 1972; Jarman, Vita-Finzi and Higgs 1972), is yet another way of looking at subsistence practices and territory from an ecological perspective. Mobile and sedentary peoples exploited resources from within a spatially defined site catchment area, or economic territory. The catchment area was determined by distance: a radius of two hours' walk for hunter-gatherers, and one hour's walk for agricultural peoples (Jarman, Vita-Finzi, and Higgs 1972: 63). Thus, taking into account differences in terrain and accessibility, a spatial territory, or zone of economic exploitation, was constructed based on walking time and distance from a centrally located village or home base. In site catchment analysis, the resource availability and economic productivity of this territory is calculated to answer questions about changes in economy,

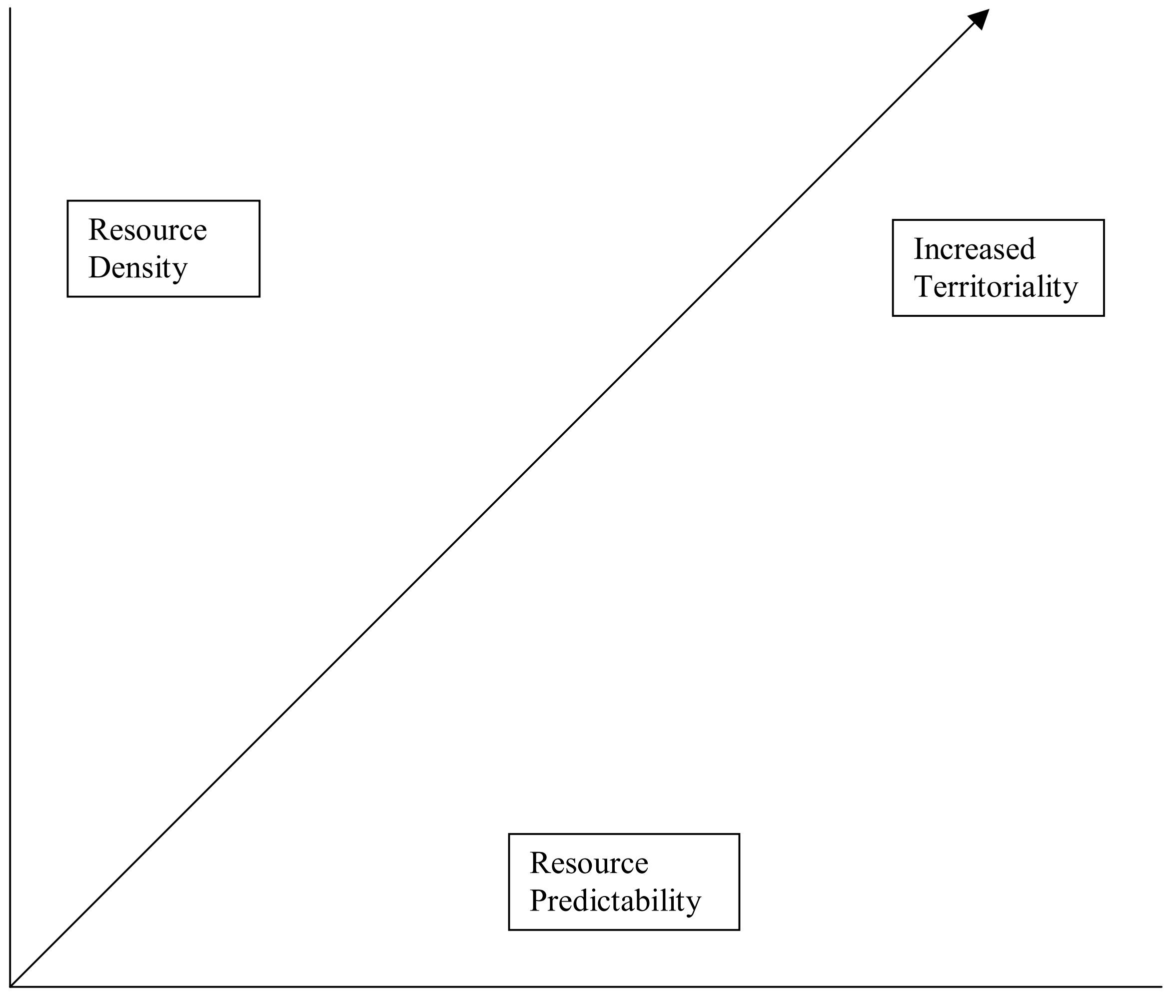


Figure 6.1: Resource availability and territoriality. (Dyson-Hudson and Smith 1978, Shackley 1990: 55)

subsistence, and population. Site catchment analysis has strongly influenced studies of territoriality, optimal foraging, and subsistence, for its calculations of potential exploitation zones and traveling distances for both mobile and sedentary peoples.

Optimal foraging theory also influenced theories of territoriality. Optimal foraging theory, in its strictest sense, suggests that humans will exploit resources that provide the maximum amount of energy for the minimum amount of effort (Bettinger 1987). Territoriality from this perspective required a balance between the costs and benefits of territorial behaviors, including the energy expenditure of territorial defense and the guaranteed access to resources within defined territorial boundaries. The investigation of territoriality in archaeology today is both an expansion and modification of these earlier ideas.

One of the principal factors in an ecological approach to human territoriality is the role of resource availability. There was an inverse relationship between territory size and resource density, however resource predictability was also a factor. As predictability and density increased, there was a subsequent increase in territoriality (Dyson-Hudson and Smith 1978: 21-41, Shackley 1990: 55). Predictability refers to “the confidence that can be placed in predictions of the abundance of resources at some time or times in the future” (Cashdan 1983: 48). If food or other resources exhibited predictable availability, it may be economically worthwhile to defend that patch of resources. Resource density was also a necessary requirement for territoriality, and by extension population resource ratios must show high resource availability for the population size (Rosenberg 1998: 655). Large territories were difficult to defend, and the costs of boundary defense, even if active warfare was not a factor, may have been prohibitive when resources were sparsely scattered within the territory (Shackley 1990: 52, Eerkens 1999).

Ecological theories suggest that there is a minimum threshold of predictability and density of resources required for boundary defense to be economically feasible, as suggested by optimal foraging theory. However, this minimum threshold may be considerably lower in humans than in animals. Humans, as creative, intelligent beings, devised lower-cost methods of boundary defense, which allowed for territoriality in regions exhibiting sparse and unpredictable resources and larger territories.

Organizational models comprise a second theoretical approach to the study of hunter-gatherer territoriality and boundary defense. There are two types of organizational models, which specifically address ways in which human groups maintained their territorial boundaries and excluded outsiders. Specifically, these are perimeter defense and social boundary defense (Cashdan 1983: 49, Shackley 1990: 51-52, Casimir 1992: 10-11). These models are not mutually exclusive, and hunter-gatherers may have used a combination of the two in the past.

Perimeter defense entailed marking the perimeter of the territory boundary and controlling access. It occurred in areas of relatively dense and predictable resources (Casimir 1992: 11). "Foragers of this group 'look' territorial… boundaries are advertised and marked, social units correspond to territory units, and there is usually little movement of individuals across territory boundaries" (Cashdan 1983: 49). In this model, territories were relatively small and boundaries actively defended. However, communication and aggressive threats limited the instances in which conflict actually occurred, and non-aggressive means served to effectively maintain geographic boundaries (Wilmsen 1973:

5). Monitoring territory perimeters may have been the most costly aspect of boundary defense in this type of territoriality.

Social boundary defense entailed defending the boundaries of the social group rather than the perimeter of the territory itself. "If resources are unpredictable and scarce, foragers control access with more or less delayed reciprocal altruism, not to the territorial space itself, but to the social group having rights to this territory" (Casimir 1992: 12). In this model, groups maintained geographic boundaries by concocting elaborate greeting and trespass rules for outsiders who wished to enter a given territory, though territories were often large and difficult to defend. Instead, groups relied on communication, kin and trading networks, and reciprocal behavior to maintain territorial order. Societies that depended on social boundary defense may grant outsiders permission to use local resources, but expected to receive the same type of leniency in the future when they trespass on another's property (Cashdan 1983: 49-50).

> Honesty in these relationships may be maintained simply by economy. The holders of the territory often have the most updated information on the various resources, and visitors can save energy simply by asking the 'owners' during the greeting ceremonies (Shackley 1990: 58).

Finally, the degree to which potential trespassers cooperated with the cultural constructs of social boundary defense techniques may depend on a number of issues. First, interlopers must consider the possible value of information regarding unpredictable resources, which may be obtained during social greetings. Second, they must contend with the probability and consequences of detection if they are discovered trespassing without permission. Third, uninvited guests forgo potential exchange and social relationships that were an additional benefit of contact (Kelly 1995: 194). It appears that there were distinct advantages in seeking permission to trespass, rather than venturing into a territory unannounced (Cashdan 1983: 51). It was thus better to 'play along' with territorial constructs than to attempt to circumvent physical or social defense mechanisms.

Organizational models of territoriality and boundary defense address issues of territory maintenance. Perimeter defense and social boundary defense existed on a continuum of action, with outright hostility on one extreme and permissiveness in the context of social etiquette on the other. Additionally, these two models are not necessarily mutually exclusive, for hunter-gatherer societies employed each technique based on changing situations of resource availability and social context (Casimir 1992: 16). As illustrated in figure 6.2, perimeter defense may have been more common between geographically and biologically closer groups, while social boundary defense may have cross-cut social and geographic boundaries. Nonetheless, as circumstances changed, hunter-gatherers employed different territorial behaviors, and both social boundary defense and perimeter defense may have been used in alternative situations and encounters.

A third theoretical approach to the study of territoriality deals not with the construction or maintenance of the territory itself, but with the effects of territoriality on subsistence and social organization. Territoriality and population pressure have been used as a causal factor in the emergence of sedentism. Rosenberg states "sedentism is a process of territorial compression that operates in contexts where the costs of territorial defense outweigh those of intensified exploitation" (1998: 653). When hunter-gatherer mobility required that groups move to another area, other groups may have displaced

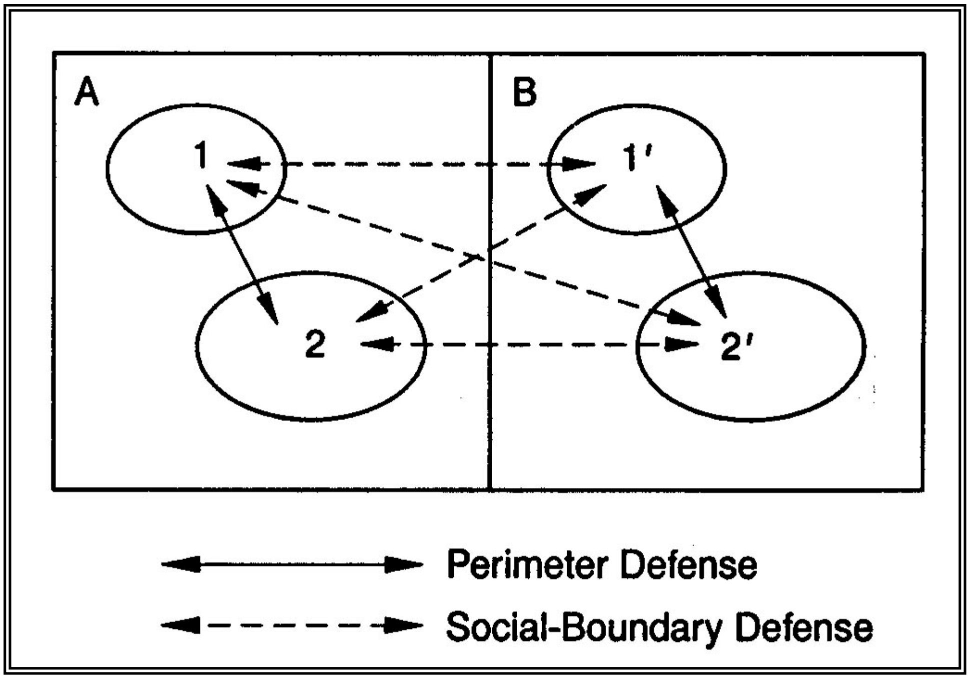


Figure 6.2: Perimeter defense and social boundary defense (Kelly 1995: 201)

them, and taken over their temporarily abandoned territory. Rosenberg (1998) argues that the need for territorial defense rose with increasing population pressure until it reached a level in which it is of greater advantage to remain in one area, exploiting what resources were available there, rather than to move elsewhere and expend time and energy defending a larger territory. In this model, territoriality, specifically the increased costs of boundary defense in situations of competition for resources, resulted in a greater degree of sedentism among hunter-gatherers. Rosenberg proposes that groups chose to defend smaller territories and exploit secondary resources rather than maintain larger and less cost-effective territories and a mobile lifeway.

The three approaches discussed above outline basic tenets of some of the issues addressed in studies of hunter-gatherer territoriality. Additional research on territoriality that has focused on modern pastoralists and industrial societies (see Taylor 1988, Rao 1992, Mirga 1992, Sack 1986: 92-127) is beyond the scope of this chapter. Territoriality can be further examined in hunter-gatherers through a discussion of the methodological approaches used by anthropologists and archaeologists.

Ethnographic studies among modern and historic hunter-gatherers have documented the presence of territoriality and offered insight into the techniques used to maintain and defend territorial boundaries (Andrews 1994: 65-93, Williams 1982: 131-153, Peterson 1975: 53-68). These studies have contributed to models of perimeter defense and social boundary defense as discussed above. Two examples will be elaborated here, first, a study of Australian Aborigines and second, ethnographic research on the Akulmiut of western Alaska.

The Yolngu inhabited the northeastern portion of Arnhem Land in Australia. They were traditionally a hunting and gathering group, who even in modern times relied heavily on wild food resources despite their transition to permanent settlements in the early 1970's (Williams 1982: 133). The Yolngu maintained territories based on kin ties and clan membership. Natural features including elevation changes, landforms such as hills or cliffs, streams or drainages, and vegetation or soil changes marked boundaries. Territories to the Yolngu did not necessarily exist for the sake of excluding outsiders, but instead they "used boundaries to express varying categories of rights, both of users and owners. To request permission to enter, camp on, or use the resources of a particular area is to acknowledge the right of the owners to accede or deny permission" (Williams 1982: 148). However, permission was almost always granted. In this instance, territories did fulfill an economic function in that by restricting access, even nominally, owners were capable of protecting resources within their boundaries. Despite this, territories also fulfilled a social function by creating and maintaining ties between neighboring groups through contact, and by suggesting an "us" and "them" relationship between kin groups and clans. Additionally, the social boundary defense utilized by the Yolngu served to reinforce and create power relationships across territory boundaries (Williams 1982: 131-150).

The territory of the Akulmiut of western Alaska was maintained and defended differently than that of the Yolngu. The Akulmiut were a hunting and gathering Alaskan Eskimo group inhabiting the tundra between the Yukon and Kuskokwim Rivers. Their subsistence rounds were characterized by aggregation in large settlements in the winter, and dispersal to seasonal camps in the summer. These practices have continued through the 1980's, when ethnographic research was conducted, despite the increased permanence of local villages (Andrews 1994: 65-73). Territorial boundaries corresponded to geographic features, which were given significant names to communicate their role as boundary markers and, in some cases, to serve as a reminder of a battle between the Akulmiut and non-Akulmiut trespassers. Territories for the Akulmiut served to define areas of exclusive resource use, and to protect dense and predictable resources such as seasonal fish runs and waterfowl. Boundary defense occurred through outright warfare and aggressive posturing, although they also utilized other mechanisms such as "ceremonies, naming conventions, kinship, and place names to communicate and delineate a unique area and its resources" (Andrews 1994: 92). Additionally, Akulmiut advertised their identity through easily recognizable clothing and kayak designs. Ceremonies also served as a means to create and reinforce Akulmiut community, and further emphasized the difference between members and non-members of the society. Therefore, through a combination of perimeter defense and social boundary defense techniques, the Akulmiut maintained and protected territorial boundaries. Costs of defending the territory were offset by advantages obtained through exclusive use of the territory and its resources. Andrews states "even with dispersed or mobile resources, predictability and abundance of critical food resources secure these hunting-gathering people with a nearly guaranteed food supply, contributing to a territorial system of land and resource use" (1994: 93).

As the two examples cited above illustrate, ethnographic studies reveal the presence of territoriality and boundary defense in modern hunter-gatherer societies. Additionally, models of perimeter defense and social boundary defense are exposed in practice through the techniques utilized by these peoples. The archaeological record also provides evidence of prehistoric hunter-gatherer territoriality. Two examples are summarized here: the first traces the role of petroglyphs in marking territorial boundaries (Bouchet-Bert 1999: 27-46), and the second uses geochemical materials characterization to reveal cultural and territorial boundaries in northeastern California (Luhnow 1997).

Bouchet-Bert reanalyzed archaeological data from a large petroglyph site in the Great Plains to determine its potential role as a boundary marker for the ancestors of the modern Blackfoot Nation. The site is located within ethnographically recorded Blackfoot territory, and the petroglyphs are situated such that they are highly visible. The petroglyphs are realistic representations of warriors displaying military paraphernalia such as bows, arrows, and shields. Previous interpretations of this site had suggested a spiritual meaning for the petroglyphs or concluded that they were depictions of hunting or battle prowess. However, Bouchet-Bert maintains that this site marks a territory boundary, and the depictions serve to intimidate the enemy and discourage trespass. His conclusions are based on ethnographic data, site location, and the subject matter of the petroglyphs. In this situation, the petroglyphs were a form of aggressive posturing and a threat to possible interlopers, and document boundary defense in prehistoric times (Bouchet-Bert 1999).

A second example of the study of prehistoric territoriality employs the use of obsidian characterization to define and distinguish the presence of a prehistoric territory boundary in northeastern California. This research is an excellent example of the types of territorial information that may be obtained through synthesis of Cultural Resources Management data. Luhnow used obsidian source characterization through X-ray fluorescence to delineate the boundary between the Gumbatwas and Kokiwas bands of the Modoc Nation (1997). At the time of contact the Modoc occupied the far northern portion of California and their territory extended into southern Oregon. The ethnographically recorded Gumbatwas territory included the area around Tule Lake and the Medicine Lake Highland, which contains a number of high-quality obsidian sources. The territory of the Kokiwas was located near Clear Lake and Blue Mountain, which contained another tool quality obsidian source. Luhnow calculated the percentages of Blue Mountain and Medicine Lake Highland obsidian sources in the archaeological assemblages of sites located near the ethnographically recorded boundary between the two bands. She found that there was a significant difference in the assemblage composition on either side of the boundary line. The Kokiwas Modoc were using Blue Mountain obsidian for most, and in some instances all, of their stone tool requirements. The Gumbatwas Modoc utilized Medicine Lake sources, including Glass Mountain, Grasshopper Flat, Lost Iron Wells, Cougar Butte, and East Medicine Lake sources (Luhnow 1997: 158-175). Luhnow concluded that despite the Modoc's traditionally mobile hunting and gathering lifeway, they respected territorial boundaries and primarily exploited resources within their own territory.

It is interesting to note that the boundary Luhnow investigated is between two small bands within the Modoc Nation rather than between vastly different cultural groups. Kin affiliations and cultural ties certainly crossed this territorial boundary, yet the Gumbatwas and Kokiwas Modoc were still largely respecting a defined spatial boundary between the two (Luhnow 1997). In this study and in similar research conducted in California addressing the distribution of chemically traceable artifacts

(Bettinger 1982: 103-127, Hughes and Bettinger 1984, Lyneis 1984), archaeological assemblages reflect culturally and spatially defined territories as they existed prehistorically.

Archaeological research is also just beginning to address the role of the cultural frontier in interaction and exchange between different cultural groups (Lightfoot and Martinez 1995), and the ways in which territories form (Zedeño 1997). These new studies may help us understand the ways in which bounded, territorial societies first created boundaries, and then interacted and exchanged goods, information, and people across them.

TERRITORIALITY AT GLASS MOUNTAIN

Making territoriality explicit in archaeology allows us to incorporate this aspect of the past into research questions and project designs. One of the goals of this dissertation is to investigate how territories and territorial boundaries affected the procurement and exchange of obsidian and obsidian bifaces, and how this information may identify the prehistoric knappers who worked at Glass Mountain.

Ethnographic and archaeological investigations at Glass Mountain offer initial data with which to formulate questions involving territoriality in prehistory. Obsidian bifaces were recorded ethnographically as important regalia displayed during the White Deerskin Dance among the Yurok, Hupa, Tolowa, and Karok. Additionally, ethnographic references mentioned the use of bifaces by the Shasta, Chimariko, Wiyot, and Wintu, though not in the context of the White Deerskin Dance (Kroeber 1925, 1957).

Figure 6.3: Ethnographic territories (after Kroeber 1925)

Prehistorically and during early historic times, extensive trade networks linked the obsidian sources of northeastern California to coastal peoples.

Ethnographic documentation and obsidian source characterization data both indicate that Glass Mountain was one source for black obsidian used to manufacture the bifaces discussed here (Hughes 1978, 1982, Davis 1961: 15, Goldschmidt and Driver 1940: 120). However, there is some discrepancy in the literature as to who actually manufactured bifaces. Davis (1961: 15) attributes obsidian exchange to the Shasta and Achumawi. Voegelin suggests that bifaces were manufactured by interior tribes, in this case the Eastern Shasta and the Karok, and traded to the west (Hughes 1978:54). Goldschmidt and Driver state, "no Hupa remembers seeing any other Hupa make these flints [bifaces], though some have seen a Karok man make them" (Goldschmidt and Driver 1940:120). Finally, Kroeber (figure 6.3) places Glass Mountain within the ethnographic territory of the Modoc (1925). To summarize much of the ethnographic literature however, the Karok are the most frequently cited as the producers of the large obsidian bifaces from Glass Mountain (Goldschmidt and Driver 1940, Hughes 1978).

In light of the existing ethnographic and archaeological data, several potential hypotheses can be considered:

1. Did the Karok procure the obsidian to make bifaces and manufacture them at the quarry? And if so, did the territorial behaviors of the Modoc restrict access to this raw material source?
2. Alternatively, did the Modoc grant the Karok permission to procure and manufacture bifaces of Glass Mountain obsidian?

3. Did the Karok procure obsidian at Glass Mountain, but manufacture bifaces within their own territory?
4. Or, did the Modoc manufacture bifaces and trade them to the Karok, who in turn traded them to coastal Nations?

Ethnographic data offer potentially the strongest support for the first hypothesis. Hupa informants claim to have witnessed Karok flintknappers making bifaces at locations away from the Glass Mountain quarry (Goldschmidt and Driver 1940: 120), though there are discrepancies with this record. Applying theoretical models of perimeter and social boundary defense addresses both the first and second working hypotheses. If the Modoc actively employed perimeter defense strategies, the Karok may have surreptitiously procured obsidian from Glass Mountain. Northeastern California was a relatively sparsely populated region in prehistory, and the Karok may have entered Modoc territory undetected. Additionally, given the number of obsidian bifaces present in coastal sites, the Karok must have visited the quarry numerous times. However, this scenario seems unlikely. The Modoc maintained a reputation for aggressiveness and hostility towards neighbors, according to the ethnographic record. In fact, they were known to raid neighbors for slaves during the early historic period (Murray 1959). If perimeter defense was practiced, interlopers contended with the probability and consequences of detection if they were discovered trespassing without permission (Kelly 1995: 194), and it may have been easier and safer to merely request permission to enter. If Glass Mountain was a sacred site, punishments for trespassing may have been even more severe.

In the second hypothesis, social boundary defense may have been employed. Karok flintknappers may have retained special permission to trespass in order to procure and manufacture large bifaces in Modoc territory. If social boundary defense was practiced in addition to or instead of active perimeter defense, the Karok may have used the Glass Mountain obsidian source with Modoc knowledge and permission. In this scenario, Modoc control of Glass Mountain and the social boundaries of the Modoc Nation remained intact. There is scant evidence to support or falsify this hypothesis, except for the ethnographic accounts of Modoc interactions. However, in a parallel example, Luhnow's research as cited above, indicates that individual bands of the Modoc retained almost exclusive use of obsidian sources within their territories (1997), and it is possible to project that restrictions on obsidian procurement by outsiders such as the Karok would be even more extreme.

To address the third hypothesis, archaeological data is necessary to document biface production in Karok territory. Archaeological evidence to support biface manufacture in Karok territory is non-existent. To date, Glass Mountain obsidian is extremely rare in the debitage assemblages west of Glass Mountain. Instead, Medicine Lake Highland obsidian is represented by Grasshopper Flat/Lost Iron Wells sources (Baker et al. 1990, Bevill and Nilsson 1996). Though the lack of evidence does not necessarily falsify this hypothesis, an alternative explanation may offer another clue to obsidian procurement at Glass Mountain.

The final hypothesis suggests that instead of Karok obsidian procurement and biface manufacture, the Modoc may have been knapping bifaces within their own territory, and then trading them to the Shasta or directly to the Karok, who then exchanged the bifaces with coastal peoples like the Yurok or Hupa. As will be discussed in detail later, the archaeological evidence suggests that the knappers spent a considerable length of time at the quarry, and reveals that they did not feel threatened in Modoc territory. Additionally, bifaces of this type are found, though rarely, at other sites within the ethnographically recorded territorial boundaries of the Modoc (Sampson 1985). Finally, as already mentioned, individual bands of the Modoc retained almost exclusive use of obsidian sources within their territories (Luhnow 1997), and it is possible to and may have placed extreme restrictions on procurement by outsiders such as the Karok.

The suggestion that the Modoc, and not the Karok, manufactured obsidian bifaces at Glass Mountain is contrary to the ethnographic reports. Due to the Modoc's reputation for hostility and aggression, the Karok would have been reluctant to spend extended periods of time at Glass Mountain. Instead, we would expect the Karok to reduce obsidian nodules to manageable-size preforms and take them away to be completed elsewhere. This behavior is not represented at Glass Mountain. Instead, bifaces were knapped to the final stages of manufacture at the quarry.

The evidence presented here and in subsequent chapters, strongly favors the fourth working hypothesis: that Modoc flintknappers manufactured bifaces at Glass Mountain. The Karok were not making bifaces as suggested ethnographically, but were only the final middlemen in a long, down the line exchange system that served to transport Glass Mountain bifaces from the Modoc producers, across territorial boundaries, to coastal nation consumers. The ethnographic reference to Karok biface production may merely be an artifact of early 20th Century fieldwork practices, including interviews with coastal nation Elders.

CONCLUSION

Archaeological and ethnographic research demonstrates ways in which territoriality operated in the past, and obsidian, with its chemically traceable composition and prehistoric availability throughout much of California, offers a unique medium through which to investigate these issues. Of utmost importance in this research is the archaeologist's awareness of and inclusion of prehistoric territoriality in research designs. Territoriality is not just a geographic construct, but also a cognitive and social construct. If it is assumed that territories played a part in the spatial and cultural organization of prehistoric peoples, then it must be assumed that territoriality affected the ways in which people communicated and interacted across these boundaries. The archaeological record is not territorially neutral. Instead, it is necessary to incorporate hypotheses involving territorial behaviors into archaeological research questions.

This chapter has provided a brief overview of some of the theoretical and methodological approaches used in the analysis of hunter-gatherer territoriality, and argues for a more territorially explicit approach to hunter-gatherer archaeology. Ecological and organizational models are commonly employed in hunter-gatherer territory research, but little is often said about how territoriality affected interaction within and between territorial boundaries. The models discussed in this chapter provide a theoretical base for studies of hunter-gatherer territoriality and boundary defense, and should be made explicit when studying hunter-gatherer prehistory. Archaeology cannot maintain a territorially neutral view of the past, for to do so neglects the complexity of interactions in prehistoric societies. The study of territoriality and boundary defense combines cognitive, social, cultural, and economic aspects of hunter-gatherer behavior, helping archaeologists and anthropologists achieve a more holistic view of the functioning of hunter-gatherer societies in the past and present.

CHAPTER 7

EXCHANGE

INTRODUCTION

Glass Mountain obsidian exchange occurred throughout late prehistory in northern California (Hughes 1978, Davis 1961). This exchange was integral to value creation and belief systems, and was also inextricably intertwined with culture contact and territoriality in the region. Exchange can be defined as "the spatial distribution of materials from hand to hand and from social group to social group" (Earle 1982: 2). However, exchange also reinforced and created social ties, promoted information sharing, and established and maintained positions of status. It commanded both economic and social roles within and between prehistoric societies. Exchange was a form of resource redistribution (Torrence 1986), provided a buffer against resource fluctuations (Cohen 1981: 290, Arnold 1992: 77), introduced and circulated prestige items (Appadurai 1986, Hughes 1978: 53, Bennyhoff and Hughes 1987: 161, Munn 1986), created communication and information networks, and served as a social tie between spatially and culturally distant peoples (Sahlins 1972: 186).

Archaeologically, exchange is visible through the spatial distribution of artifacts and stylistic patterns. Chemical characterization techniques such as X-ray fluorescence, PIXE-PIGME, and neutron activation analysis have been used to characterize and source lithic materials and ceramics (Ericson 1981, Tykot 1998: 76-79, Summerhayes et al. 1998: 146-155, Deutchman 1980: 128-130). Through chemical characterization, it is possible to determine the geologic point of origin of materials such as obsidian, basalt, and ceramic tempers. Stylistic patterning also helps to identify exchange and culture areas in contact (Fry 1980: 16; S. Plog 1978: 143-150).

Archaeologists study exchange in order to "explain economic formations and their articulation with broader sociocultural contexts" (Earle 1982: 1). Exchange served to move objects and ideas through the landscape and across cultural boundaries. This movement was accomplished through mechanisms of reciprocal exchange, gifting, redistribution, feasting, marriage exchanges, and trade fairs. Exchange occurred as internal trade, between individuals *within* a social or geographic unit, or as external trade, between individuals of different social or geographic units (Renfrew 1984: 86). By recording patterns of the spatial distribution of archaeologically visible exchange objects, models have been developed to reconstruct prehistoric exchange networks. These models propose ways in which prehistoric people and societies interacted in the past. However, purely economic models are insufficient to fully comprehend exchange. Hodder states that many models are "inadequate because they fail to incorporate the symbolism of the artifacts exchanged" (1982: 199). As a result, alternative approaches, such as a contextual approach, provide additional insight into the many aspects of exchange in the past.

In this chapter, the ways in which archaeologists have approached the study of exchange will be examined. Theoretical approaches and models serve as tools for the study of exchange and interaction. This chapter provides an overview of these approaches and models, with brief examples from the archaeological record. The geochemical techniques used to document exchange, such as X-ray fluorescence, PIXE-PIGME, and neutron activation analysis will not be discussed in detail here. Instead, I focus on the theoretical and methodological approaches used in the study of prehistoric exchange.

FORMALIST VS. SUBSTANTIVIST APPROACHES

The study of exchange is broadly defined by two approaches: the formalist approach and the substantivist approach (Earle 1982: 2). These two theoretically distinct approaches loosely encompass most, if not all, studies of prehistoric exchange. Formalists and substantivists examine exchange through the context of the individual and the social group, respectively, and both approaches are subject to criticism. However, a discussion of formalist and substantivist approaches provides a general overview of the broad themes addressed in the study of prehistoric exchange.

A formalist approach to the study of exchange closely resembles methods used by the formalist school of economic anthropologists (Hodder 1982: 201). "Formalists seek to investigate the outcome of rational decision making with regard to the choices available to a population" (Earle 1982: 2). It illustrates models of economy and efficiency through mathematical models such as regression analysis and fall-off curves, and predicts the distribution of exchange items based on the assumption that humans will behave rationally and efficiently. Formalist approaches explain the evolution of exchange systems through studies of cost efficiency, and aid in understanding the organization of exchange. In sum, the formalist approach assumes that "sociopolitical institutions establish constraints in terms of the distribution and value of items. Then, individuals, acting within these institutional constraints, procure and distribute material in a cost-conscious manner" (Earle 1982: 2). This produces regular patterns visible archaeologically, and suggests a predictive element for expected percentages of exotic items in the archaeological assemblage.

Substantivist approaches to the study of exchange focus instead on the “way economic behavior, including exchange, is embedded in broader social and political institutions” (Earle 1982: 2). Substantivists such as Sahlins (1972), Mauss (1950), and Polanyi (1957) examine the social elements of exchange and argue that exchange and social relations are intertwined. Hodder states that substantivists “are concerned with understanding exchange as a part of social process – functioning to provide essential resources, maintain alliances, or to establish prestige and status” (1982: 200). Ethnographic data are often used to create social models of exchange, to be applied to the archaeological record. Exchange, in the substantivist view, is controlled by moral and social obligations.

Other means of examining prehistoric exchange, closely allied with substantivist approaches, include aspects of symbolism, information flow, and social change (Earle 1982: 3). Hodder argues for a contextual approach in which the “symbolic and ideological dimensions of exchange” are considered (1982: 199). Hantman and Plog suggest that archaeologists look at “the potential effects of social differentiation and complex political and economic systems” on information exchange (1982: 241). Exchange is also suggested as a factor in the emergence of complex societies and social ranking among hunter-gatherer populations (Arnold 1992, 1991: 953).

Archaeological and ethnographic studies of exchange systems are loosely categorized as either formalist or substantivist. However, the boundary between the two schools is blurred, and exchange research often incorporates aspects of both formalist and substantivist approaches. Economic and social models are necessary to reveal a clearer picture of prehistoric exchange.

ECONOMIC MODELS OF EXCHANGE

Exchange is often examined from an economic perspective. From this viewpoint, exchange served to move goods through space from producers to consumers. Exchange provided a way of redistributing necessary resources, served as a buffer against resource fluctuation, and as a means to obtain exotic status or prestige items. These economic functions are extremely important, however as will be discussed below, exchange did not occur in a vacuum, and the social contexts of exchange are equally significant.

One notable function of exchange was as a means of resource redistribution. In regions of patchy resources or where territorial circumscription limited travel to desired resources, exchange served to bring them to the consumer. In this manner, exchange functioned as a form of redistribution by moving goods throughout a region. Renfrew states "in cases where there is also marked local diversity, with ecological variations within the region, a desire to obtain the products of a neighboring niche will inevitably promote exchange" (1984: 91). He also suggests that this will eventually lead to centralized exchange in the form of markets or trade fairs.

Chiefly redistribution was another type of exchange in some complex societies, such as sedentary hunter-gatherers of the Northwest Coast. Redistribution in this context was a form of exchange in that it served to transport goods from one place to another and from one person to another. Redistribution, specifically chiefly redistribution, was a means of pooling and sharing resources within a group (Ames 1995: 159, Bayman 1995, Polanyi 1957). According to Sahlins, it is a "*within* relation, the collective action of a group" (1972: 188) and is thus a form of exchange within the confines of a kin or social group. Sharing among hunter-gatherers also falls within this category (Kelly 1995: 164-168).

Exchange also worked to buffer resource fluctuations in environments where the productivity of a specific patch varied from year to year (Hodder 1980: 154). O'Shea illustrates this dilemma by stating:

> Neither the stark view of tradition nor the idyllic image of Sahlins accurately portrays the true nature of primitive subsistence. For most groups, be they hunter-gatherers or agriculturalists, the acquisition of necessary food is unproblematic in good years, but they are faced with mortal deficiencies in the occasional 'bad year'. The problem, which must be solved by any primitive economic system, is how to utilize the abundance, which may be available in any given year as a defense against scarcity in poor years. (1981: 168).

Exchange was an important method for mitigating resource fluctuations by serving as a form of social storage (O'Shea 1981: 173). Food resources during years of abundance were exchanged for more durable goods, which retained a culturally recognized value. During periods of resource stress, these valuables were in effect, 'cashed-in' for food resources from individuals or groups experiencing relative abundance. There are two main types of social storage: complementary and redundant systems.

Complementary systems are those in which there is a directional movement of goods through exchange. O'Shea states that "exchange systems of this kind are robust and their motivation is obvious, as the exchange system allows the goods from different ecological zones to move in respect to scarcity and abundance" (1981: 173). In this type of system, valuables were included as exchange items and were traded for subsistence goods during times of resource stress.

In the American Southwest, complementary exchange networks linked bison hunters of the Plains with agricultural communities of the eastern Pueblos. Economic modeling of agricultural productivity and transport costs has been used to determine the amount of grain surplus a hypothetical Pueblo community would have available for exchange, and of the number of bison that would be economically advantageous for a hypothetical Plains group to bring to a Pueblo community. Exchange of corn for bison was a least-cost strategy, given that enough bison were exchanged and corn surplus was sufficient (Spielmann 1982: 239). However, when corn yield was low, there was little advantage to Pueblo groups since protein requirements could be met through locally available species. Therefore, exchange of bison meat may have been a way of guarding against low deer or antelope population, or may have involved other causal mechanisms, such as a desire to obtain bison hides or maintenance of the Plains/Pueblo relationship. Other important benefits of exchange, such as marriage partners, political alliances, kin relationships, and the exchange of items other than bison or corn, may have made the system viable even in times of resource stress.

Redundant systems involve the exchange of items which "are more or less available to all participants and do not have any regular directional nature to their flow… food may be traded for a craft good or other durable item which either group could (and probably did) manufacture" (O'Shea 1981: 173). These types of systems provided a buffer against resource stress in isolated areas, through trade of subsistence items for non-food goods during periods of shortage. The advantage of this type of system falls not during periods of abundance, but during periods of stress, at which time existing exchange networks provided necessary foodstuffs.

Many studies of economics and prehistoric exchange have emphasized the trade of prestige items, rather than subsistence goods. The reason for this is twofold. First, food items are difficult to trace archaeologically since they often are not preserved in the archaeological record. Some prestige items, on the other hand, are archaeologically visible. Prestige goods can include obsidian bifaces and shell beads in California (Hughes 1978, Bennyhoff and Hughes 1987, Arnold 1991, 1992), or ceramics and turquoise in the Southwest (Toll et al. 1982: 95-118, Deutchman 1982: 119-135, Crown 1994). Second, prestige items generally were transported longer distances through more elaborate networks than subsistence goods (Renfrew 1984: 128). Therefore they serve to illuminate extensive prehistoric interaction spheres, and provide clues about cultures in contact and prehistoric information flow. Furthermore, prestige item exchange has been the topic of many ethnographic studies, particularly in the South Pacific (Malinowski 1920: 97-105, 1922, Thomas 1991, Munn 1986), and in California (Kroeber 1905: 690-695, 1957: 404-411, Davis 1961).

Sahlins believed that prestige items and subsistence goods circulated on different planes, in different exchange networks, and were not exchanged for each other except under dire circumstances (1972: 218). However, O'Shea suggests that such exchange did occur, as prestige goods were one form of social storage. Rather than falling neatly into categories of subsistence goods and prestige goods, all potential objects for exchange existed on a continuum, in which all items could potentially be exchanged for any other item (O'Shea 1981: 177).

A classic ethnographic example of a prestige item exchange network is the kula ring of the Massim as described by Malinowski (1922). In this system, armbands and shell necklaces circulated in opposite directions through an interconnected ring of trade partners. Kula armbands were important status items, and success in the kula trade conferred high rank upon an individual (Munn 1986: 8). Kula shell armbands traveled hundreds of miles, passed through the hands of numerous owners, and played an important role in the lives of those engaged in kula exchange. Kula served to link widely dispersed peoples through economic exchange, although Weiner (1976) has since demonstrated that Malinowski's version of the Kula may be incomplete and oversimplified.

The Chumash of central California used exchange of prestige goods as a buffer for resource stress (Hudson and Blackburn 1982), and elites capitalized on the exchange of valuables to enhance their personal and community status. Archaeological evidence indicates that a period of increased ocean water temperatures was associated with a drastic decline in marine resources, which formed the base of island Chumash subsistence. Skeletal material from Chumash archaeological sites displays evidence for resource stress, including cribra orbitalia, Harris lines in long bones, and depressed cranial fractures representing an increase in violence (McHenry 1968, McHenry and Schulz 1974, Walker 1986, Walker 1989). This period of resource decline was also associated with an increase in shell bead and chert microlith manufacture. These items were important in the pre-existing exchange networks between island and coastal Chumash tribes. During times of food shortage, elites centralized their power and influence by controlling and encouraging the manufacture of non-food trade items such as shell beads. Elites, who owned canoes and thus controlled trade routes, then exchanged these valuables with coastal tribes for food items to be distributed within island populations. In the case of the Chumash, exchange functioned as a buffer for spatially and temporally isolated resource fluctuations (Arnold 1992: 60-78). However, exchange can only mitigate resource shortages in instances when the shortages are limited in scope. Exchange requires that groups experiencing resource stress were able to trade with those experiencing resource abundance.

SOCIAL MODELS OF EXCHANGE

Purely economic approaches to the study of exchange often lack an emphasis on the social contexts surrounding the actual trade of goods (Schortman and Urban 1987).

> An exchange act involves an appropriate choice of gift within a social and ideological context. The thing exchanged was not arbitrary and its associations and symbolism played an active part in the construction of social strategies. As archaeologists, we need to examine the symbolic and ideological dimensions of exchange (Hodder 1982: 199).

Exchange did not occur within a vacuum; social interaction took place on some level in every type of exchange. "Understanding exchange processes depends on an adequate description of the social context within which exchange occurs" (Hodder 1982: 209). Exchange played an important role in the negotiation and maintenance of social ties, the sharing of information (Sahlins 1972), the emergence and maintenance of status differentiation (Arnold 1992: 60-84, Ames 1995: 155-187), and in the creation of value (Appadurai 1986: 3-63, Simmel 1978, Munn 1986). As Renfrew so eloquently writes "these different interactions or exchanges, with their flow of goods and of information, are what remove the individual in his Crusoe-like isolation… from a condition of brute independence, making him part of a functioning society of a kind we term civilization, with a high degree of interaction and specialization" (1984: 90).

Sahlins was one of the first, and remains one of the foremost, advocates for a social model of exchange. He suggested that exchange is both constrained and dictated by social boundaries and cultural etiquette. Exchange cannot be separated from its social context, which dictated and controlled the type of exchange and the objects involved. Reciprocity, or direct one-for-one exchange between two individuals or groups, must therefore be viewed within a cultural environment, and thus can be divided into three main categories on a continuum from the pure gift on one extreme to theft on the other. These categories were created by the social and cultural context of the exchange situation and included generalized reciprocity, balanced reciprocity, and negative reciprocity (Sahlins 1972: 193-196).

Generalized reciprocity was the closest to the pure gift. In this context, repayment of obligations was socially repressed, for there was no specific time frame of exchange nor was any type of material expectation made explicit (Sahlins 1972: 193). Repayment was usually made, but not always required. However, according to Mauss, there was no such thing as a pure gift, and there was indeed a reciprocal exchange for every type of gift (1950).

Balanced reciprocity was the direct exchange of one good or service for another. It is this type of exchange that is usually brought to mind when studying trade and interaction in the past. In situations of balanced reciprocity, repayment of the initial good was expected and made explicit. This type of exchange was analogous to buying and selling, and was less personal and more economic than generalized reciprocity. Balanced reciprocity created a form of social contract in that there occurred "some renunciation of hostile intent or of indifference in favor of mutuality" (Sahlins 1972: 220). The types of contracts created and affirmed through balanced reciprocity included formal friendship or kinship, corporate alliances, peace-making, and marital alliance.

Negative reciprocity was the attempt to get something for nothing. Repayment was denied and not expected. Negative reciprocity included theft, gambling, or haggling. In some instances, raids and counter-raids were staged in an attempt to seize repayment for stolen items. This type of reciprocity was very impersonal and often harmed exchange relations between individuals or groups (Sahlins 1972: 194).

The type of reciprocity performed was contingent on social context. Reciprocity was strongly affected by social distance. In many prehistoric societies, kinship and residence groups created concentric spheres of social distance, from household and immediate family in the center and out to intertribal relations. As a result, types of exchange are also modeled as concentric spheres, with generalized reciprocity most common in the inner circles and negative reciprocity limited to the outer rings of the social sphere.

Interestingly, in the context of kula exchange among the Massim, exchange partners adopted the role of kin despite biological, cultural, and spatial distance (Munn 1986). Exchange partners were hosted at feasts and given gifts, a type of generalized reciprocity. However, these gifts were repaid in time through reciprocal hosting and feasting. Yet, balanced reciprocity also occurred within the kula, as armbands, shell necklaces, and other valuables were exchanged.

Exchange was not limited to the trade of goods, but also involved the exchange of information and knowledge. Renfrew states, "the trade situation is an exchange situation, and an exchange situation is an information flow situation" (1984: 104). Knowledge may be passed inadvertently from one person to another within the context of exchange, but may also be exchanged for, as in the situation of esoteric rituals or advice.

One way information exchange is visible archaeologically is through stylistic similarities in locally produced objects, such as ceramic styles (Hantman and Plog 1982: 240), and technological advances or innovations. However, much of the information exchange that probably occurred in the past is invisible. This information exchange could have included details on productive resource patches, songs and stories, and ideas. Information exchange was contingent on some form of contact, whether through objects, middlemen, or direct face-to-face interaction. Renfrew states "the study of trade is central to the study of society because of the association of goods and information in most exchanges, an aspect of the embeddedness of the economy" (1984: 89). There are two models used to illustrate this embeddedness and to describe information diffusion: the contagious wave model and the hierarchical diffusion model (Hantman and Plog 1982: 241).

The contagious wave model suggests that innovations will expand outward from a central point, and may be adopted by any or all members of the population. It implies a steady and complete diffusion across a culture or region. However, Hantman and Plog find fault with this model saying "it fails to recognize the potential effects of social differentiation and complex political and economic systems on the spatial pattern of information communication" (1982: 241). The hierarchical diffusion model says that traits will spread through a system in a hierarchical structure. In this model, traits first appear in areas with the greatest amount of regional interaction, and later trickle down to more isolated areas (Hantman and Plog 1982: 241).

In the American Southwest, similar pottery styles have been found in two distinct regions approximately 150 miles apart. Petrographic analysis revealed that the ceramics were produced locally, and were generally not exchanged between the two regions. They argue, “this homogeneity results from unbounded, nonhierarchical information exchange” (Hantman and Plog 1982: 250). In areas of unpredictable resources, information exchange provided valuable data on the availability of wild foods. Stylistic information, represented through archaeologically recoverable ceramic sherds, may have been an intentional or unintentional by-product of the exchange of archaeologically invisible subsistence information or goods.

In the Salado culture area of the international four corners region in the southwestern United States and northern Mexico, distinctive Salado pottery has been found throughout a wide region. Like the example cited above, this pottery displayed a great deal of homogeneity throughout the area. Indeed, this may be representative of the spread of a broad ‘Southwestern Cult’ that served as a unifying force for unrelated peoples and cultures (Crown 1994). Exchange and interaction between disparate groups contributed to the spread of ideas and beliefs across this region.

Economic models only expose a small segment of the true role of exchange in prehistoric societies. Social interaction takes place on some level in every type of exchange. Hodder’s suggestion that an understanding of the social and cultural environment in which exchange is occurring is thus an important one (1982: 209). The social models outlined above show that exchange plays an important role in the negotiation and maintenance of social ties, the sharing of information (Sahlins 1972), the emergence and maintenance of status differentiation (Arnold 1992: 60-84, Ames 1995: 155-187), and in the creation of value (Appadurai 1986: 3-63, Simmel 1978, Munn 1986). The challenge for archaeologists therefore, is how to see exchange in the archaeological record and determine what visible patterns indicate about past cultures.

ARCHAEOLOGICAL METHODS AND IDENTIFICATION

Research on archaeological exchange identifies the form and context of exchange and explains exchange as the product of individual agency and cultural context. Laboratory characterization techniques derived from the physical sciences pinpoint the original geologic and geographic point of origin for raw materials used in exchange objects. Descriptions of spatial patterning are valuable in constructing prehistoric exchange mechanisms and interaction spheres.

Spatial patterning exhibited by the exchanged material is determined through several mechanisms. The first, and simplest, is a point scatter distribution of the locations of exchanged materials. When mapped, the point scatter provides a visual representation of the material components of a prehistoric exchange system (Earle 1982: 6).

A second method used to visualize prehistoric exchange systems is regression analysis. In regression analysis, frequency and distance are plotted such that a relationship between the two is represented by a regression line, which is then used to predict the point scatter of artifacts (Earle 1982: 6, Hodder and Orton 1976). Regression analysis frequently illustrates the Law of Monotonic Decrement, which states that frequency decreases with increasing distance from the source (Renfrew 1984: 136), though departures from the expected pattern may be significant in understanding the past.

A third method for describing prehistoric exchange systems is through computer generated distribution maps of artifact frequencies. Ideally, the result of this kind of exercise would consist of concentric circles of decreasing artifact frequency with distance from source. However, such visual depictions are particularly useful in illustrating asymmetrical patterns, which may represent distribution routes, territorial boundaries, or competing sources (Earle 1982: 6, Ericson 1977).

Finally, archaeologists use a variety of models to reconstruct the organization of exchange. Earle states that the purpose of this is "aimed at recognizing the institutional framework of exchange and, more broadly, the function of the exchange in the prehistoric society" (1982: 6). This is often accomplished through analysis and interpretation of spatial patterning. Regression analysis, as outlined above, is one method used in the interpretation and reconstruction of prehistoric exchange. Fall-off curves, created by graphing distance and frequency of artifact types, visually indicate the type of exchange that occurred in the past (Renfrew 1984: 135-152). Specifically, the shape and gradient of this falloff is affected by factors of transportation, value, and organization (Earle 1982: 7). By analyzing the shape of the fall-off curve, archaeologists try to understand the form of exchange taking place in the past, such as direct access or down-the-line exchange. Additionally, fall-off curves may function as a predictive tool for the proportions of exotic goods in archaeological assemblages.

Another technique used to interpret and reconstruct prehistoric exchange is through the analysis of network patterning. Network patterning involves the reconstruction of possible exchange routes based on geographic and archaeological data. It is helpful in identifying the most efficient routes for exchange, and in determining potential middlemen who were centrally located and may have participated in the transportation of exchange goods. This technique has been applied to exchange networks in the South Pacific, and is well suited to the region due to the lack of physical or territorial boundaries in the open waters between island nations (Irwin 1978).

A third technique in the reconstruction and interpretation of exchange networks is performed through modeling their changes and structure. This largely subsumes much of what has been discussed in this chapter. A number of factors must be considered: content of the goods exchanged, magnitude or quantity, diversity of artifacts, size of the region, duration over time, direction of exchange, symmetry of the system, centralization, and social complexity (F. Plog 1977, Kirch 1991: 146). It requires extensive archaeological work, a large data set, and careful sampling in order to succeed. However, temporal changes in the structure of a regional exchange system, which would be illuminated with this type of research, could provide greater insight into the function and context of exchange in past cultures.

The methods and models discussed in this section facilitate the description of the form and content of exchange from the archaeological data, and the explanation of exchange as it is determined by individual choice and by cultural context. By using techniques derived from the physical sciences in combination with models of distribution, quantification, and networks, archaeologists attempt to understand the role of exchange in economic and social contexts of prehistory.

CONCLUSION

This chapter presents broad theoretical and methodological approaches, which have been used in the study of prehistoric exchange, through a discussion of economic and social models and the techniques currently used to identify and understand exchange. It is impossible to separate the economic from the social contexts for exchange, and so many approaches, techniques, and ideas are employed concurrently. As more archaeological data become available and analytic techniques are perfected, there will be more opportunities to study and interpret exchange as it occurred in the past.

Already there are many ways in which exchange has been used to understand prehistoric societies. As discussed in this chapter, exchange was a form of resource redistribution (Torrence 1986), provided a buffer against resource fluctuations (Cohen 1981: 290, Arnold 1992: 77), introduced and circulated prestige items (Appadurai 1986, Hughes 1978: 53, Bennyhoff and Hughes 1987: 161, Munn 1986), created communication and information networks, and served as a social tie between spatially and culturally distant peoples (Sahlins 1972: 186). Exchange linked individuals and groups across geographic and cultural boundaries, and involved the trade of goods as well as information.

In this dissertation, exchange will be discussed as a means by which obsidian bifaces were transported from Glass Mountain to the northwest California coast. Chemical characterization technology, specifically X-ray fluorescence, is used to determine the geologic source for these objects, and archaeological reconnaissance identifies biface production at Glass Mountain. However, exchange research at Glass Mountain does not stop there. In order to explore the role of exchange in biface production and use, I also choose to examine its cultural context. I look at the role of Glass Mountain obsidian exchange in value creation and prehistoric belief systems. In addition, territoriality and culture contact also affected and were affected by exchange, and are an essential aspect of this discussion.

Exchange served economic functions, but also occurred within a specific social and cultural context. As a result, investigations of prehistoric exchange networks must look at the big picture and move beyond merely tracing patterns of things across the landscape. "Exchange networks do many things, and our models must be mindful of the multiple economic, social, political, and ideological possibilities" (Kirch 1991: 160), and it is the cultural component that makes exchange such an exciting and potentially revealing part of archaeological research.

CHAPTER 8

CULTURE CONTACT IN NORTHERN CALIFORNIA

INTRODUCTION

Culture contact studies focus specifically on contact and interaction between two disparate cultures, and explore the biological, environmental, cultural, and demographic changes that occurred as direct or indirect effects of contact. In North American archaeology, this often encompasses the initial contact between Europeans and Native Americans, and spans the breach between historic and prehistoric periods. Culture contact occurred in a whole range of spatial and temporal settings, but for the sake of this dissertation, I choose to focus specifically on contact between Native Americans and Europeans in northern California.

Culture contact studies in North American archaeology utilize a variety of sources to reconstruct and interpret the changes and impacts of contact on both Native peoples and Europeans. Historic documentation such as explorers' journals, mission records, settlers' diaries, and other written documents provide part of the database for contact studies in northern California. However, other sources of information including oral histories, archaeology, linguistics, and ethnography also serve as valuable elements necessary for reconstructing the past.

Lightfoot states that "an important feature of social theory and studies of culture change in anthropology today is understanding how indigenous peoples responded to European contact and colonialism, and how the outcomes of these encounters influenced cultural developments in postcolonial contexts" (1995: 199). In this chapter, the effects of European contact on Native culture will be examined with a particular emphasis on the peoples of northern California.

The contact period in North America was a period of rapid change, both from a biological and a cultural standpoint. Studies of culture contact examine the impacts of disease (Dobyns 1983, Erlandson and Bartoy 1995, Johnson 1998, Lightfoot and Simmons 1998, Preston 1996, Walker and Johnson 1992), environmental changes (Allison 1994, Dobyns 1983, Eidsness 1988, Moratto 1973), and introduced European goods (Crosby 1972, Davis 1961) on Native American cultures as a way of determining the effects of contact and the types of adaptations that occurred during this dynamic period. Additionally, archaeologists and historians are beginning to investigate ways in which Native Americans resisted the effects of contact, often through warfare and raiding (Johnson 1998, Murray 1959, Cook 1976). Each of these issues will be examined further within the context of Native Californians.

European introduced diseases had a devastating impact on Native American peoples. Because Native Americans had little immunity to Old World pathogens, epidemics spread very rapidly through populations also weakened by dietary changes and territorial circumscription resulting from European settlement. According to Dobyns, epidemic disease had three main effects on Native populations. First, "it affected later biological conditions among survivors by conferring immunity to a second invasion of the same pathogen" (1983: 10), however, this would not provide any immunity for the individual against other diseases. Second, it "profoundly influenced Native American mental health" and diminished the spirit and will to resist the Europeans. Third, epidemics drastically changed Native American cultures by undermining faith in their spiritual and cultural institutions and disrupting the continuity and transmission of cultural traditions (Dobyns 1983:10). The journals of missionaries, explorers, and settlers document widespread population declines caused by rampant disease. However, in order to better understand demographic changes in Native American populations and to gain further insight into the spread of these diseases, archaeologists also study the health of Native American populations just prior to European contact as evidenced through bioarchaeological data (Larsen et al. 2001, Ubelaker and Verano 1992: 2, Cook 1976). By comparing demographic, bioarchaeological, and historical data, a clearer picture emerges of disease as a factor in the rapid changes of the contact period.

Environmental impacts directly resulting from European contact also profoundly affected Native Americans and caused changes in subsistence strategies and mobility. Introduction of livestock damaged fragile grassland ecosystems (Allison 1994: 84). Timber harvesting destroyed plant resources and game habitat (Cook 1976: 484, Cronon 1983: 108-113). Mining operations silted previously productive fish streams and prevented Native American access to fishing grounds (Cook 1976: 485). Hunting by new settlers reduced available game (Cronon 1983: 133). Finally, territorial circumscription by European settlers removed foraging and hunting grounds from Native American use (Cronon 1983: 54-71, Cook 1976: 480). Even today, fire suppression policies of State and Federal agencies limit traditional Native American burning practices which formerly served to increase game habitat, encourage the growth of beneficial plant species, and create open forest and grassland environments (Anderson 1993). New ways of looking at land and land ownership were often at odds with Native American beliefs and practices, contributing to contact period tensions. The impacts of European land use were largely subsistence related, and served to reduce Native American access to and availability of wild food resources.

Introduced European goods also strongly affected the Native American way of life. European items were incorporated into traditional cultural contexts, which varied along a range from prestige to utilitarian goods. European products usurped the position of Native produced prestige goods, and disrupted long-distance trade networks (Johnson 1998). Also, the introduction of the horse changed the lives and culture of Native Americans throughout the continent (Layton 1981: 128). Horses facilitated increased mobility, affecting subsistence, trade, and social organization. European goods were adopted within the existing Native American framework, and European trade items influenced cultural changes evidenced during the contact period.

Finally, warfare and Native American resistance to European incursion is attracting attention in culture contact studies. Both sides initiated raids and battles in the fight for North American territory. Because Native American populations were already weakened by other factors such as disease and hunger, Europeans maintained a decided advantage. Outright warfare was waged through large sections of the west as Native Americans struggled to maintain a traditional way of life. Warfare resulted in numerous casualties on both sides, but only postponed European settlement. Native Americans effectively fought European settlement on a more subversive level through raiding, theft, and destruction of property. Cultural resistance and the persistence of traditional belief systems enabled Native Americans to affect at least a passive resistance to European influence (Jackson and Castillo 1995, Castillo 1989: 377). Abortion and infanticide of children fathered by Europeans was another form of passive resistance practiced during the contact period. Historical documents, oral histories, archaeology, and ethnographic data provide culture contact studies with information regarding resistance to European influence by Native Americans, and also facilitate a better understanding of the beliefs and practices of modern Native American Nations.

In order to comprehend changes that occurred as a direct result of culture contact, it is necessary to examine both prehistoric and historic contexts. Archaeologists who study the culture contact period look at the late prehistoric period, through the archaeological data, to obtain a baseline through which to determine the changes that occurred when Europeans arrived. In this chapter, culture contact is discussed with reference to northern California. I first present a brief overview of the late prehistoric period. Because of the vast differences between northeastern and northwestern California culture groups, environment, and European influences, these regions are examined separately. Prehistorically however, northwestern and northeastern California Native Americans were linked economically and culturally through a wide-reaching trade network. Second, I present the historical data relevant to northern California, again split into eastern and western geographic areas. This information is gleaned largely from journals and other historic documents of early explorers and settlers. Finally, I present an analysis of the effects of culture contact on northern California in general, addressing issues of disease, environment, European goods, and warfare, and the changes these affected during the contact period in this region.

LATE PREHISTORY: NORTHEASTERN CALIFORNIA

Northeastern California peoples were mobile hunter-gatherers living in a high desert sagebrush and juniper environment. The Nations discussed here include ancestors of the Modoc, Achomawi, Atsugewi, Shasta, and Northern Paiute. The Achomawi and Atsugewi, also known as the Pit River, and the Shasta speak dialects of the Hokan language family (Kroeber 1925, Heizer and Elsasser 1980: 17). The Modoc and the Klamath in southern Oregon are closely related and speak a language associated with the Sahaptin and Penutian families (Aoki 1963). The Northern Paiute language is part of the Numic family (Heizer and Elsasser 1980: 18-19).

Northeastern California groups shared similar subsistence and cultural systems, despite their diverse linguistic origins. The village formed the central political unit, though village level groups split up into family units for summer foraging (Dixon 1908: 215, Rodeffer and Galm 1985: 24, Ray 1963). Religion revolved around the natural world, encompassing anthropomorphic and zoomorphic figures, and guardian spirits (Ray 1963, Dixon 1908: 218-219, Rodeffer and Galm 1985: 24). High places were very important and served as destinations where people obtained power and spiritual guidance. Archaeologically, rock circles and stacks mark important places on mountains and hilltops.

Subsistence in northeastern California involved a hunter-gatherer lifeway that followed seasonal rounds of resource availability with minor variations between different geographic areas. Shasta, Achomawi, and Atsugewi staples included acorns, salmon, and large game animals such as deer and antelope (Dixon 1908: 212, Kniffen 1928: 302, Rodeffer and Galm 1985: 24). Camas (Camassia quamash), epos (Perideridia gairdneri), and other roots, seeds, and berries composed an important element of the subsistence system (Rodeffer and Galm 1985: 28).

The Modoc and their close relatives the Klamath of Oregon exploited a very similar resource base as discussed above, with a few notable exceptions. Acorns and salmon were not available due to location and terrain variations. However, these groups hunted and gathered in local marshland environments, particularly in the area of Tule Lake, subsisting heavily on waterfowl, eggs, wokas (Nupher polysepalum), and fish (Kroeber 1925). The Northern Paiute subsistence base was also similar to those discussed above, with an increased focus on desert resources (Rodeffer and Galm 1985:31).

It has been suggested that the Modoc were perhaps relatively late entrants into the area (Hardesty and Fox 1974:4).

> It is possible, therefore, that prior to Modoc entry, the Achomawi occupied a vast area up to and including the southern shores of Tule Lake, and that they evacuated the region only because of pressure from the intruding Modoc. After this time, they continued to exploit the resources of the Lava Beds, but at considerably greater risk (Masten 1985).

Settlement patterns throughout the region involved winter residence at large congregated village sites in pithouse dwellings along waterways. Winters in northeastern California are cold and harsh, with most precipitation falling as snow. Summer climate is hot and dry. Summer residences were temporary campsites occupied during seasonal gathering forays (Ray 1963).

Trade and exchange, particularly of obsidian, was important in the maintenance of regional communication and trade networks linking northeastern and northwestern

California. Ethnographic literature documents the inclusion of obsidian gathering during normal summer rounds (Ray 1963, Dixon 1908), and geochemical analyses of archaeological samples reveal northeastern California obsidian in coastal archaeological sites (Rodeffer and Galm 1985, Basgall and Hildebrandt 1989, Mikkelsen and Bryson 1997, Hughes 1990, 1978).

Prior to European contact, northeastern California peoples commanded large territories for their subsistence rounds and were economically linked throughout much of the northern portion of the state. However, when Europeans arrived, their diseases, livestock, settlements, and reservations drastically changed the traditional lifeway of these peoples.

LATE PREHISTORY: NORTH COAST

Northwestern California peoples, including ancestors of the Yurok, Hupa, Tolowa, Karok, and Wiyot Nations maintained a relatively sedentary lifeway and are commonly associated with Northwest Coast cultural traditions. Language groups represented include Athabascan, Algonkian, and Hokan stocks (Kroeber 1925). These peoples were markedly different from northeastern California Nations, yet maintained links with the region through exchange.

Despite language differences, the California north coast tribes were remarkably similar in subsistence strategies, and shared many cultural traits. All exploited riverine and coastal resources, including fish, shellfish, sea mammals, salmon and freshwater species. They also hunted deer and elk, and gathered acorns. Coastal peoples were more or less sedentary, subsisting off of abundant aquatic and terrestrial resources.

The late prehistoric, known as the Gunther Pattern (AD 900-1850) exhibits a strong influence from the Northwest Coast. “Wealth consciousness and distinctive artifact types including zoomorphs, large obsidian ceremonial blades, antler spoons, steatite pipes and bowls…[and] dentalium shells” were central to the system. “Exchange networks were regularized. Dentalium shells, indigenous to Vancouver Island, became the common medium of exchange along the northwest coast of California” (Eidsness 1988:12), and obsidian was imported from sources over 280km to the east.

Obsidian bifaces were an important part of a shared wealth system that also valued dentalium, woodpecker scalps, and white deerskins. These items were important in the ceremonial realm, but also served purely monetary purposes. During the historic period, they were used to purchase wives, settle debts, emphasize social standing, and pay fines for crimes ranging from minor infractions of etiquette to murder and adultery (Hughes 1990, 1978; Heflin 1982, Sampson 1985, Kroeber 1925: 54).

Coastal peoples maintained a vastly different cultural, economic, and religious system from that of northeastern California tribes. Yet, despite these differences, they were closely connected throughout late prehistory by means of extensive exchange networks that served to transport such chemically traceable and archaeologically durable items as obsidian. Once Europeans arrived however, the subsistence, cultural traditions, and demographic profile of these Nations significantly changed. Furthermore, due to the close proximity of sedentary villages, European introduced diseases flourished and devastated coastal tribes.

HISTORY OF CONTACT: INLAND REGIONS

In northeastern California, direct contact arrived much later than in most of the United States, but “there is little doubt that stories of the ‘Bostons’ and the Mexicans had been reaching the peoples of this area for hundreds of years before the first explorers came through” (Allison 1994: 84). The first direct contact between Native Americans and whites in northeastern California occurred through the explorations and trapping expedition of Peter Skene Ogden of the Hudson’s Bay Company. Ogden trapped along the Pit River in 1826 and 1827, and continued his explorations and travels in Modoc County in 1829 and 1830 (Cline 1963).

Ogden’s journal details his journey through the Modoc Plateau of northeastern California during the winter of 1826. Specifically, three entries outline his travels through Modoc territory, which includes Tule Lake, Glass Mountain, most of the Medicine Lake Highlands, and as far east as the shores of Goose Lake.

By December 25, 1826 his party entered territory of the Kokiwas band of the Modoc, Ogden’s journal notes that the Modoc were wearing feather blankets from ducks and geese. Interestingly, Ogden’s guide indicated that the Modoc were at war with the Shasta, a nation ethnographically recorded as trading with the Modoc people (Davis 1961). It is possible that Ogden’s group may have reached the ethnographic villages of Wuka and Welawa’sh just east of Tule Lake (LaLande 1983: 14).

On December 27 they reached the village of Gu’mbat in the southwest corner of Tule Lake. There they were warned of the “cut rocks”, certainly part of Lava Beds National Monument (LaLande 1983: 15). Ogden states that his hunters “corroborate the

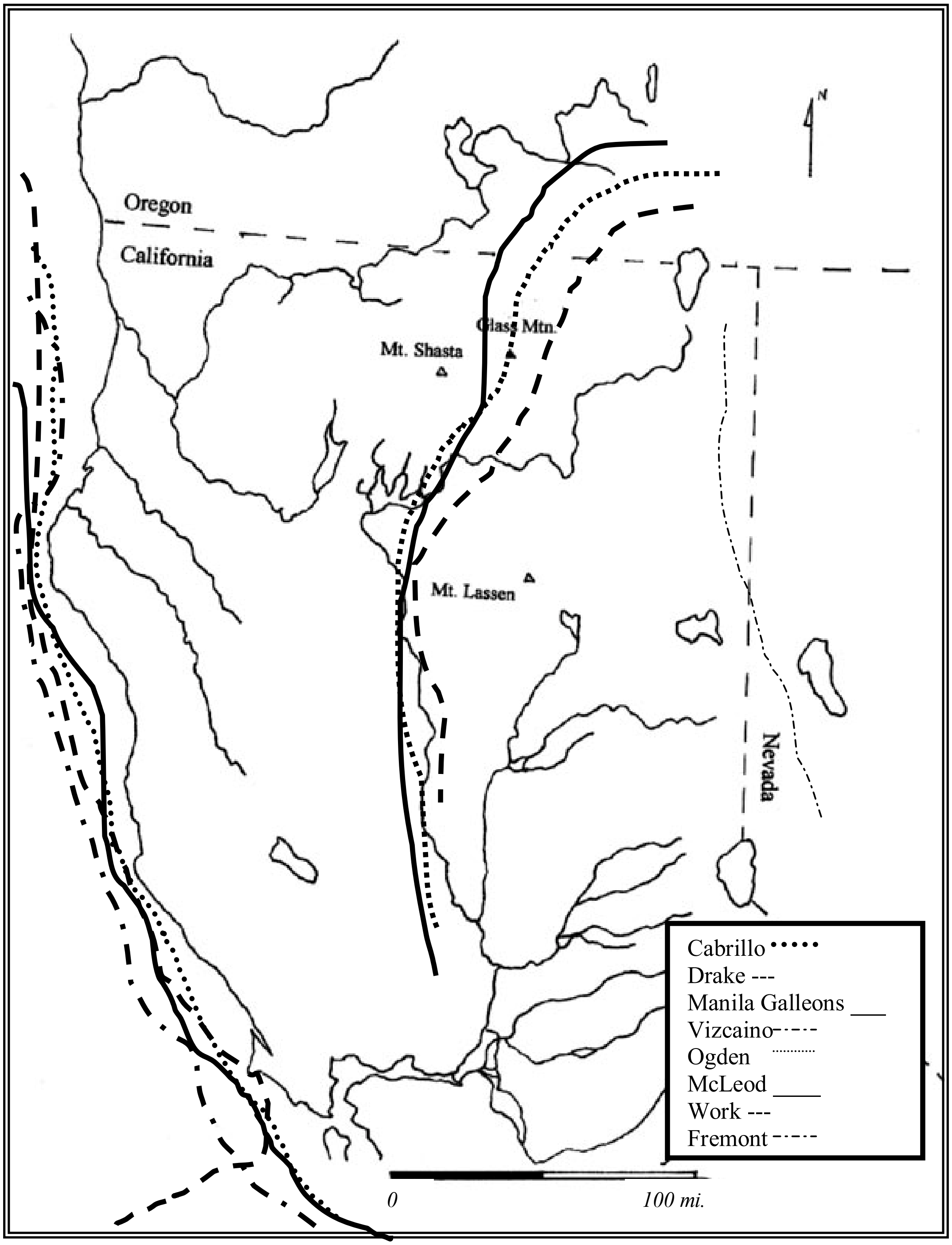


Figure 8.1: Early explorations in Northern California.

account the Indians give us of the advance Country in a South direction being one continued Mountain and cut Rocks" (Davies et al. 1963: 47).

On Thursday, December 28, 1826 Ogden's journal states "altho we persist in making it appear we intend taking a Southern Course they warn us from the Cut Rocks Mountains" (Davies et al. 1963: 47). It is quite likely that the "Cut Rocks Mountains" referred to in Ogden's journal is in fact the Medicine Lake Highland, a region characterized by extensive lava flows and difficult terrain (LaLande 1983: 47). However, Ogden did not heed the Modoc's warnings, and sent out an exploratory expedition to ascertain the possibility of passing through the region. Additionally, Ogden believed the Modoc were hiding information, perhaps the knowledge of rich watersheds for trapping. He states in his journal:

> The men I sent on discovery also made their appearance one reports that following (Course) South with some difficulty but without endangering the lives of our Horses we may reach the end of the chain of Rocks, this is so far satisfactory and tomorrow we shall make the attempt, the others report most unfavorable of the quarter they visited and this is exactly contrary to the accounts I received this morning from the Natives and it appears self evident to me from what we have seen they must have motives for deceiving us as they have done for some time past, it is certainly their intent to keep us amongst them as it enables them to collect few trifles for their Roots, and again they may know where there are Beaver and wish to keep it a secret from us but this we shall soon discover (Davies et al. 1963: 48).

Ogden's expedition passed through portions of the Medicine Lake Highland, but never reached Medicine Lake itself. Instead they continued south and westward, becoming the first to pass over the Siskiyou Mountains. Aside from information provided by their guide, Ogden's journal gives few details regarding their interaction with native peoples in the area.

Alexander McLeod, who is often erroneously given credit for being the first over the Siskiyou summit in 1829-1830, followed Ogden's route south from Oregon to the Sacramento Valley (LaLande 1983). McLeod thus became the second white explorer to travel through northeastern California and engage in contact with Native Americans in the region.

In 1832-1833, John Work of the Snake Country Expedition from Hudson's Bay Company also traveled much of Ogden's route (Cline 1963). He too was looking for rich streams of fur-bearing animals to trap and trade, but did not spend much time in the territory of the Modoc.

John C. Fremont's Second Expedition in 1843-1844 explored some of the Great Basin, including much of Nevada, where he found and mapped the location of Pyramid Lake. Fremont then continued across the mountains into California (Cline 1963). He traveled through Modoc and Pit River territory after crossing the Warner Mountains along the border with Nevada.

Contact between northeastern California Native Americans and whites up until the mid-1840's was thus largely limited to explorations and fur-trapping expeditions. However this quickly changed with the opening of the Applegate Trail in 1846. The trail brought immigrants and livestock through Modoc and Pit River territory en route for the Willamette Valley of Oregon. Native Americans were forced to compete with immigrants for resources, which in the desolate high desert were often sparse to begin with. Livestock, starving from the trek across the deserts of Nevada, devoured grasslands and trampled valuable flora. Immigrants hunted game and displaced wildlife. Some immigrants abandoned their search for the fabled Willamette Valley, and established homesteads in Modoc territory. As a direct result of these disturbances, Modoc and Pit River raiding on wagon trains increased dramatically (Murray 1959: 17). Immigrants also brought smallpox into Modoc territory between 1847 and 1849, providing a reprieve from the raiding, but drastically reducing the Native population. As a last resort, groups banded together to fight white invasion. The Rogue River Indian Wars of 1851-1856 united the Modoc, Klamath, Shasta, Takelma, and others in the struggle to maintain traditional lifeways and homelands (Nilsson and Bevill 1992: 7).

In 1864, a treaty was signed confining the Modoc and Paiute to a reservation with the Klamath on traditional Klamath land. Allison states:

> On October 14, 1864, numerous large communities and numerous assorted individuals of the indigenous peoples were moved from more than 30 million acres, of the extreme northwest corner of the Great Basin and adjacent portions of the southern Cascade Mountains and the southwest corner of the Columbia Plateau, that had always been their home. These people included, but were not limited to several Northern Paiute/Numa 'bands', numerous families of the widespread wetlands communities who became known as the Klamath and Modoc Tribes, and a number of descendants of Modoc, Mollala, Takelma, Latgawa, Shasta, and Pit River people. The 27 leaders of these politically autonomous groups ceded approximately 95% of their 21 million acres of U.S. Government defined land base in a treaty negotiated under military duress by the United States. This and later boundary adjustments resulted in a 'Klamath Indian Reservation' for surviving descendants of these many peoples. This 'reservation' was entirely based on lands that had previously been the exclusive heartland of the Lake people and the Marsh people and several other communities located around upper Klamath River sources in the Sycan Williamson, and Sprague Rivers (1994: 69).

Conflicts quickly developed between the Nations on the reservation, with the Klamath forbidding use of some resources. In 1865, Captain Jack, a young Modoc leader, took a small group of followers from the reservation to reestablish homes along the Lost River, within their traditional territory. Soldiers were sent out to return them to the reservation, but once back with the Klamath, the same problems appeared. Again, Captain Jack fled the reservation, but this time he had 371 people in tow. Due to a lack of soldiers and equipment to round up the renegade Modocs, Captain Jack's group was allowed to remain in the Lost River area. However, in 1871, Captain Jack's niece fell ill. Since the Modoc shaman was unavailable, a Klamath shaman was summoned. He was so certain that he could heal the young woman, that the shaman received payment prior to treatment. The illness proved more severe than expected, and the young woman died. As a result, and fitting with Native law, Captain Jack killed the shaman for inefficiency. However, the local law enforcement and reservation authorities claimed Captain Jack was bound by the laws of the reservation, since he had initially signed the original treaty, and accused him of murder. Captain Jack became a fugitive. Additionally, at about this time, the Ghost Dance was making its way through northeastern California and was performed among the Modoc and on the Klamath reservation. The prophecy behind the Ghost Dance indicated that Indian ancestors would rise from the dead and assist the living in driving out the whites from Native lands.

The war began when Captain Jackson left Fort Klamath on November 28, 1872 to remove the Modoc from Lost River and take them to a newly established reservation at Yainax. However, the Modoc were not willing to leave, and the encounter ended with shots fired and the soldiers destroying the Modoc village. The fleeing Modocs attacked and killed many of the settlers they encountered.

> The Modoc Indian War was the final desperate resistance to the impact of white man's culture on the ancient Indian folkways. It marks the concluding stages of the decline in vigor and numbers among a fierce people, beginning in the early years of the nineteenth century and ending when a band of beaten and spiritless prisoners were forced aboard a Central Pacific Railroad train bound for exile on a tiny reservation in Oklahoma (Murray 1959: 4).

The Modocs took shelter among the lava tube caves and rough terrain of the Lava Beds. Numerous small battles waged over the next six months, with few deaths on the Modoc side. Many of the military leaders, including General Canby, lost their lives in the Lava Beds. Water was available in ice caves within the lava flows, and the Modoc held out until June 5, 1873, at which point Captain Jack was forced to surrender. Captain Jack and his fellow leaders were tried and executed for their role in the battle, and the Modoc people were sent to a reservation in Oklahoma. However, the war provided encouragement to other Native groups, by the success of a small group of renegades against trained and well-equipped soldiers.

> The Modoc War was the most costly Indian war in lives and money in United States military history if one considers the number of Indians involved. When the war was over, the ghost dancing had not stopped. The Indians were not all on reservations. In fact, all Indian tribes in the west were encouraged to resist the army because Jack had been able to do so much with so little. The Indian Service seems to have learned nothing from the affair. And the Army has a cairn of stones standing beside Tule Lake to mark the spot where its leader lost his life (Murray 1959: 81).

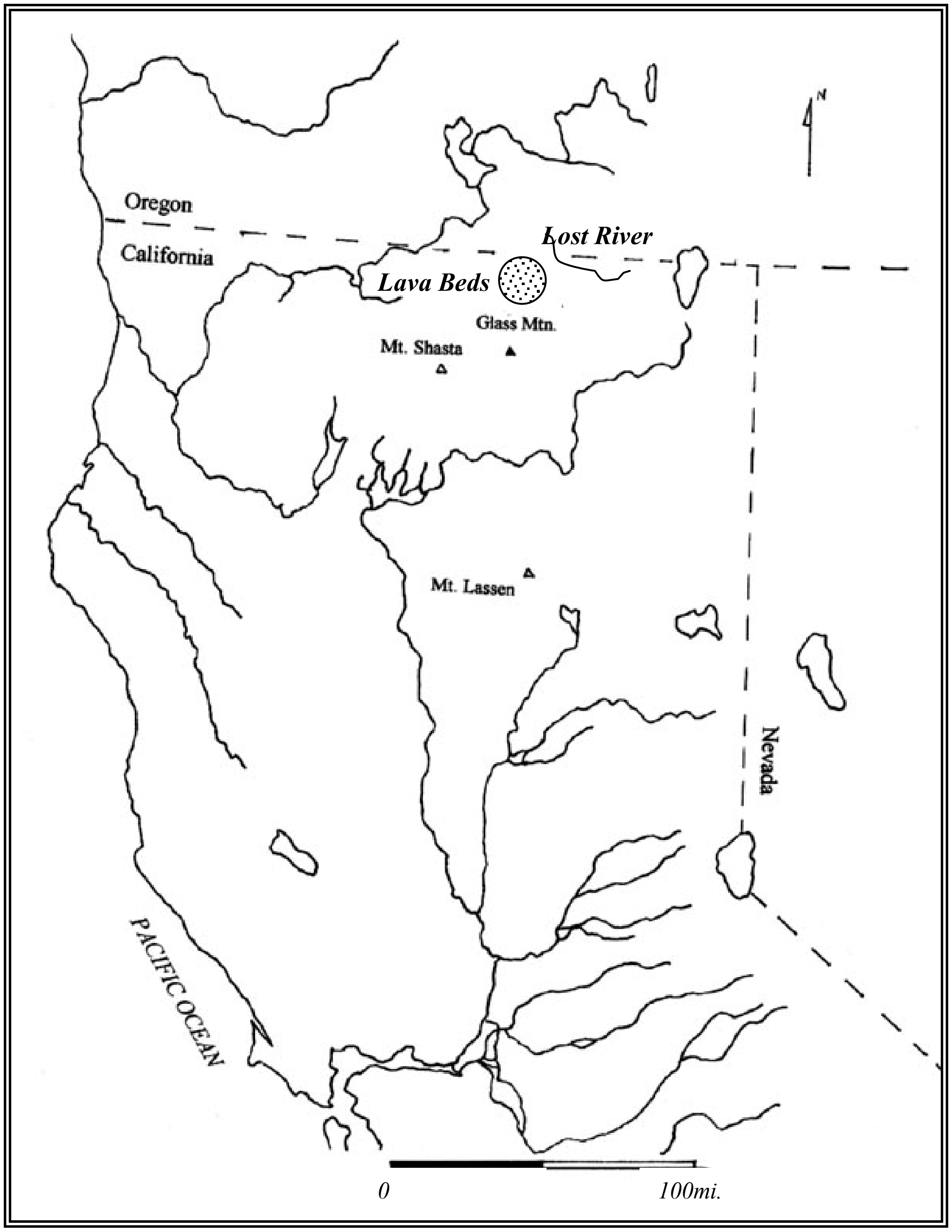


Figure 8.2: Lost River and Lava Beds, northeastern California.

In 1909, the Oklahoma Modoc were offered the option to return to the Klamath reservation, however many had been born and raised there and declined the offer to relocate (Nilsson and Bevill 1992: 7). Currently, many Modoc still remain on the reservation lands in Oklahoma.

HISTORY OF CONTACT: NORTH COAST

The north coast of California was subjected to a series of brief contacts from European and Spanish explorers. This began an ever-increasing flood of exploration, exploitation, settlement, and displacement of Native peoples by Europeans. Such contact, though limited initially, had drastic effects on the health and culture of north coast Nations.

The first significant contact between European explorers and Native Californians was the Cabrillo Expedition of 1542-43 (Erlandson and Bartoy 1995). Cabrillo left Navidad, on the western coast of Mexico, on June 27, 1542 to explore the pacific coast to the north. His first contact with Native peoples in Alta California was at San Diego, where his crew enjoyed six days ashore (Engstrand 1998). From there, they sailed to the Channel Islands, where they sheltered from a storm in one of the harbors. Cabrillo and his crew proceeded north and explored and mapped the coastline, finally pulling ashore at Sardinas, probably Santa Barbara (Erlandson and Bartoy 1995). While at Sardinas, the crew took on supplies of wood and water, and interacted with the local Native population. Some of the Native people may have spent a few nights aboard the ships. Cabrillo's crew then sailed north to further explore the coastline, but winter weather forced them to return to the Channel Islands. Erlandson and Bartoy (1995) state, "it is almost universally accepted that Cabrillo and his men then wintered among the Chumash." During the winter, Cabrillo died from gangrene resulting from an untreated broken arm (Engstrand 1998). In the spring, his crew headed north again, now under the leadership of Bartolome Ferrero. They sailed as far north as the present California-Oregon border, and the crew reached the mouth of the Rogue River, in southern Oregon (Moratto 1973: 37). Unfortunately, due to rough weather and a rocky shoreline, there are no documented landfalls north of Mendocino (Eidsness 1988: 26). However, Native Americans may have witnessed the arrival of these ships, despite the lack of direct communication. Because of poor sailing conditions off the Oregon coast, the expedition returned to Navidad on April 14, 1543 (Engstrand 1998).

The next major contact between Europeans and Native Californians came not from Europe directly, but from the Philippines. Previously, trade between the Philippines and Spain was carried across a long route around the tip of Africa to the Atlantic. As early as 1566, ships began travelling across the Pacific to Mexico, and then on to Spain (Engstrand 1998). However, the ocean and wind currents of the Pacific are not conducive to travel directly east from the Philippines, and therefore ships were required to travel north, then across the Pacific and then south to Mexico. This resulted in contact with California Native peoples. Sailors suffered from scurvy and other diseases, and "for this reason the California coast was looked to as a stopping place where the weak and dying galleon crews could obtain relief" (Engstrand 1998). Coastal people likely had repeated contact with Philippine crews traveling south to Mexico, however it is unknown how far north these landfalls may have occurred. It is possible that contacts between

Philippine and Spanish sailors and Native Peoples along the northern coast of California may have occurred during this time (Engstrand 1998).

Spanish Commander Sebastian Vizcaino and his crew probably entered the Eel River in 1603 in an attempt to locate a safe harbor for Philippine trading vessels. Due to heavy rains, the swollen waters of the Eel resembled a large bay, prompting Vizcaino's investigation. The inlet proved insufficient shelter for the Philippine vessels, but while there, Vizcaino encountered local Native Americans "who offered fish, game, hazelnuts, chestnuts, and acorns" (Eidsness 1988: 26) and noted "boats made of 'pine and cedar'" (Moratto 1973: 37).

The first English contact with the California coast took place in 1579. Francis Drake reached what was probably Coast Miwok territory in northern California on June 17, 1579, and explored as far north as Humboldt Bay, however Eidsness states "landfall… is unlikely, probably because they failed to discover the entrance to Humboldt Bay, which lacks obvious landmarks and is often shrouded in fog" (1988: 26). Records regarding his expedition are minimal, but it appears that he engaged in "friendly and frequent contact" (Engstrand, 1998) with the Coast Miwok. There is some dispute regarding the exact landfall location of Drake's crew during this summer, though Heizer makes a strong argument for Drake's landing at Drake's Bay.

> The ethnographic evidence indicates strongly, indeed almost conclusively, that Drake landed in territory occupied by Coast Miwok Indians. Since Pomo culture and Coast Miwok Indian culture were so similar as to be almost indistinguishable… no solution would be forthcoming were it not for the additional fact that all the unquestionably native words [recorded in historic documents] are of Coast Miwok derivation. It may therefore be concluded that

> Drake had contact mainly with the Coast Miwok (Heizer 1947: 278).

In 1775, two ships commanded by Bruno de Heceta traveled north from Mexico. One of these vessels landed at Trinidad Bay, and remained from June 9th to 20th. During this time, sailors had contact with the Yurok and noted aspects of their material culture. Of particular interest is the observation that metal implements, particularly knives, were already in use, despite limited European contact (Moratto 1973: 38, Curtis 1924: 39-40).

In 1792, English Captain George Vancouver and his fleet explored the Pacific coast, landing in Trinidad Bay from May 2nd to 5th. The Russians also began exploring and trading along the northern California coast. Between 1803 and 1805, American vessels carrying Russian and Native Alaskan laborers explored the Humboldt Bay region with the ultimate goal of finding a site for occupation (Moratto 1973: 38).

By the early 1800's, fur-trading activity became a major draw for European trading vessels in the northern California region. Johnathan Winship led a massive sea otter hunting expedition in northern California in 1805, beginning in Trinidad Bay and including other coastal otter colonies. By 1809, local sea otter populations were decimated and many local Yurok villages abandoned (Moratto 1973: 38). Fur trapping and trading remained the major European economy in the region until gold was discovered in 1848.

In 1848, gold was reported along the Trinity River in northern California. A rapid influx of miners swelled the population of Trinity and Siskiyou counties, and conflicts between Native Americans and whites soon erupted. In 1850, the lack of large, permanent white settlements in the regions between the Columbia River and Fort Ross

(Moratto 1973: 40) prompted explorations of the Klamath River. Explorers searched for a water route to isolated mining camps. The increased population densities, and widespread exploration of vital river basins led to violence and strained relations between Indians and whites. Yurok and Tolowa traditions frowned on violence, and therefore they were reluctant to engage in conflict with white settlers. However, "tensions increased as hydraulic mining upstream silted the rivers and diminished the salmon runs" (Moratto 1973: 41). These tensions escalated into open hostilities between whites and Native Americans. Miners congregated into larger settlements in anticipation of attack, and Indians sent families into hiding in the mountains. Some miners destroyed Native villages and raped Native women. Yurok and Karok warriors attacked the mining town of Weitchpec in retaliation and killed six men. The establishment of the Klamath River Indian Reservation in 1855 averted outright warfare between the two groups temporarily. However, hostilities continued and culminated in the Gunther Island Massacre on February 25, 1860 when approximately six white men attacked the Wiyot village there and killed and mutilated 188 people (Moratto 1973:47, Loud 1918: 331).

Raiding continued into the mid-1860's, at which point Colonel H. M. Black was sent out to end the 'Indian problem'. He took approximately 350 Indians captive during his escapades in the region (Moratto 1973: 50). By 1870, many of the local Native Americans had been removed to reservations at Hoopa and Round Valley, limiting their contact with white settlers. This event marked the end of significant raiding and conflict in the northern California coast, and reservation life only served to further limit traditional practices and subsistence.

BIOLOGICAL EFFECTS OF CONTACT: HEALTH AND DISEASE

It is generally assumed that California's Native peoples remained relatively isolated from European diseases before direct contact with early explorers or missionization. Preston (1996) however, states that it is unreasonable to think that California could have remained isolated to diseases sweeping through the rest of the continent during the early contact period. The smallpox epidemic that ravaged much of Central and South America could easily have traveled northward to California through trade routes and population centers of the Southwest. As a result, the population estimates of pre-contact California may not accurately represent prehistoric demography. Early explorers to California could have easily brought other European diseases to Native groups before the mission period, but some bioarchaeologists disagree with this point. Clark Larsen (1999: personal communication) suggests that diseases do not travel through populations as easily as Preston implies, particularly among mobile hunter-gatherers. Walker cites anomalies in population pyramids for early contact period Chumash groups as possibly indicating a short-term decline due to disease, however there is little other evidence to support the introduction of European diseases prior to extended contact (1999: personal communication, Kealhofer 1996).

Sherborne Cook (1955) indicates that an epidemic struck southern Oregon and northern and central California between 1830 and 1833. Unfortunately, it is difficult to determine the type of illness, based on ethnographic records, but he concludes that it was possibly malaria, first introduced by the ship *Owyhee* from Boston that arrived at Fort Vancouver in 1829. Malaria was then carried by infected individuals south to the Sacramento River valley, where it was spread by mosquitoes. On August 21, 1832 the expedition of John Work set off south from The Dalles past Klamath Lake and down the Pit River to Red Bluff, Sacramento, and into the territory of the Maidu. Many of the men were already sick with malaria when they departed from Oregon. Work documented densely populated villages during the winter in the early part of his expedition, but by the summer months mentions that villages were largely deserted and the few inhabitants remaining were suffering from illness. Cook also speculates that Ogden's expedition may have contributed to the spread of the disease. This epidemic devastated Southern Oregon, northern California, and Sacramento Valley populations, killing perhaps 75 percent of the Native inhabitants and causing the survivors to abandon many villages "thus creating the impression of total extermination" (Cook 1955:315).

The missions provide a well-documented source of information on disease and health in the contact period for Southern and Central California. One of the most notable diseases to affect the missions was syphilis. It was generally spread from the Spanish soldiers to Native women and then to the rest of the population (Levy and Claassen 1992:113). Syphilis did not kill its victims outright, but instead inhibited reproduction, infected newborns, and easily spread through sexual contact. As a result, a large percentage of the mission population was affected with the disease, and low reproduction rates followed (Jackson and Castillo 1995, Walker and Johnson 1992, Crosby 1972).

Sexual contact between soldiers and Native women was common on the Klamath reservation as well, and it is plausible that syphilis was a common affliction. Meacham, Indian superintendent of the area including Klamath reservation was horrified by conditions he found on the reservation.

> He was scandalized at their [reservation agents] morals. He reported one of his agents as saying 'that he thought the best way to civilize Indians was to *wash out* the color,' an expression implying that interbreeding between whites and Indians was the solution to the Indian question. Meacham observed dryly that some of his agents 'had accomplished what they were able to in that line' (Murray 1959: 45).

European settlers introduced smallpox to the Great Basin Indians between 1847 and 1849, killing a large percentage of the population. The Modoc were among the tribes affected, and an estimated 25 to 50 percent of the population perished (Murray 1959: 18). Those weakened through hunger, other illnesses, or old age were the hardest hit by the epidemic. Tribal elders traditionally held positions of leadership and prestige within the community, and their death wreaked havoc on the political structure of Native American bands (Dobyns 1983). White immigrants travelling through the region were thankful of the reprieve granted by the epidemic, for many Indians were too ill to cause serious damage through raiding. Murray states that during the epidemic, "the South Emigrant Road was open and safe" (1959: 18). However, after two years of free passage, "a government report … asserts that eighteen whites were killed in 1849 as notification that the Modocs were back in business" (Murray 1959: 18).

Few archaeological studies have been completed in north coast California regarding health as seen through skeletal remains. Many of the north coast tribes practiced cremation of their dead, and so skeletal material is often unsuitable for such studies. Walker (1986) has performed the most extensive analyses, though these apply to the Chumash of the Channel Islands. However, since north coast peoples relied on many of the same food resources, we may speculate that some of the same health conditions were shared across most of coastal California.

Walker has found high percentages of porotic hyperostosis in late prehistoric and pre-contact historic period Native populations from the Channel Islands and adjacent mainland coastal sites. Porotic hyperostosis is the result of iron deficiency anemia and is generally associated with maize-based agriculture in prehistoric populations. However, in the Channel Islands, maize was not grown and, unless traded in to the region from the American Southwest or Colorado River region, not consumed as part of the inhabitants' regular diet. Therefore, iron deficiency anemia must have been caused by other factors.

There are four possible causal factors resulting in porotic hyperostosis in Channel Island and adjacent mainland populations: prolonged breast-feeding, weanling diarrhea, fish-borne parasites, and protein-calorie malnutrition (Walker 1986). Prolonged breast-feeding contributes to anemia due to the fact that human breast milk is low in iron. Breast-feeding for longer periods can deprive infants of sufficient amounts of iron early in life. Weanling diarrhea probably resulted from contaminated water sources on the Channel Islands, though mainland sites likely had more freshwater sources, and thus might not have been as susceptible to this cause of childhood anemia. Ethnographic evidence suggests that Channel Island and adjacent mainland populations consumed considerable amounts of sea mammal, fish, and shellfish, and preferred the meat raw, and this might have also been the case for northern California coastal peoples. It is likely that they fell victim to many parasites in uncooked meat. Finally, protein-calorie malnutrition may have resulted from periodic food shortages and starvation. Walker states that there is some evidence for increased incidence of cribra orbitalia during warm water periods, which may have limited marine resources (1986).

Northeastern California tribes also cremated their dead, and so we are left with few adequate skeletal remains with which to conduct analyses of health and disease. Ethnographic documentation, as cited above, provides insight into disease and malnutrition that may have affected northeastern California peoples.

Disease and poor health resulting directly from European contact greatly weakened northern California populations. Vast numbers of villages were depopulated due to disease, causing social and economic chaos and weakening the traditional structure of Native California. Additionally, depopulation may have disrupted regional trade and exchange and destroyed long distance relations between northern California Nations.

ENVIRONMENTAL EFFECTS OF CONTACT

Encroachment of white settlements and emigration impacted the fragile environmental balance of northeastern and northwestern California. Beginning with early explorers and immigrants, livestock fed on meadows and wetlands in the northeastern part of the state. Immigrants arriving from the east grazed their cattle and horses, starved from a trek across the barren Nevada deserts. Large cattle drives began in the 1840's and 50's in the area of the Applegate Trail. These ravenous ungulates transformed local vegetation and affected the ecological balance.

> Within a few years of 1850, the increased pressure of grazing herds of European cattle caused a serious depletion of the grasslands that contained much of the vital foods and fibers that were the heart of the indigenous economy. Sheep drives further depleted the resilience of the grasslands and marsh-margins and added to the erosion channels around springs and streams. About 150,000 sheep ranged in Surprise Valley in 1920 (Allison 1994: 84).

Once settlers arrived in Indian lands, they often maintained the right to exclusive use of their landholdings. Fences and rangeland hindered the movements of wild game species and destroyed native plant resources, and settlers intentionally and unintentionally introduced non-native plants to the area. Settlers and immigrants also hunted and trapped animals important to Indian subsistence. For example, Ogden and Work, both early explorers of the Modoc Plateau, were seeking beaver pelts for trade on behalf of the Hudson's Bay Company. "The variables introduced into the Indian seasonal rounds by settlers' protective attitudes toward private lands in prime gathering areas and the depletion (and in some species, near extinction) of game caused by trappers also rendered a formerly adaptive subsistence strategy ineffective" (Raven 1980: 12).

On the north coast of California, the situation was very similar. Early hunters and trappers had a dramatic effect on the fur-bearing animal populations. Johnathan Winship led a massive sea otter hunting expedition in northern California in 1805, beginning in Trinidad Bay and including other coastal otter colonies. By 1809, local sea otter populations were decimated and many local Yurok villages abandoned (Moratto 1973: 38). "Trade in sea otter furs attracted American, Russian, and British ships to the north coast over the next decade. Following the depletion of sea otters, overland expeditions by British and American trappers were conducted more regularly, mostly in the interior valleys" (Eidsness 1988: 27), which in turn further impacted Native populations.

In 1848, gold was reported along the Trinity River in northern California. The large influx of miners affected the region through hunting and settlement, however mining operations had a negative effect on the environment as well and directly affected the Native American livelihood. Mining spoils silted the rivers and dramatically decreased salmon populations (Moratto 1973: 41), which were a major subsistence resource for many northern California peoples.

Environmental impacts of contact had a significant effect on Native Americans in northern California. Settlers, miners, and livestock reduced available food resources and thus created a situation that may have encouraged raiding. Furthermore, malnourished and undernourished people were particularly susceptible to disease, another impact of European and Anglo-American contact.

ECONOMIC EFFECTS OF CONTACT

Contact had a significant effect on the economic systems of northern California peoples largely through the introduction of European goods and horses. One example of this type of effect is documented for the Chumash of the southern California coast. In prehistoric times, extensive trading linked coastal island villages with interior peoples, and provided not only interaction with other groups, but an important mechanism for the procurement of terrestrial resources. Once the Spanish arrived, glass beads became the primary form of payment and exchange, replacing the shell beads previously used in Chumash trade networks. These glass beads were of higher value than Native produced beads. Additionally, other European items such as clothes, blankets, and metal objects were also highly desired, and these new goods quickly disrupted traditional exchange networks (Johnson 1998). In northern California, where exchange networks were vital to the wealth systems of coastal peoples, we may imagine that European goods to some degree disrupted the value systems there as well.

Among the tribes of northeastern California, European contact increased raiding and exchange capability through the introduction of the horse. Layton (1981:128) speculates that introduction of the horse may have occurred by the late seventeenth century. Use of horses permitted increased mobility and allowed northern California people to participate in the trading systems of the Pacific-Plateau (Columbia River) and Middle-Missouri.

Peter Skene Ogden of the Hudson's Bay Company was the first European to visit and describe the Klamath. He observed that by 1826, they were already living in defensible houses in wetlands accessible only by canoe and that he saw one horse at the Klamath village. Layton suggests that these defensive structures were a direct result of raiding parties to the north. However he states that "they, in turn, learned to prey upon their California neighbors to the south" (1981: 128). These raiding expeditions were seeking slaves for trade to the north.

The Modoc also raided their neighbors, particularly for slaves who were then traded at the big trade fair at The Dalles on the Columbia River. Gatschet states that the Klamath and Modoc "would surround the camps, kill the men, and abduct the women and children to their homes, or sell them into slavery at the international bartering place at The Dalles…. The Hot Springs and the Big Valley Indians [Pit River] were the principal sufferers of these incursions. In a raid of 1857, fifty-six of their women and children were enslaved and sold on the Columbia River for Cayuse ponies, one squaw being rated at five or six horses and a boy, one horse" (1890: ix-x).

> The Astariwa [Pit River] had always been prey to the raids of Modoc warriors. The northernmost part of Astariwa territory was a kind a buffer zone from their unfriendly

> neighbors, who would have to walk many rocky miles to get to the major villages near the rim at Warm Springs Valley. Two factors after 1850 destroyed this uneasy peace. The Modoc acquired horses, which greatly increased their mobility, making the journey to Warm Springs an easy jaunt, and facilitating the capture of the horseless Astariwa. Also Ray records three Modoc village sites occupied between 1850 and 1865 that are well within most recognized Pit River boundaries, and this cocky imperialism made the trip shorter yet. And the risk of attack was made much more worthwhile by both the decimation and vulnerability of the Astariwa at this time and the ready market for slaves at The Dalles where Willamette farmers were clamoring for free labor (Raven 1980: 8).

Northeastern California tribes utilized northern and eastern trade routes. The northern route went to The Dalles through an intermediate node at Yainax Butte near the Oregon border, 30 miles east of Klamath Lake. The Yainax node served as a local trade center for northeastern California and southern Oregon tribes. Columbia traders sometimes came south to trade at Yainax for slaves from the Klamath and Modoc, and tribes from the Snake may have also participated. Predatory bands of Snake Indians are documented as living in the Warner Valley for perhaps 37 years, preying on immigrants and Indians. The eastern route went through the Humboldt River with an intermediate node at Humboldt sink (Layton 1981: 129). This route probably connected northeastern California tribes with peoples on the California coast.

Long distance trade connected Columbia River Indians to groups as far south as Sacramento. Since traders had to pass through Klamath and Modoc territory to get there, Layton speculates that the Klamath perhaps acted as middlemen between California and Columbia River peoples. It appears that such widespread trading was probably purely a protohistoric/historic period phenomenon. Smaller trade networks did exist prehistorically, but horses allowed for coverage of greater distances. Horses appear to have been introduced to northern California Native Americans prior to direct contact with European explorers and settlers (Layton 1981).

There is little archaeological research into the adoption of European goods and economies during the protohistoric and early historic period in northeastern California. Much of the data to date was recorded through ethnographic research (Kroeber 1936: 29-38, Kniffen 1928: 55-59), rather than archaeological excavations. In some instances, archaeological surveys have recorded sites that may represent ethnographic villages from the early historic period; however there has been little research on contact period sites in the region (Gates 1999: personal communication).

WARFARE

Conflicts between Native Americans and white emigrants resulted in numerous deaths on both sides. However, Murray notes that these tales of savagery were greatly exaggerated. He states:

> It is impossible to state accurately how much damage was done to the trains. Since the Modocs did more damage than any of the other Northern California Indians, legend later ascribed many killings to them that never took place. Claims of damage were often based on the wildest of rumors. Killings to the number of 350 were laid at the door of the Modocs, but this number included people killed well outside of Modoc territory – along the coast, in the Umpqua and Rogue River valleys, at the head of the Deschutes, and even on the Colombia. Tales were told and widely believed that men had been killed and mutilated, that children had their heads struck against a rock or had been carried into captivity, and that maidens had been ravished and then burned at the stake over sagebrush fires by cruel captors. The legends ran the gamut of the popular 'down-with-the-redskin-

> varmint' tradition. In the minds of the frontiersmen, the Modocs were the worst of all Indians for depravity (1959:17).

By 1850, the population of miners in northern California was so high that altercations were inevitable. Indian raids for livestock and horses were punished by vigilante parties seeking revenge. A young miner named Ben Wright quickly made a name for himself as a ruthless and successful Indian hunter. He led several successful sorties against the Modoc and Shasta peoples. Ironically Wright "became more Indian than the Indians themselves. He let his naturally curly hair grow long – Indian style. In his fights with the Indians he copied the deeds of his enemies and mutilated the bodies of his victims. He took scalps… He boasted of the fingers and noses he had cut from the bodies of the dead and wounded Indians" (Murray 1959: 21). Such actions on the part of the whites resulted in deep bitterness and hatred from Native Americans.

The Achomawi and Atsugewi, otherwise known as the Pit River tribes were also victims of white attacks. Lt. Crook started a war against the Pit River in 1857, resulting in many fatalities. However, his reports were certainly exaggerated. Raven notes sarcastically that "A quick tally of the reported numbers of Indians killed during the campaign which promoted Crook to General indicates that he killed every possible Pit River Indian alive at that time at least twice during his forays" (1980: 7).

Small battles continued between raiding Native Americans and white settlers in the northeastern California plateaus. In the northwest, cultural traditions frowned upon warfare and in some ways limited the amount of raiding along the coast. However, tensions still existed. It was not until miners attacked Native villages and raped Native women that Yurok and Karok warriors attacked the mining town of Weitchpec, killing six men. On February 25, 1860, whites fought back by attacking a Wiyot Village on Gunther Island and killing 188 people (Moratto 1973:47, Loud 1918: 331). In the mid-1860's, Colonel H. M. Black began attacks against coastal tribes, and killed or captured hundreds of Native people (Moratto 1973: 50). By 1870, many Native Americans were resettled on reservations at Hoopa and Round Valley, which limited their contact with white settlers.

Attacks between whites and Indians, in some cases escalating into outright warfare resulted in numerous deaths on both sides. Consequently, there was a drop in the male population of Native villages, and when combined with other factors such as disease and hunger, greatly affected the demographic profile of northern California Native Americans. These skirmishes also compelled European settlers to clamor for Indian reservations as a way to remove the Native American threat.

NATIVE CALIFORNIAN RESISTANCE

Much of the existing documentation of Native American resistance in what is now California comes from mission records, though many of the ways in which mission Indians fought the Spanish missionaries, both in active and passive forms, were not unique to the California missions. However, the written records from priests and visitors to the missions along with archaeological evidence provide excellent sources of information on the mechanisms used by Native Californians to assert their resistance to European influence.

Native American resistance in the southern and central regions of California, where missions were established, was enacted in two distinct waves, referred to as primary and secondary resistance. Primary resistance was the first resistance to the initial establishment of the missions. This form of resistance was generally a localized occurrence, and was organized like traditional Native American warfare in that village chiefs and religious leaders often led the attacks (Jackson and Castillo 1995: 73). For example, in San Diego, the Kumeyaay directly attacked a Spanish camp in 1769. The Spanish mistakenly thought it was an attempted raid on their supplies, however it was more likely retaliation for rape of Native women and the destruction of crops and food resources. The Kumeyaay wanted to wipe out the Spanish, who were perceived as powerful shamans (Jackson and Castillo 1995). This type of primary resistance effectively slowed the establishment of missions because it necessitated the protection of the missions by Spanish soldiers, who were expensive to provide and often in short supply. However, soldiers, once they did arrive, possessed superior weaponry and horses, and in many cases were very effective in protecting the missions from Native American attacks (Jackson and Castillo 1995: 74-76).

After the establishment of the missions, secondary resistance worked from inside the mission system. Often individuals who were either born in the missions, or were brought in as converts, instigated this resistance movement. In many cases, Indians who commanded positions of power and influence in the mission system led the resistance (Jackson and Castillo 1995: 73). One of the most common forms of resistance was flight from the missions and murder of the Spanish missionaries. For example, in 1795, at least 280 people fled the San Francisco mission, and in 1796, an additional 200 fled San Francisco. Some of these refugees established villages in the more remote interior regions of California, while others joined existing villages (Jackson and Castillo 1995: 77-79). In

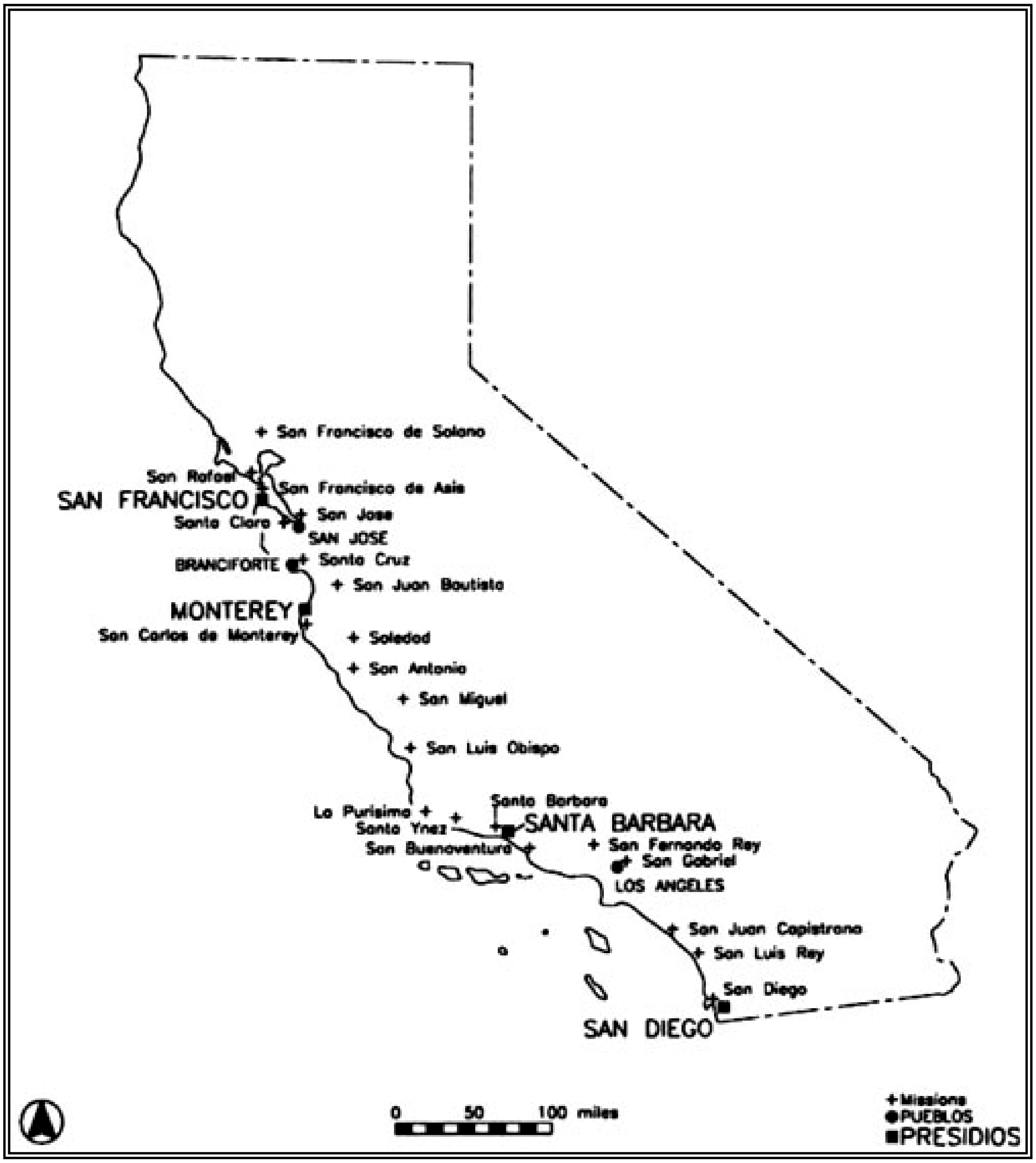


Figure 8.3: California Missions (Kealhofer 1996: 66).

1811, Fr. Panto at the San Diego mission was poisoned by the cook Nazario after Nazario had been subjected to harsh punishment by being given 124 lashes in a 24-hour period (Jackson and Castillo 1995: 80).

Secondary resistance was accomplished by both active and passive resistance. Active resistance included violent uprisings, flight, murder, and raids; while passive resistance often included noncooperation, work slowdowns, theft, or destruction of property. Little infrastructure existed in the Native mission community within which to effectively establish an armed force to fight the Spanish. However, Native peoples used whatever means they could to inhibit the efficient functioning of the mission system.

Active resistance was rare, but did occur. For example, the Ipai and Tipai of San Diego attacked the mission. The attacking force was a group made up of nine villages with an army of eight hundred. The Ipai and Tipai were angered at the Spanish intrusion into their territory and several incidents of rape of Native women. The Native people demanded Spanish goods in exchange for the use of their land, and attempted to seize these goods by force. The attackers planned to simultaneously destroy both the mission and the presidio, but an early charge on the mission caused them to halt the campaign against the presidio for fear that the army may have been alerted. The Ipai and Tipai were successful in destroying the mission, but not in driving the Spanish from their land. Several small skirmishes followed, but none were of the magnitude of the first attack. In the end, mission was rebuilt and the Native leaders who coordinated the attack were arrested and executed (Castillo 1989).

Another large uprising occurred among the Quechan people of the Colorado River drainage area. Spanish trade routes to Alta California ran through this area, and eventually two pueblos and missions were established in the heart of Quechan territory. The Quechan attacked both pueblos, killing 55 Spaniards. The revolt was largely successful in that it drove the Spanish from Quechan territory and broke the trade route between New Spain and Alta California (Castillo 1989).

A female shaman named Toypurina planned a third attack at the San Gabriel mission. Several villagers joined her, including the chief of a neighboring village. However, the plot failed when mission sentries were warned of the impending attack. Toypurina was exiled from the area by the Spanish missionaries (Castillo 1989).

Finally, a large uprising among the Chumash included Native Americans at La Purisima, Santa Ines and Santa Barbara missions. La Purisima mission remained in rebel hands for several weeks, but eventually fell to Spanish cannons (Jackson 1998). Many of the rebels fled to the interior of California, where they re-adopted traditional ways. However, most fugitives eventually returned to the missions, rather than remain in exile. Interestingly though, 10 years later, Joseph Reddeford Walker's trapping party encountered a rebel Chumash sanctuary with a population of about 700 to 800 people along the rivers of northeastern Kern County. The community subsisted on farming crops such as corn, pumpkins, and melons, and engaged in horse-trading (Castillo 1989).

Another form of resistance was through assassination of mission priests. Priests at San Miguel and San Diego were poisoned, and a priest at Santa Cruz was strangled. All the assassinated priests had reputations for being particularly sadistic in punishing Native laborers (Castillo 1989).

Additionally, fugitivism was another method of resistance to Spanish missions. Often Native people would leave the mission to visit relatives in their traditional lands and would not return. In other cases, runaways took advantage of lax supervision and escaped. Unfortunately, Spanish intrusion had so affected the environment that many runaways had difficulty subsisting outside the missions. Some attempted to join other villages, but brought Spanish diseases with them. Also, Spanish soldiers rounded up runaways and any other Native Americans they could find and brought them back to the missions, making fugitive communities particularly dangerous places. Finally, runaways were punished severely after they were returned to the missions (Castillo 1989).

Passive resistance to Spanish missionaries and soldiers was far more common. Many instances of resistance, such as work slowdowns or feigned illness were minor. However other types of passive resistance were far more severe.

One form of passive resistance practiced by Native women is the act of abortion and infanticide. Missionaries desperately wanted Native women to reproduce to replenish rapidly diminishing populations. However, a number of factors ranging from disease to living conditions hampered reproduction. Therefore, the practice of abortion and infanticide frustrated mission priests. Thus, reducing the number of surviving children served as another form of resistance to the Spanish (Castillo 1989).

Finally, clandestine resistance to Christianity can be seen in the form of graffiti found inside the buildings of five missions, including the church at San Miguel. Some of the graffiti forms at San Juan Capistrano include depictions of Tobet, the Juaneno god. Additionally, it has been suggested that the faces of Jesus’ tormenters in a mural at Mission San Fernando resemble those of the Indian overseers. Additionally, the retention of Native superstitions and dances emphasizes the importance of traditional beliefs. Such resistance suggests some continuation of Native religious beliefs (Castillo 1989).

CULTURE CONTACT AND THE USE OF GLASS MOUNTAIN OBSIDIAN

Use of the Glass Mountain obsidian source overlapped with initial European contact in northern California. This period was a time of drastic change for Native peoples, resulting in demographic, religious, cultural, and economic upheavals. Direct contact impacted coastal Nations first, while northeastern California groups remained relatively isolated until the 1800's. However, once contact did occur, disease, warfare, and cultural turmoil soon followed.

The direct effects of contact on the use of Glass Mountain obsidian and obsidian bifaces are most obvious in the apparent dichotomy between archaeological and ethnographic records of biface use in the past. Archaeologically, obsidian bifaces are found in burial contexts in northwestern California (Hughes 1978, Goldschmidt and Driver 1940, Heflin 1982). However, ethnographic records indicate that bifaces are not buried with their owner upon death, but instead passed down as heirlooms within a family (Kroeber 1925, Rust 1905). One possible explanation for this dichotomy may be that during prehistoric times, personal property such as bifaces was in fact truly personal property, to be buried with the owner upon their death, and this may have been the ultimate act of conspicuous consumption, in effect raising the status of the deceased. Bifaces were taken out of the system of wealth, ceremonial display, and exchange, and entered a new system of remembrance and pedigree. By burying bifaces with the deceased, descendants enhanced the status of their dead ancestor and as a result, increased their own status as well.

After the demographic and social upheavals associated with contact, the traditional pattern of burying bifaces ceased. Previously, the memory of a prestigious ancestor would remain in the oral histories and stories of a society, however, with the vast population decline, and social and geographic upheaval associated with European diseases, there was no guarantee that a high-status ancestor would be remembered. Therefore, it became necessary to retain possession of obsidian bifaces and other status and wealth objects as tangible evidence of a family's prestige. Thus bifaces became family heirlooms and symbols of status for a family line.

Furthermore, declining population densities with European contact may have relaxed territorial controls and potentially increased access to the Glass Mountain obsidian source. Immigration by way of the Applegate Trail brought white settlers into northeastern California, and introduced smallpox to an already weakened population. Records indicate that a smallpox epidemic between 1847 and 1849 provided settlers with a reprieve from Modoc raids along the Applegate Trail (Murray 1959: 17). It is therefore likely that territorial defense also decreased during this time, and access to Glass Mountain may have been more open in the mid-1800's than during any previous time period.

Contact had a significant effect on the economic systems of northern California peoples through the introduction of European goods and horses. In southern California, European goods replaced traditional prestige items such as shell beads. Once the Spanish arrived, glass beads became the primary form of payment and exchange, replacing the shell beads previously used in Chumash trade networks. Other European items such as clothes, blankets, and metal objects were also highly desired, and these new goods quickly disrupted traditional exchange networks (Johnson 1998). In northern California, where exchange networks were vital to the wealth systems of Coastal peoples, European goods may have disrupted the value systems there as well, however there exists scant evidence for any particular object truly replacing obsidian bifaces as wealth and prestige objects in the White Deerskin Dance.

Among the tribes of northeastern California, European contact also increased raiding and exchange capability through the introduction of the horse, which may have occurred as early as the late seventeenth century (Layton 1981: 128). Use of horses permitted increased mobility and allowed northern California people to participate in the trading systems of the Pacific-Plateau (Columbia River) and Middle-Missouri. Potentially, the horse could have vastly increased the range of northern California exchange systems, and allowed for direct procurement of valuable materials such as Glass Mountain obsidian.

CONCLUSION

Contact between Native peoples and Europeans in northern California had a dramatic effect on culture, health, and demography (Lightfoot and Simmons 1998:165). Studies of culture contact and its effects give us insight into the changes that shaped later, historic Native and European culture in the region.

Direct effects of contact on Native culture included disease, environmental impact, increased warfare and raiding, and economic impacts. Indirect effects probably included disrupted trade networks, social and political chaos, changes in mobility and slave raiding due to the introduction of the horse, and the adoption of European goods and cultural traits into the Native way of life.

The study of culture contact requires the united efforts of linguistics, archaeology, history, bioarchaeology, and other sciences to glean a more comprehensive view of the past. As Lightfoot states "culture contact studies may revitalize holistic anthropological approaches that consider multiple lines of evidence" (1995:199). By examining both late prehistory and early historic periods, through a variety of techniques, diachronic changes are apparent in both Native and European cultures as a direct result of contact.

CHAPTER 9

THE GLASS MOUNTAIN ARCHAEOLOGICAL PROJECT

INTRODUCTION

Extensive archaeological survey and sampling at Glass Mountain was designed to investigate quarrying and production behaviors with a goal of determining the types of objects produced at Glass Mountain and the knapping stages represented. Fieldwork for the Glass Mountain Archaeological Project was conducted with three main purposes in mind: first, to identify and record archaeological sites along the glass flow margins; second, to document lithic production or retooling at Glass Mountain; and third, to collect archaeological and geological samples for geochemical characterization and obsidian hydration dating. These goals were accomplished using a combination of archaeological survey, test excavation, and sampling. Production at Glass Mountain was atypical, and suggests that Glass Mountain was predominantly used for large biface production. The results of this fieldwork are ultimately used to support the hypothesis that there existed cultural beliefs about the suitability of particular raw materials for specific types of objects.

The fieldwork was conducted during the summers of 1999 and 2000, with a two-year total of 6 months in the field. Sixteen undergraduate and graduate students participated in the Glass Mountain Archaeological Project. Laboratory analyses, reports, and funding applications were completed during the winter months.

ARCHAEOLOGICAL SURVEY

The archaeological reconnaissance of Glass Mountain was conducted during the months of June, July, and August of 1999 and July and August of 2000. Over 15 linear miles were systematically surveyed around the base of the glass flow (figure 9.1). Random surface survey was also conducted on the top of the glass flow in places where access was not too limited due to steep crevasses and large obsidian spires. Ground visibility on the top and at the base of the glass flow was excellent, due to minimal soil development and extremely sparse vegetation, permitting very thorough surface survey coverage. Snow occasionally obscured visibility in some areas, but these sections were noted and revisited later in the season.

At the base of the glass flow, surveyors employed transects spaced 10 meters apart and walked parallel to the edge of the flow. The surveyor closest to the flow walked in the slope toe, and the remainder of the crew adjusted positions to maintain 10 meter spacing. In undisturbed or relatively flat areas, it was desirable to expand survey coverage further out from the glass flow. Therefore, in such instances, the distal member of the survey team tied flagging along their initial survey line, and a second sweep was covered, using the flagging line as a point of reference. Depending upon the number of persons in the field and the number of sweeps made across the survey area, the total coverage extended between 30 meters and 300 meters out from the base of the glass flow. Areas of 30 meter coverage were those in which active pumice mining abuts the obsidian flow and any archaeological material has been destroyed or is no longer in situ. Survey paths often zig-zagged across transects, and individuals occasionally halted the crew to

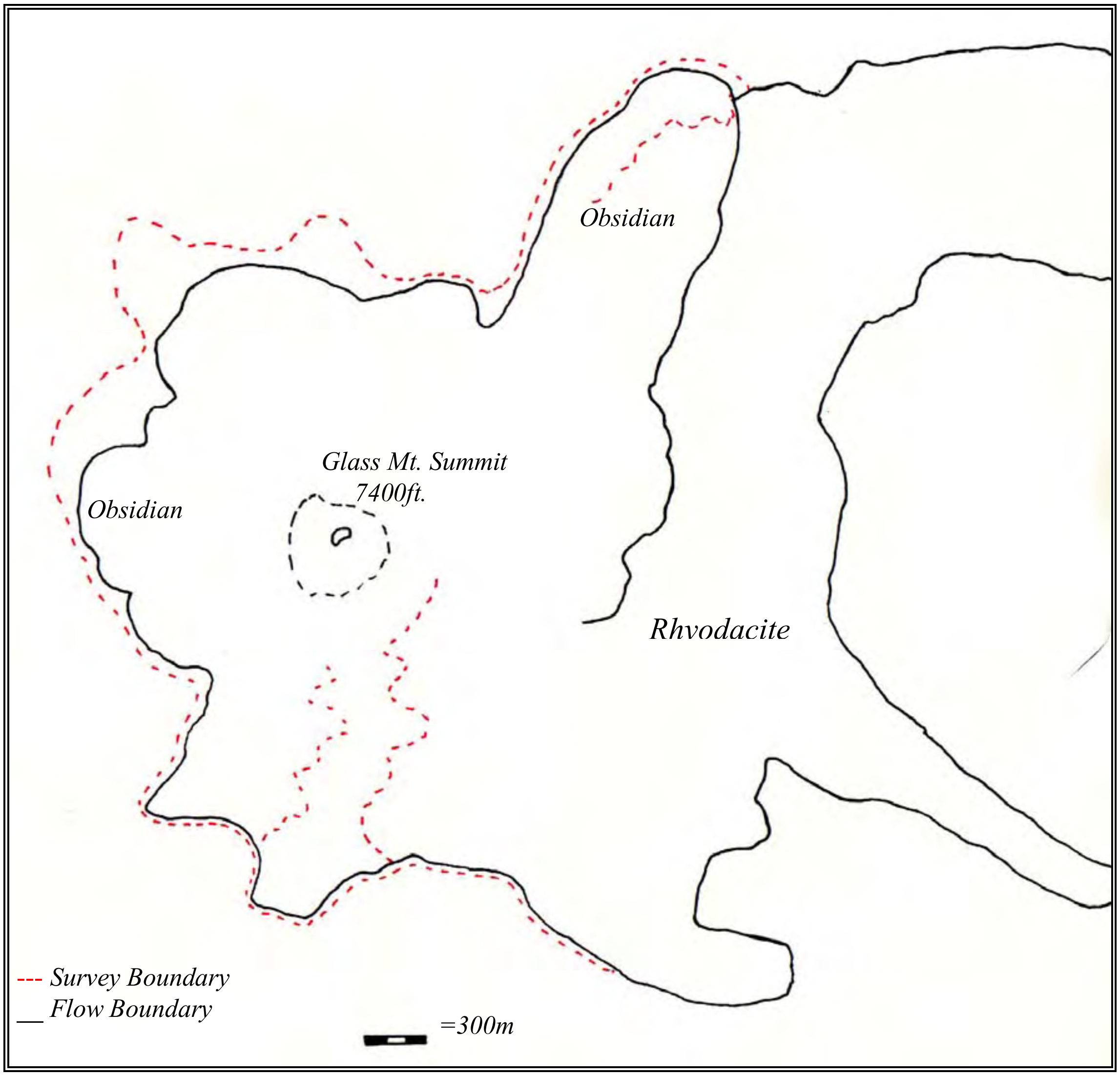


Figure 9.1: Glass Mountain Archaeological Project Survey Area

investigate unusual features or potential archaeological material falling outside the designated coverage area.

Surveyors recorded three main types of information: cultural material, geologic features, and environmental conditions. Cultural material included prehistoric or historic archaeological sites, and modern campsites, trash, Forest Service markers, and pumice mining activity. Geologic features included changes in the color, texture, or quality of the obsidian, other non-obsidian lava flows, lava tube caves, caves and crevasses containing ice or water, and ash fall deposits. Environmental conditions encompassed any notable environmental feature that affected prehistoric use of Glass Mountain or may have altered archaeological deposits. This included wildlife, water, evidence of burning, and vegetation cover. Cultural, geologic, and environmental information was recorded on Forest Service site record forms, GMAP locus record forms, and GMAP geologic sample collection forms, as well as in daily field notes and photographs.

SITE CRITERIA AND RECORDING METHODOLOGY

Because Glass Mountain is located within the boundaries of Modoc National Forest, every effort was made to maintain consistency with Modoc National Forest's cultural resources recording and documentation practices. Prehistoric sites were thus defined and recorded based on a criteria of ten or more unmodified flakes within a 20-30 meter radius, or five or more unmodified flakes in association with at least one modified tool (Gates and Adkison 2000: 1). A full 30 meters free of archaeological material was needed to determine the placement of site boundaries, based on Modoc National Forest guidelines. However, due to the expected density of flakes associated with obsidian quarrying at Glass Mountain, these criteria resulted in extremely large sites, and yielded little of interpretive value. It was therefore decided to record reduction loci, defined as isolated concentrations of debitage and broken bifaces within the site boundaries. Loci were assumed to represent the knapping activity of a single individual or a small group of prehistoric flintknappers, based on size and artifact density. As a result, loci provide a record of individual actions within the context of quarrying and biface production. However, in order to consistently follow Modoc National Forest site recording criteria, loci were observed and recorded within much larger site boundaries, and site designations continued to be used for management purposes. The site record form used by Modoc National Forest was also employed here, again to maintain consistency and comparability with other archaeological investigations conducted on National Forest property.

During survey, when a flake was encountered, it was flagged and the survey halted to inspect for additional debitage or biface fragments. If the number of flakes and formed tools was high enough to meet the criteria for a site, flagging tape was tied to a nearby tree and marked “site boundary”. Survey then continued until careful inspection revealed an absence of flakes for 30 meters, at which point the survey team turned around and surveyed back until a flake was encountered and another flag placed and marked again as “site boundary”. A similar method was employed to determine the site boundary opposite the glass flow, while the slope of the obsidian flow commonly also formed a site boundary. Within these boundaries, systematic and random surveys were conducted to look for individual reduction loci, features, or formed tools. Bifaces and biface fragments were mapped, sketched, and photographed in the field. Reduction loci were recorded

Figure 9.2: Modoc National Forest Site Record Form.

USDA Forest Service (Region 5) **PRIMARY RECORD**	 Other Listings: Review Code:	Primary #: HRI #: Trinomial: CA-Mod- NHRP Status Code: Reviewer: Date:

Page 1 **of** 8

Forest Service #:
Current Name:
Historic Name:

P1. Other Identifier:

P2. Location (restricted information):

a. County: **State:**

b. USGS 7.5' Quad: **Date:**

T N, R E; ¼ of ¼ of ¼ of Sec. ; MDM **B.M.**

c. Address: N/A

d. UTM: Zone: 10; **mE x** **mN** (GPS: X Yes __ No)

e. Other Locational Data:

Elevation: ft. **Parcel #:** N/A

Directions to resource:

P3a. Description:

Boundary:

P3b. Resource Attributes: AP2.

USDA Forest Service (Region 5)	Primary #:
	HRI #:
PRIMARY RECORD (cont.)	Trinomial: CA-Mod-

Page 2 **of** 8 **Forest Service #:**

P4. Resources Present (NR Class): Building __ Structure ___ Object ___ Site X District ___ Other ___

P5a. Photograph/Drawing:

P5b. Description of Photo:
View:
Date: **Photo Accession #:**
Sources:

Date Acquired by FS: N/A

P6. Date Constructed/Age (Site Type): Prehistoric ____ Historic ____ Both ____

P7. Owner: Modoc National Forest [Doublehead Ranger District]

Address: 800 W. 12th Street, Alturas, CA 96101 [same]

P8a. Recorded by:

Affiliation:

Address:

P9a. Date Recorded:

P8b. Updated by:

Affiliation:

Address:

P9b. Date Updated:

P10. Survey Type: Reconnaissance____ Intensive ____ Incidental ___

P11. Report Citation HRR #:
Project Name:

Required Attachments:
___Archaeological Site Record (FS-DPR 523C 2/97)
___Plan/Map (Site Map)
___Topographical Map (Site Location Map)
___Recent Photograph(s) for Historic Buildings and Structures
Optional Attachments: __ Artifact Sketch Sheet
__ Feature Sketch Sheet

FS-DPR 523A/ModNF (05/97)

Air Photo No.:

A.1 Dimensions: Length: m (Axis: N-S) x Width: m (Axis: W-E)
ft ft

(Area: acres; Sq. m)

Method of Measurement:

Reliability of Determination:

A2. Depth: **Method of Determination:**

A3. Human Remains:

Describe:

A4. Features:

Prehistoric:

Describe:

Historic:

Describe:

__House/Cabin	__Dam	__Prospect
__Trash Dump	__Cut	__Mine Shaft
__Well	__Ditch	__Mine Tunnel
__Wood Fence	__Rock Fence	__Claim Post
__Rock Alignment	__Railroad Tracks	__Tailings
__Rock Foundations	__Cement Foundations	__Stamp Mill
__Landscaping	__Privy Pit	__Walkway/Path
__Other ( )		

A5. Cultural Constituents:

Artifact Density: Average: /sq. meter Greatest: /sq. meter

Class	Type	Style	Technology	Mat. Class	Mat. Source	Sourcing Method

A6. Artifacts Collected:
Accession #: **Artifacts Curated at:** Modoc National Forest

A7. Site Condition:

Disturbances:

Describe:

A8. Nearest Water Type: Distance to Water: Direction to Water:

Describe:

A9. Elevation:

A10. Environmental Setting:

Vegetation/Habitat in Vicinity:

Vegetation/Habitat on Site:

Describe:

Soil Family: **Soil Profile:**

Describe:

Landform Context:

Immediate Landform:

Geographic Context:

Geology:

Immediate Slope: **Surrounding Slope:** **Aspect:**

Describe Slope/Aspect:

A11. Historical Information:

A12. Age: Prehistoric ___ Protohistoric ___

Chronological Indicators
(Prehistoric)

___None evident

____Terminal (DSN, Cottonwood, Gunther/Guntheroid)
____Late Archaic (Rose Spring/Eastgate series)
____Middle Archaic (Elko series, Martis series)
____Early Archaic (NSN, Bare Ck/Gatecliff, Humboldt)
____Paleo (Type:)

Historic ____ Undetermined ____

__WWII - Modern (1940+)
__Depression (1930 - 1939)
__Post WWI (1920 - 1929)
__WWI (1910 - 1919)
___Turn-of-the-Century (1900 -1909)
___1890's (Late Settlement)
___1870's-1880's (Settlement/Modoc War)
___1840's-1860's (Explorer/Emigrant)
___Pre-1840 (Fur Trapper)

A13. Interpretations:

Function:

Prehistoric Site Type [from GATES (1983) Cultural Resource Overview, Modoc N.F.]

__Permanent/Seasonal Village
__Seasonal Base Camp
__Temporary Camp
__Lithic Scatter
__Groundstone
__Burial/Cemetery/Cremation
___Rock Shelter/Cave
___Hunting Blind
___Rock Art
___Rock Cairn/Stack/Alignment
___Lithic Quarry/Source

Prehistoric Data Categories:

__Settlement Patterns
__Subsistence Patterns
__Economic Pursuits
__Lithic Technology
__Chronology
__House Construction & Use
___Domestic Organization
___Religious Practices
___Floral & Faunal Communities
___Paleo-Environments
___Physiography & Geomorphology
___Geochronology/Sedimentation/Stratigraphy

Historic Site Type [from GATES (1983) Cultural Resource Overview, Modoc N.F.]

__Trail/Road
__Homestead/Ranch
__Hunters Camp
__Logging
__Civilian Conservation Corps
__Other (___________)
___Military/War
___Pastoral Camp
___Burial/Cemetery
___Mining
___Forest Service
___Rail Road

Historic Data Categories:

__Settlement Patterns
__Economic Pursuits
__Mining Technology
__Domestic Organization
__Forest Service History
___Subsistence Patterns
___House Construction & Use
___Military History
___Ranching/Agricultural Practices
___Civilian Conservation Corps History

Significance Level:
___Very Significant (Level I)
___Significant (Level II)
___Limited Significance (Level III)

USDA Forest Service (Region 5)	Primary #:
	HRI #:
ARCHAEOLOGICAL/ENVIRONMENTAL RECORD	Trinomial: CA-Mod-

 Forest Service #:

NRHP Eligibility:
___On NRHP (FS Class I)
___Yes (FS Class II)
___Unevaluated (FS Class II)
___Not Eligible (FS Class III)

Management Recommendation:
____Preservation
____Conservation
____Interpretation
____None

Ethnographic/Cultural Affiliation: __ Achomawi __ Atsugewi __ Modoc
__ N. Paiute __ Other (______)

A14. Remarks: None.

Management Area:

Timber Compartment:

__ >20cf/ac/yr __<20cf/ac/yr __ Non-Timber

Range Allotment:

Other:

A15. References:

USDA Forest Service (Region 5) **SITE SKETCH MAP**	Primary #: HRI #: Trinomial: CA-Mod-

Page 7 **of** 8 **Forest Service #:**

LEGEND:

- Datum
- Site Boundary
- Glass Flow
- Pine
- Locus
- Snag/Stump

SCALE: 1cm=1meter **BY:**

USDA Forest Service (Region 5)	Primary #:
	HRI #:
SITE LOCATION MAP	Trinomial: CA-Mod-

Page 8 **of** 8 **Forest Service #:**

USGS Quad Name/Date:

FS-DPR 523 (1/97)

using the GMAP Locus Record Form, and make up the primary investigative unit for this project.

A locus is defined here as a concentration of lithic debitage, often containing bifaces or biface fragments, within the boundaries of a much larger site. Loci were often very small, in many cases measuring only one meter in diameter, and contained very high densities of lithic debitage. Surface densities ranged from approximately 100 flakes per square meter to 3000 flakes per square meter. Many loci were found abutting pumice boulders, suggesting that prehistoric flintknappers may have sat on the boulders while working (figure 9.4).

Loci were recorded using the GMAP Locus Record Form. When encountered, a locus was initially flagged and assigned a field number. Next, the center of the locus and any observed biface fragments were mapped using a Trimble Geoexplorer 3 Global Positioning System. Additionally, for each locus, at least one 20 x 20 centimeter surface unit was collected and analyzed in the field. This sample was used to calculate flake density and the percentage of biface thinning flakes, general core reduction flakes, and flake fragments or shatter in each locus. Finally, all bifaces and biface fragments were recorded, sketched, and photographed. The GMAP Locus Record Form also prompts for such information as distance to glass flow, slope, a sketch map, and notes on any unusual features found associated with the locus.

Archaeological sampling was a major factor in the field investigations of the Glass Mountain Archaeological Project. As with most quarries, debitage densities were extremely high in some areas (figure 9.5), creating an overwhelming artifact count if some form of sampling was not employed. In addition, processing costs, curation fees,

Figure 9.3: GMAP Locus Record Form.

Glass Mountain Archaeological Project

Locus Record

Site No: 05-09-56-_______ Locus No: ___ of ___

UTM: Zone 10, ______________ mE x _______________ mN

Elevation: _________ ft. Slope: _______ degrees, Aspect:_______

Distance and direction to glass flow: ___________ m @ ______________ degrees

Dimensions: Length _________ m (Axis: ______), Width __________m (Axis:_____)

Direction from Site Datum: _________ m @ _________ degrees from Site Datum

Locus description:

Approximately _________ flakes/20cm²

_________% biface thinning flakes,

_________% other flakes,

_________% unidentifiable flake fragments/shatter

Number of Stage 1 bifaces:_____

Number of Stage 2 bifaces:_____

Number of Stage 3 bifaces:_____

Number of Stage 4 bifaces:_____

Number of hammerstones:______, Hammerstone diameter________ cm

Other artifacts: (describe)

Were artifacts collected? ___yes, ____no (if yes, complete artifact collection tag)

Photographs: Roll______, Exposures (range)________ through ________

1. Subject: _____________________________, Direction_________
2. Subject: _____________________________, Direction_________
3. Subject: _____________________________, Direction_________

Locus checklist:

__Sketch map (on back)

__Artifact sketch/photo

__Map locus to site datum

__Artifact collection record

__Locus overview photo

__GPS loci and collected artifacts

__Hang flagging with locus number

__Map locus on site form and master map

Site FS-05-09-56-_______
Locus #____ of _____

Locus Sketch Map:

North

= ______ meters

Legend:
=pine
=sagebrush
=bush
=loci boundary
=collected artifacts
=biface

Figure 9.4: Locus overview with high density of obsidian debitage around base of pumice boulder.

Figure 9.5: Typical density at loci.

Native American concerns, and time constraints all pressed for minimal debitage collection. As a result, a probabilistic sampling strategy was employed within loci boundaries in order to obtain a representative sample to quantify debitage densities and types. Simple random sampling within each locus was selected for this exercise. "Simple random sampling is a method of generating samples such that every sample of size *n* has exactly the same probability of selection" (Thomas 1986: 126). This strategy was carried out through the use of a 20x20 cm square template (figure 9.6), which was randomly tossed within the boundaries of a locus. The sample was collected from within the template wherever it fell. Debitage, which was visible on the surface within the template, was analyzed in the field and placed back inside the collection square when analysis was complete. This could result in some high or low estimates of artifact densities or types, based on the location of the template. However, statistically, it should make little difference if the variation is truly random.

Under some circumstances, artifact collection was necessary. First, two flakes were collected from probabilistically selected loci for obsidian hydration analysis. As before, the locus and samples for collection were selected using a random sampling strategy. Second, in areas of easy road access to the obsidian flow and associated archaeological sites, bifaces and biface fragments were collected non-probabilistically to prevent looters and casual antiquities collectors from carrying them away. Glass Mountain receives daily visits from geologists, archaeologists, rockhounds, and tourists. It is marked on all Forest Service maps, and well-maintained pumice mining roads provide access to portions of the north and south sides of the glass flow. For this reason, bifaces and biface fragments from the areas of easiest road access were collected and are

Figure 9.6: 20x20cm template for sampling and analysis in the field.

now housed in the Heritage Resources Management curation facility at the Modoc National Forest in Alturas, California. Almost all bifaces and biface fragments more than 50 meters from the access roads were left in situ. However, there were three biface fragments recovered more than 50 meters from the access roads that were also collected. One of these fragments was a completed stage 5 biface, which was only one of two biface fragments observed in the final stage of production. The two additional collected biface fragments included two halves of one large stage 4 biface. These collected bifaces are illustrated in chapter 10.

All sites, loci, biface fragments, and collected samples were mapped using a Trimble Geoexplorer 3 Global Positioning System (figure 9.7). The GPS unit was programmed to receive position information for several different data categories including: site boundaries, glass flow boundaries, archaeological samples, geologic samples, loci, site data, roads, trees, and other features. In addition, the unit was programmed to prompt the user for identification information such as site number, locus number, sample number, and biface stage, as well as providing fields for debitage density and type quantities. Much of this information was duplicated on the GMAP Locus Record Form and the National Forest Site Record Form, however the Trimble Geoexplorer 3 and associated software linked the data with position information collected in Universal Transverse Mercator units and provided a backup in the event of incorrect or insufficient data in the field record forms. Data were downloaded and processed using Pathfinder Office 2.51 software. Site and locus maps were printed directly from the Pathfinder Office program. In addition to GPS, sites and loci were also mapped on aerial photos (series date: 1984) and USGS 7.5' topographic maps.

Figure 9.7: Mapping using the Trimble Geoexplorer 3 Global Positioning System.

Glass Mountain Archaeological Project field survey and recording methodologies were practiced in a manner consistent with the techniques and documentation required by Modoc National Forest Heritage Resources Management. However, data collected as part of this project go above and beyond the minimum requirements for Forest Service field reconnaissance. Research questions addressed procurement and production of obsidian artifacts, namely large bifaces, with a goal of demonstrating how prehistoric beliefs about the suitability of particular raw materials for specific types of objects may be represented in the archaeological record.

ARCHAEOLOGICAL SITES

A total of 18 archaeological sites were recorded along the margins of the Glass Mountain glass flow. Four additional sites were previously recorded for other Cultural Resources Management surveys at Glass Mountain and were revisited as part of this project. These twenty-two sites will be briefly discussed here. Furthermore, seven sites were recorded or re-recorded along the rhyodacite flow, which makes up the eastward extending arms of the Glass Mountain lava flow. Because these seven sites do not represent direct quarrying of obsidian at Glass Mountain, since obsidian is minimally available within the rhyodacite flow, they will not be summarized here. Historic components associated with pumice mining activity will also be omitted from this section.

Sites were generally located immediately adjacent to the glass flow, and extended as far as 100 meters out from the toe of the flow. Interestingly, archaeological sites are

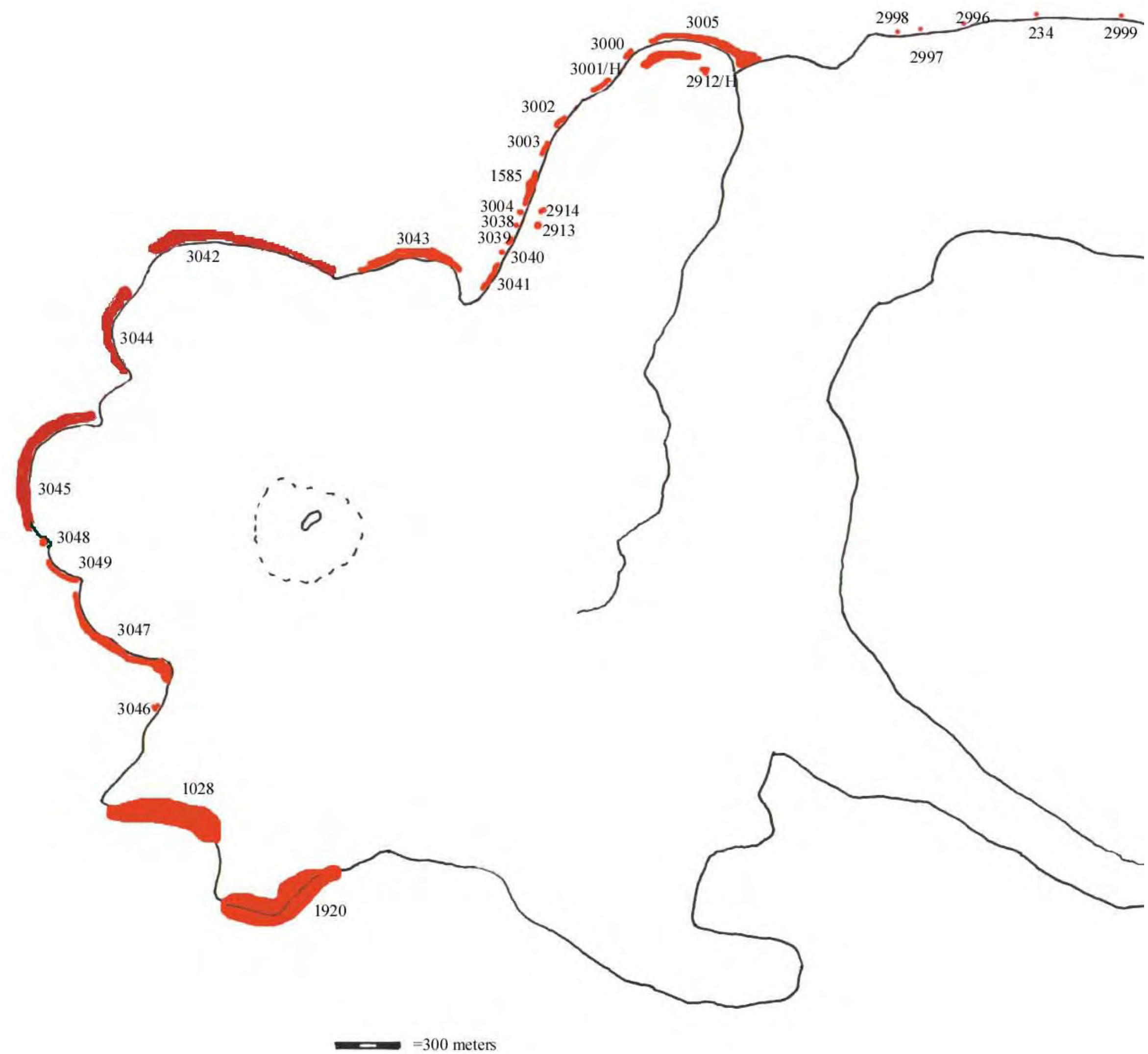


Figure 9.8: Location of Glass Mountain Archaeological Project sites recorded or revisited.

rarely recorded in the Medicine Lake Highland, and except for quarry locales such as Glass Mountain, the region is considered a low-probability zone for prehistoric archaeological resources (Gates 1999: personal communication). However, at the Glass Mountain glass flow, archaeological material was almost constant around the base of the flow, resulting in large sites with varying densities of lithic concentration.

Archaeological sites were situated in an area of relatively sparse vegetation (figure 9.9). Trees included sugar pine, incense cedar, fir, and Ponderosa pine. Ground cover was limited to occasional shrubs and grasses, including manzanita and sage at the lowest elevations. Almost all vegetation was located in the pumice and ash deposits at the base of the glass flow. Except for a few trees growing in isolated pockets in the obsidian flow or along the steep slopes at the edge of the flow, the obsidian was completely devoid of vegetation.

Glass Mountain rises from approximately 5500 feet above sea level at its lowest point, to 7500 feet at the highest elevations. Initially, it was expected that archaeological deposits would be concentrated at the lower elevations. Snow is present throughout the year at the higher elevations, which contributed to the hypothesis that archaeological material would decrease with increasing elevation, since in some places during heavy-snowfall years, it would be necessary to dig through snow to reach the obsidian even in the summer. However, survey revealed that this was not the case. Archaeological sites were found at all elevations, and some of the highest concentrations of loci and biface fragments were found above 7000 feet. Therefore, another factor must be considered: surface water is not available at Glass Mountain because water rapidly filters through the porous pumice and obsidian matrix. As a result, snow may have formed the only

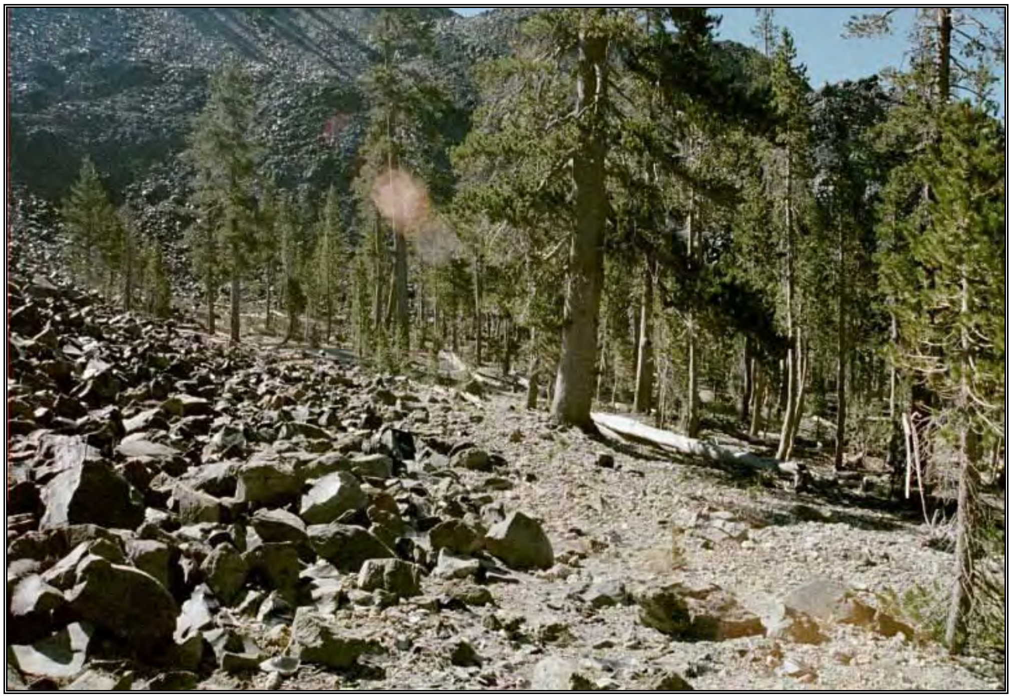


Figure 9.9: Overview of typical Glass Mountain vegetation and ground visibility.

available water source for Glass Mountain flintknappers, and it is possible that sites were located at higher elevations in order to take advantage of this readily available source of fresh water during the summer months. No differences in obsidian quantity or quality were observed between higher and lower elevations.

The geology of Glass Mountain is complex, and is discussed in detail in chapter 4. Sites were located on pumice and ash deposits, which in turn overlay older basaltic and rhyolitic lava flows. Along the western edge of the Glass Mountain glass flow, a buried lava flow is visible. In this area, collapsed lava tubes create steep sided crevasses, and lava boulders protrude through the overlying pumice fall. Archaeological sites along the western margin generally occur immediately adjacent to the flow and on top of lava outcrops, but are rarely situated at the base of lava tubes or crevasses.

Sites were made up of between one and 75 reduction loci, with an average of 20 loci per site. These loci ranged in size from 1 to 20 square meters in area, and contained between 75 and 3025 flakes per square meter. The mean flake density for loci was 584 flakes per square meter with a standard deviation of 344, though non-loci areas contained only approximately 5-10 flakes per square meter. As mentioned earlier in this chapter, loci form the primary unit of investigation. The relationship of different loci to each other is uncertain. Loci may represent temporally distinct flintknapping episodes, or the concurrent work of several different knappers. For this reason, debitage and biface counts and percentages are calculated for each locus, however every indication suggests that similar types of products (i.e. bifaces) were being made at various loci.

In the process of recording sites and loci, the debitage composition was sampled and quantified for each locus, and the mean calculated for each site. Debitage was

FS Site Number	Flakes/meter (mean)	Biface Thinning mean percent	Core Reduction mean percent	Flake Fragments mean percent	Biface Fragments (sum in loci) Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	total bifaces in loci:
05-09-56-3000	100.00	3.00	45.00	52.00	0	0	0	0	0	0
05-09-56-3001	158.93	8.93	46.50	44.50	8	2	5	1	0	16
05-09-56-3002	107.14	10.57	41.43	48.00	2	1	0	0	0	3
05-09-56-3003	150.00	1.00	39.50	59.50	0	0	2	0	0	2
05-09-56-3004	500.00	30.00	20.00	50.00	0	0	0	0	0	0
05-09-56-3005	1000.00	5.00	45.00	50.00	3	0	2	1	1	7
05-09-56-3038	375.00	13.00	20.00	67.00	0	0	1	1	0	2
05-09-56-3039	1615.00	7.20	49.00	43.80	0	4	5	1	0	10
05-09-56-3040	453.57	23.14	26.86	50.00	0	2	0	0	0	2
05-09-56-3041	561.36	14.91	29.82	55.27	14	6	0	5	0	25
05-09-56-3042	614.53	6.39	38.39	55.22	34	26	13	11	0	84
05-09-56-3043	510.00	6.33	36.47	57.20	13	14	8	7	0	42
05-09-56-3044	616.25	4.15	32.70	63.05	4	5	3	1	0	13
05-09-56-3045	327.50	5.20	41.45	53.35	6	8	5	0	0	19
05-09-56-3046	512.50	13.50	37.25	49.25	2	2	0	0	0	4
05-09-56-3047	426.00	12.56	42.04	45.40	5	18	6	0	0	29
05-09-56-3048	675.00	11.00	48.00	41.00	0	0	0	0	0	0
05-09-56-3049	325.00	12.00	30.00	58.00	0	0	0	0	0	0

median:	511.25	11.50	36.86	54.28
mean:	584.31	10.78	36.00	53.21
SD:	344.15	5.34	8.59	7.74

Table 9.1: Locus summaries

identified as either biface thinning flakes, general core reduction flakes, or flake fragments and shatter. Biface thinning flakes were defined based on a strict adherence to the following criteria: lipped and faceted platforms, multiple and directional dorsal flake scars, and a diffuse bulb of percussion. General core reduction flakes were defined by an absence of biface thinning flake characteristics, yet a visible striking platform must be present. Unidentifiable flake fragments or shatter included distal flake fragments; flakes with crushed, missing, or otherwise obscured platforms; or non-directional shatter containing few flake characteristics. Overall, loci debitage was composed of approximately 11% biface thinning flakes, 37% general core reduction flakes, and 54% flake fragments and shatter (table 9.1). Bifaces in different stages of production were also commonly found within loci, and will be discussed in further detail in the next chapter.

In general, the archaeological sites at Glass Mountain display remarkable uniformity. Almost all contain at least one biface fragment, and most possess biface fragments in multiple stages of completion. As a whole, the sites recorded at Glass Mountain suggest that biface production was the exclusive activity conducted at this quarry. No other formed tools were recovered in any stage of production, use, or discard, and only a handful of utilized flakes were observed. In addition, biface reduction loci were the only prehistoric features observed anywhere along the Glass Mountain glass flow. There was a notable absence of the rock rings, hunting blinds, or petroglyphs that are commonly found in the region (Rodeffer and Galm 1985, Gates 1983). Historic features, largely associated with pumice mining activities, were also observed and recorded.

TEST EXCAVATION

In an effort to explore subsurface manifestations of biface reduction loci recorded during surface reconnaissance, four 1x1 meter excavation units were placed in a 2x2 meter block within Locus 2 of Site #05-09-56-3001/H. This test excavation was performed with four main goals in mind: to determine the depth of archaeological deposits, to document the stratigraphy and subsurface sediments, to collect a large sample of debitage for size-sorting and debitage analyses, and to completely collect a single biface reduction locus for lithic refits.

Excavation was conducted during August of 1999 with the assistance of a small crew. Units were excavated in arbitrary 10cm levels oriented parallel to the ground surface. Levels were removed using trowels and shovels, and all sediments were screened through 1/8 inch mesh screens. The test excavation was placed directly over Locus 2, a concentration of debitage and biface fragments. The northeast corner of Test Unit 2 was situated 5 meters at 180° from the site datum. An excavation datum was placed 4cm above ground surface and 5cm from the Northwest corner of Test Unit 1. This datum was used for all vertical measurements; horizontal measurements were taken from the unit walls.

Test excavations were terminated at shallow depth due to a lack of cultural material beyond the first 10cm level. All four units were excavated down to 10cm below surface (base of level 1), and Test Unit 4 was excavated to 20cm below surface (base of level 2). Increasing compaction and a complete lack of cultural material below the surface suggests that Glass Mountain cultural deposits are largely a surface phenomenon.

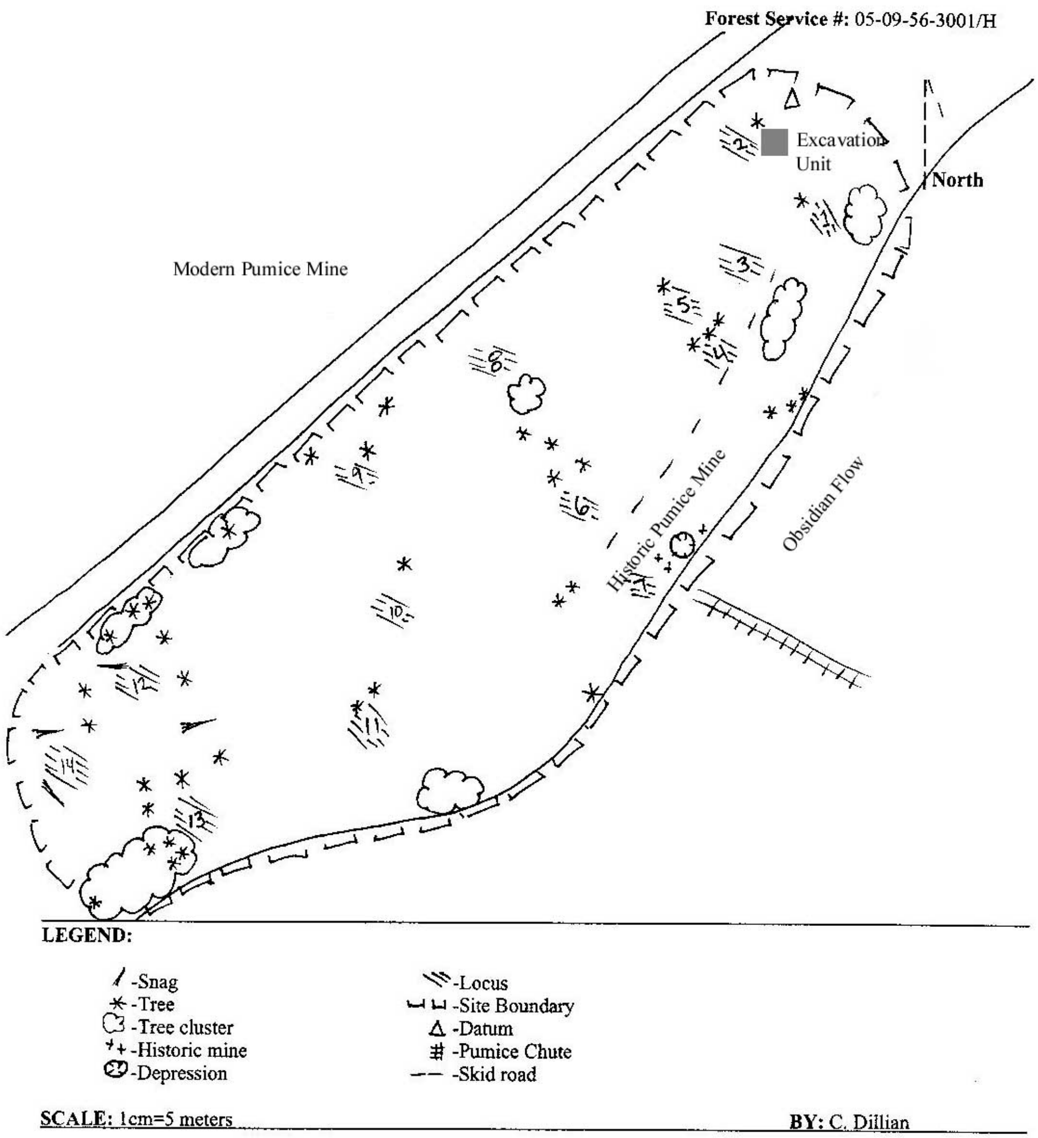


Figure 9.10: Sketch map of FS 05-09-56-3001/H. Excavation Units in Northeast corner of map.

Plan View

Test Excavation
05-09-56-3001/H
NE corner of TU2 located 5m at 180° from site Datum

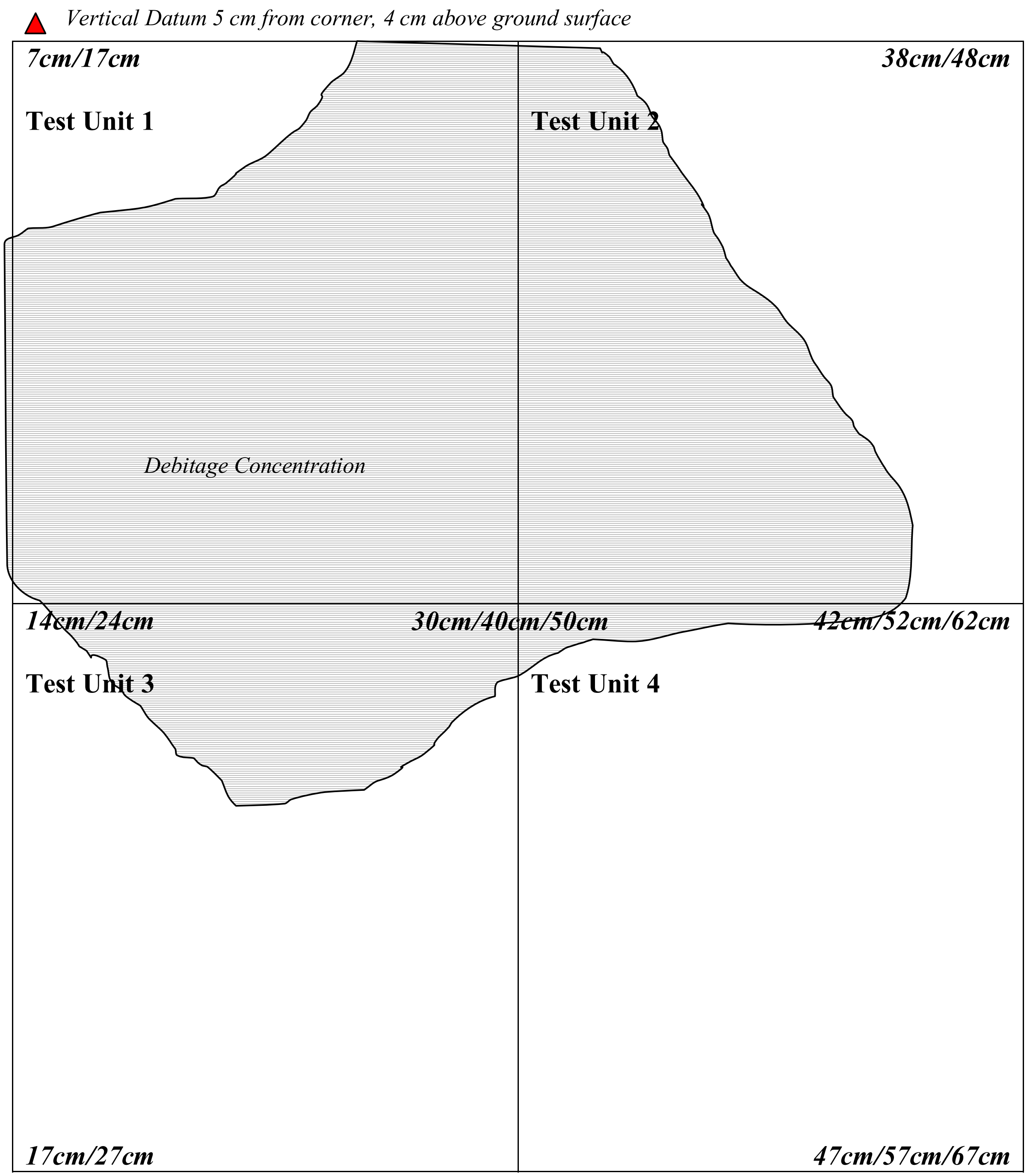
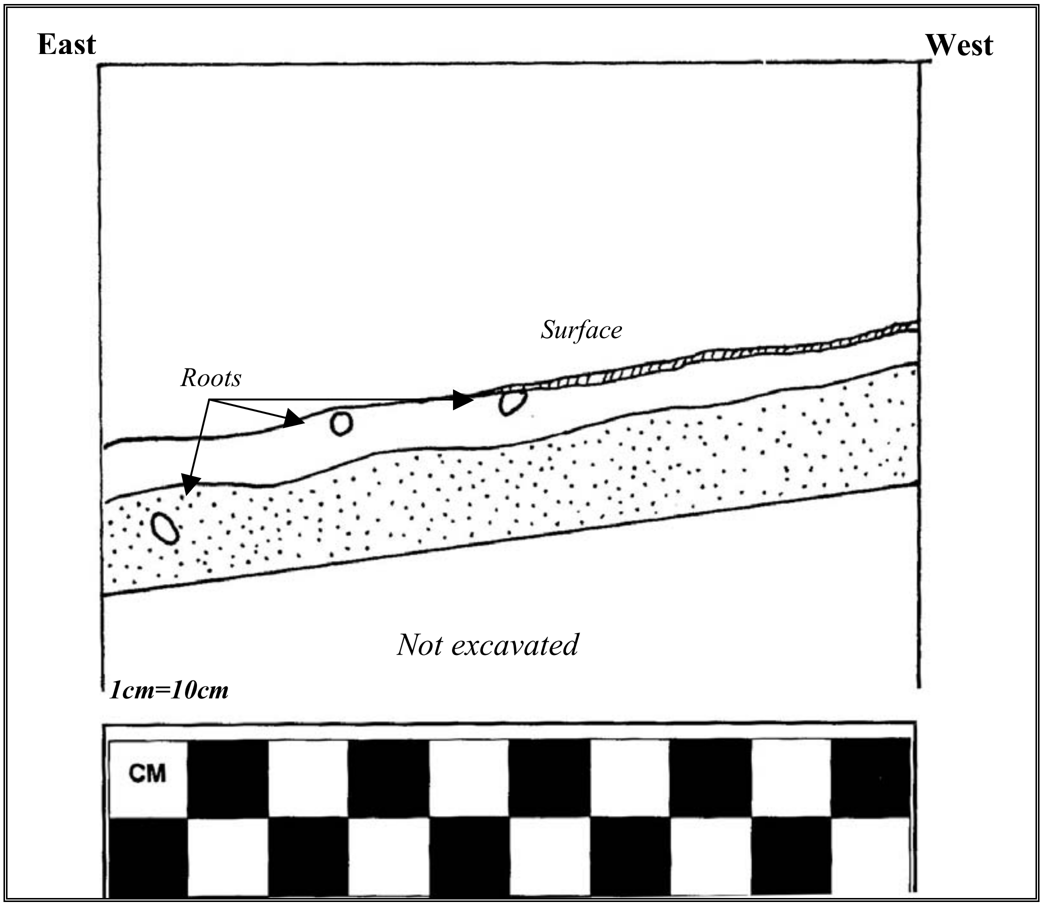


Figure 9.11: Excavation units plan view.



Duff and pine needles.

10 YR 6/2 Light Brownish Gray Sandy Ash, Very Gravelly, Compact. Clear boundary, Wavy. Few mottles, fine size, faint. Gravelly sandy ash, no structure, very fine, single grain. Dry: loose, noncoherent, Moist: loose noncoherent. Wet: nonsticky, nonplastic. Roots: few. 80% gravels of angular pumice and obsidian.

10YR 5/1 Gray Sandy Ash, Gravelly. Clear boundary (2.5-7.5cm thick). Wavy. Few mottles, fine size, faint. Gravelly sandy ash, no structure, very fine, single grain. Dry: loose, noncoherent. Moist: loose, noncoherent. Wet: nonsticky, nonplastic. Roots: few. 50% gravels of angular pumice.

Figure 9.12: South Wall Profile. Test Unit #4. 05-09-56-3001/H.

Soil development at Glass Mountain is non-existent. Sediments are almost exclusively pumice and ash, with very little organic material present. Surface survey indicates that such conditions are the norm at the edge of the glass flow. Field personnel noted ground visibility throughout the course of surface survey and site recording. Approximately 95% surface visibility was achieved across the entire survey area, and soil conditions were noted as barren pumice and ash, identical to that noted during test excavations. Furthermore, inspection of ground disturbance and excavations associated with pumice mining activities revealed identical stratigraphic profiles in the top 20 centimeters of pumice and ash deposits. Deeper deposits consisted of stratified layers of pumice and ashfall deposition, which varied slightly in pumice nodule diameter and color. Erosion channels adjacent to snow banks and on steeper slopes also revealed identical stratigraphy with no soil development and no observed indications of archaeological materials below the surface.

An astounding 36,568 pieces of debitage were recovered during the test excavation. In addition, 7 biface fragments, 4 obsidian cores, and 7 utilized flakes were also collected. Debitage was separated into size-graded categories by screening through graded ½ inch, ¼ inch, and 1/8 inch screen sizes, resulting in three size-graded groups of debitage. Additionally, each group was further separated into categories of flake types: biface thinning flakes, general core reduction flakes, and flake fragments or shatter. Given the extremely brittle nature of obsidian and the strict definition of biface thinning flakes used here, a fairly high percentage of biface thinning flakes were recovered during the test excavations. Only 1.7% of all excavated debitage was identified as biface thinning flakes, however of the complete flakes recovered during excavation, biface

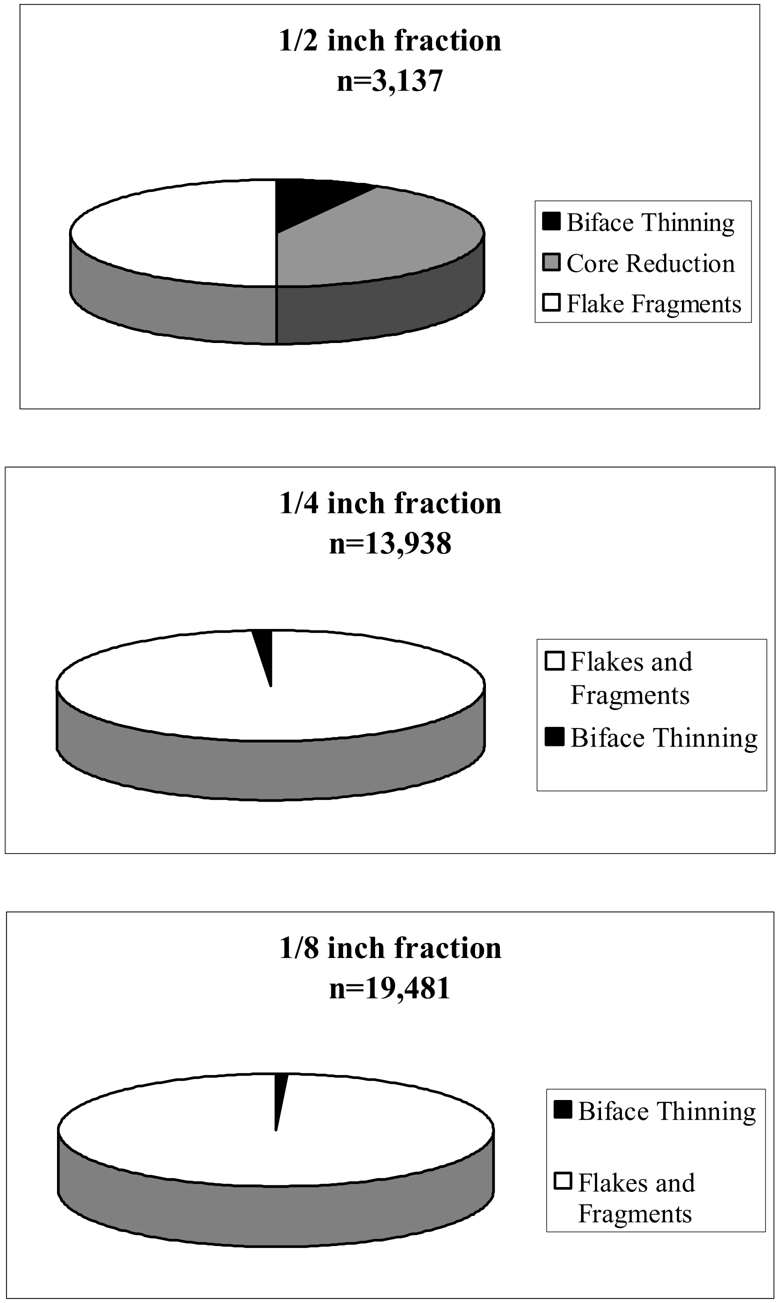


Figure 9.13: Biface thinning flakes, core reduction flakes, and flake fragments. Graph for each size grade. Excavated debitage only.

Test Unit	Level	Object Type	Size Grade	Count
1	0-10cm	Core Reduction Flake	1/2 inch	210
1	0-10cm	Flake Fragments	1/2 inch	285
1	0-10cm	Biface Thinning Flake	1/2 inch	29
1	0-10cm	Flakes & Fragments	1/4 inch	5110
1	0-10cm	Biface Thinning Flake	1/4 inch	65
1	0-10cm	Flakes & Fragments	1/8 inch	8251
1	0-10cm	Biface Thinning Flake	1/8 inch	80
2	0-10cm	Core Reduction Flake	1/2 inch	169
2	0-10cm	Flake Fragments	1/2 inch	221
2	0-10cm	Biface Thinning Flake	1/2 inch	33
2	0-10cm	Flake Fragments	1/4 inch	1157
2	0-10cm	Core Reduction Flake	1/4 inch	30
2	0-10cm	Biface Thinning Flake	1/4 inch	22
2	0-10cm	Flakes & Fragments	1/8 inch	2424
2	0-10cm	Biface Thinning Flake	1/8 inch	36
2	0-10cm	Utilized Flake	n/a	1
2	0-10cm	Utilized Flake	n/a	1
2	0-10cm	Utilized Flake	n/a	1
2	0-10cm	Utilized Flake	n/a	1
2	0-10cm	Biface	n/a	1
2	0-10cm	Utilized Flake	n/a	1
3	0-10cm	Flake Fragments/Shatter	1/2 inch	790
3	0-10cm	Core Reduction Flake	1/2 inch	650
3	0-10cm	Biface Thinning Flake	1/2 inch	148
3	0-10cm	Flakes & Fragments	1/4 inch	5886
3	0-10cm	Biface Thinning Flake	1/4 inch	101
3	0-10cm	Flakes & Fragments	1/8 inch	5772
3	0-10cm	Biface Thinning Flake	1/8 inch	34
4	0-10cm	Core Reduction Flake	1/2 inch	286
4	0-10cm	Biface Thinning Flake	1/2 inch	43
4	0-10cm	Flake Fragments	1/2 inch	268
4	0-10cm	Flake Fragments	1/4 inch	1519
4	0-10cm	Biface Thinning Flake	1/4 inch	11
4	0-10cm	Core Reduction Flake	1/4 inch	16
4	0-10cm	Flakes & Fragments	1/8 inch	2853
4	0-10cm	Biface Thinning Flake	1/8 inch	14
4	0-10cm	Biface	n/a	1
4	0-10cm	Biface	n/a	1
4	0-10cm	Biface	n/a	1
4	0-10cm	Utilized Flake	n/a	1
4	0-10cm	Utilized Flake	n/a	1
4	0-10cm	Soil Sample	n/a	1
4	10-20cm	Flake Fragments	1/2 inch	4
4	10-20cm	Biface Thinning Flake	1/2 inch	1
4	10-20cm	Flake Fragments	1/4 inch	19
4	10-20cm	Biface Thinning Flake	1/4 inch	2
4	10-20cm	Flakes & Fragments	1/8 inch	17

Table 9.2: Excavation Unit Summary.

thinning flakes comprised 31%. Due to the definition of biface thinning flake, requiring the presence of a complete platform, the calculation of biface thinning flakes as a percentage of complete flakes most accurately represents the true quantity of biface thinning flakes in the assemblage. Percentages of biface thinning flakes were also higher in the largest size grade category, which also contained the most complete flakes. Thus, identification of biface thinning flakes in the debitage assemblage is likely skewed by the fact that obsidian is brittle and fractures easily, particularly when knapped over a rock and boulder strewn surface like that present at Glass Mountain.

Lithic refits were attempted with the debitage, cores, and bifaces recovered during test excavations, but proved to be unsuccessful. Refits are a useful way to ascertain stages of lithic production and knapping processes (Cahen et al. 1979: 661-686, Cahen 1987: 1-9, Cziesla 1990: 9-44, Hofman and Enloe 1992). However, the obsidian debitage recovered during test excavations was so fragmentary that refits proved to be an overwhelming task. Additionally, due to the lack of cortex and the uniformity of Glass Mountain obsidian, few clues were available to help in refitting. After approximately 100 person-hours unsuccessfully devoted to refitting, this type of analysis was discontinued.

Test excavations were only conducted at 05-09-56-3001/H. Multiple factors contributed to the decision to excavate at only one site. In particular, Native American representatives, notably from the Klamath Nation, which generally speaks for Modoc and Klamath interests in the area, requested that artifact collection be kept to a minimum, unless required for specific analyses. By conducting surface sampling and field analyses rather than further excavations, it was possible to respect the wishes of the Native

American community. Furthermore, test excavations suggested that Glass Mountain cultural deposits were largely a surface phenomenon. Soil development at Glass Mountain was non-existent, and sediments were almost exclusively pumice and ash, with very little organic material present. Surface survey indicated that such conditions were the norm at the edge of the glass flow, since approximately 95% surface visibility was achieved across the entire survey area and soil conditions were identical to those noted during test excavations. In addition, inspection of ground disturbance and excavations associated with pumice mining activities revealed identical stratigraphic profiles in the top 20 centimeters of pumice and ash deposits. Erosion channels adjacent to snow banks and on steeper slopes also revealed identical stratigraphy with no soil development and no observed indications of archaeological materials below the surface. Finally, surface sampling provided data that could be used to address questions of production at Glass Mountain, without additional time and costs associated with test excavation and artifact curation. Extensive probabilistic sampling and field analyses were substituted for test excavations as a way to gather information about debitage types and quantities.

After weighing the costs and benefits of test excavation, it was concluded that surface sampling and field analyses of obsidian debitage were sufficient to answer questions about production and use of Glass Mountain obsidian. Further, avoiding excessive excavation and collection ensures that this study is replicable in the future, and minimizes curation and storage costs. Finally, field analyses permit the collection of archaeological information while respecting the authority and integrity of current Native American beliefs.

CONCLUSION

The Glass Mountain Archaeological Project succeeded in meeting its goals of investigating quarrying and production behaviors to determine the types of objects produced at Glass Mountain and the knapping stages represented. In order to accomplish this, archaeological sites along the glass flow margins were identified and recorded; lithic production and a lack of retooling was documented at Glass Mountain; and archaeological and geological samples were collected for geochemical characterization and obsidian hydration dating.

As will be discussed further in the next chapter, field sampling and analysis indicated that bifaces were a major product of the Glass Mountain quarry. High concentrations of biface thinning flakes, in association with broken bifaces in all stages of production, support this assertion. What is particularly interesting however, was a complete absence of projectile points, knives, formed scrapers, and other types of formed tools recovered at Glass Mountain. If retooling were taking place at the quarry, broken and exhausted tools would be expected in the archaeological assemblage. However, this was not the case. Instead, bifaces and biface production debitage dominate. The field data do little to refute the hypothesis that Glass Mountain was reserved for the production of ceremonial and wealth objects such as bifaces. Furthermore, sampling and reconnaissance suggest that Glass Mountain was one element of a prehistoric belief system concerning the suitability of particular raw materials for specific types of objects.

CHAPTER 10

BIFACE PRODUCTION AT GLASS MOUNTAIN

INTRODUCTION

Production debitage at the Glass Mountain quarry, in combination with archaeological and ethnographic data from other parts of northern California revealed a pattern of biface manufacture and specialized use that was intertwined with cultural ideology and belief systems. In order to more fully understand these mechanisms of procurement and production at Glass Mountain, the stages of biface manufacture present at the quarry were recorded and quantified for each reduction locus. Furthermore, these data revealed decreasing numbers of biface fragments with each successive stage of production, suggesting that either bifaces were removed from the quarry site at increasingly advanced stages of production, or that bifaces in which knappers had already invested a great deal of time and energy were reworked into smaller objects.

In studies of biface manufacture, is usually assumed that biface reduction at the quarry was designed to minimize both material bulk and time, and that knappers would remain at the quarry only long enough to produce easily transportable preforms that could then be completed later (Ozbun 1991, Kelly 1988, Bamforth 1986, Binford 1979). This implies that artifactual material found away from the quarry would include retouch or biface reduction debitage from larger bifaces initially reduced at quarry sites. However, it appears that at Glass Mountain, bifaces were knapped beyond the stage at which mass is sufficiently reduced for easy transport. Instead, evidence in the form of tertiary biface thinning flakes and final-stage biface fragments suggests that at least some bifaces were

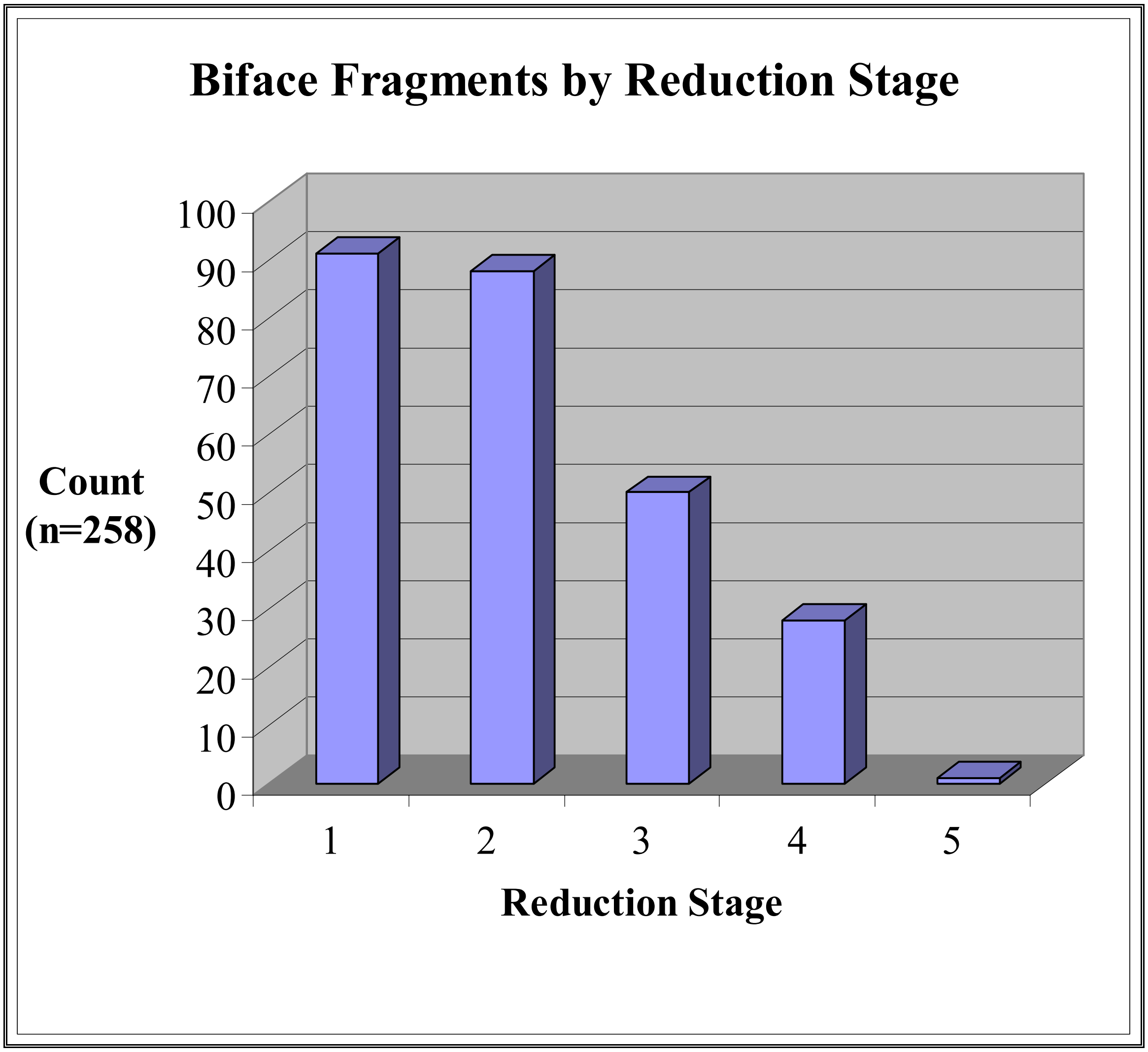


Figure 10.1: Biface fragments in Glass Mountain loci, by reduction stage (see text).

knapped to completion, or near-completion, at the Glass Mountain quarry. Furthermore, as will be discussed in chapter 11, obsidian debitage at sites away from the immediate quarry locale do not contain evidence of retouch or biface thinning of Glass Mountain obsidian objects. Perhaps, in light of additional data pointing towards an important cultural significance of the Glass Mountain source, the location where bifaces were made was just as integral to their associated cultural and spiritual value as was the source from which their raw material was obtained.

BIFACE REDUCTION STAGES

The bifacial reduction sequence is divided into five stages, based on amount of retouch (Callahan 1979, Andrefsky 1998). These stages are constructed purely for the sake of description and analysis, and do not necessarily represent any accurate divisions of the prehistoric reduction process. Biface production was instead a continuum of thinning and shaping.

Stage 1: According to Callahan (1979) and Andrefsky (1998) stage 1 is represented by the procurement of a flake blank or nodule. Archaeologically, this would be visible as an unmodified or partially modified piece of raw material. At Glass Mountain, and other quarry sites, it would be difficult to distinguish a stage 1 preform from unused raw material. Therefore, for the sake of this study, a stage 1 biface preform required some evidence that the knapper intended to make it into a biface. This was apparent through the presence of flake scars on both dorsal and ventral surfaces of a nodule or large flake of obsidian, and some initial shaping.

Stage 2: This stage is characterized by bifacial working that is limited to the margins of the nodule or flake. Callahan (1979: 10) describes this stage as appearing "Abbevillian handaxe-like" with a width/thickness ratio of 2.00 or more. At Glass Mountain, a stage 2 biface was generally twice as long as it was wide, and possessed flake scars on both dorsal and ventral surfaces. However, flake scars did not extend into the center of either surface.

Stage 3: Bifaces of this stage were characterized by flake scars that extend into the center of each surface, removing any remaining cortical material. Stage 3 bifaces begin to achieve their final shape, with a lenticular cross section, and in the case of Glass Mountain bifaces, a narrow and bi-pointed morphology. During stage 3, bifaces were considerably reduced in thickness, though flake scars may still be large and randomly oriented.

Stage 4: During this stage, bifaces were thinned and shaped further, creating a flattened cross-section. In some cases, flakes were removed in a parallel pattern across the surface. Callahan (1979: 10) refers to this stage as comprising the secondary thinning of the biface, while Andrefsky (1998: 31) associates this stage with the creation of a biface or point preform. At Glass Mountain, stage 4 bifaces were complete in all aspects except for final retouch around the lateral margins.

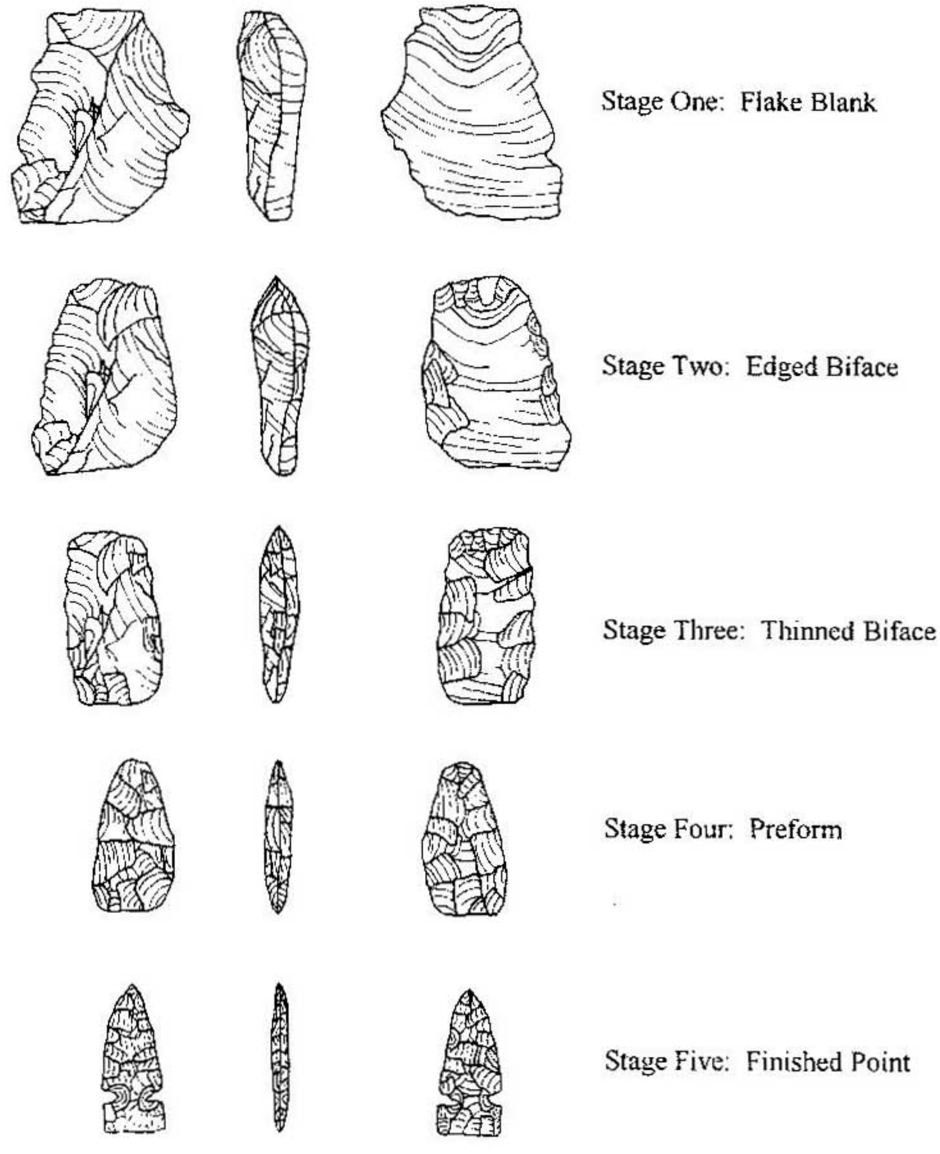


Figure 10.2: Biface reduction stages (Callahan 1979, Andrefsky 1998: 31).

Stage 5: This stage is the final edge retouch and shaping of a biface. In manufacturing projectile points, knives, or other hafted bifaces, stage 5 includes haft preparation and notching (Callahan 1979: 10, Andrefsky 1998: 31). However, at Glass Mountain, stage 5 biface reduction was characterized by the removal of small retouch flakes along the lateral margins.

Despite the use of five reduction stages in the description and analysis of bifaces at Glass Mountain, there is no indication that such stages have any validity for prehistory. Instead, they are purely a tool for recording and describing the continuum of reduction evidenced through biface fragments and debitage. Furthermore, bifaces were functionally variable tools, and their utility for different activities fluctuated with the reduction continuum (Kelly 1988, Andrefsky 1998: 30). For example, bifaces were efficient cores for the production of flake blanks and expedient tools. Large bifaces were used as chopping tools, while smaller bifaces could be used as knives, scrapers, or projectiles. Thinning and reducing a biface potentially changed the function of the specimen, suggesting that a small bifacial point may have been used previously as a knife or core or chopper. Despite these many prospective uses, Glass Mountain bifaces show no evidence of use in any stage of reduction.

BIFACE REDUCTION AT GLASS MOUNTAIN

Biface reduction was apparent at Glass Mountain through the presence of biface thinning flakes and biface fragments in all stages of production. In addition, large hammerstones of non-local material were also present and appear to have been used to remove extremely large flakes from obsidian boulders. These flakes were then also manufactured into large bifaces.

Stage 1: The procurement and initial shaping of large bifaces is represented at Glass Mountain by minimally flaked, bifacial preforms (figures 10.3, 10.4, 10.5). Stage 1 bifaces were common, and were observed on 10 of the 18 sites recorded. Many stage 1 bifaces were found in fragmentary condition, suggesting that this stage was also the point at which raw material flaws and impurities were most noticeable. Furthermore, stage 1 biface preforms represented a minimal time investment, so in many cases, it was more efficient to discard a broken biface than it would have been to try to reshape the broken piece into a smaller object.

Stage 2: Stage 2 biface fragments were also very common on Glass Mountain sites; 88 stage 2 bifaces were recorded within Glass Mountain site loci (figures 10.6, 10.7, 10.8). These specimens were thinner and flatter, yet dorsal and ventral flake scars rarely intruded into the center of each face. Flakes were instead limited to the margins of the biface preform. As was common with stage 1 bifaces, stage 2 bifaces were also often fragmentary. There was no evidence to suggest that broken stage 2 bifaces were reworked into other objects. In some cases, both halves of a fragmentary biface were found within a single locus.

Stage 3: Flake scars on stage 3 bifaces extend into the center of the specimen, distinguishing them from stage 2 preforms. These items are thinner in profile, and begin

Figure 10.3: Stage 1 biface fragments. FS 05-09-56-3041, locus 7 (not collected).

Figure 10.4: Stage 1 biface fragment. FS 05-09-56-3042, locus 11 (not collected).

Figure 10.5: Stage 1 biface fragment. FS 05-09-56-3043, locus 19 (not collected).

Figure 10.6: Stage 2 biface fragment. FS 05-09-56-3042, locus 1 (not collected)

Figure 10.7: Stage 2 biface fragment. FS 05-09-56-30-45, locus 14 (not collected).

Figure 10.8: Stage 2 biface fragment. FS 05-09-56-3043, locus 22 (not collected).

to approach the final biface morphology. At Glass Mountain, 10 out of 18 sites contained stage 3 bifaces, making them still fairly common (figures 10.9, 10.10, 10.11). All stage 3 bifaces recorded were in fragmentary form. Stage 3 bifaces represent an increased time and labor investment, and large fragments may have been reworked into smaller bifaces.

Stage 4: Bifaces at this stage of reduction are almost complete. They may have parallel flake scars across the surface of the piece and have achieved the final thin and bipointed morphology. Stage 4 bifaces were rarer than earlier preforms, and were only found on 8 out of the 18 recorded sites (figure 10.12, 10.13, 10.14). All of the stage 4 bifaces recorded at Glass Mountain were fragmentary and small. It seems likely that large stage 4 fragments were reworked into smaller bifaces, given the time and labor already invested in the object.

Stage 5: The final reduction stage for Glass Mountain bifaces involved retouch of the lateral margins of the piece. Only two stage 5 bifaces were observed at Glass Mountain, and both specimens were collected and are now curated at Modoc National Forest (figures 10.15, 10.16). Yet it was surprising that any stage 5 fragments were recovered at all. Models of lithic material procurement and production suggest that minimal time investment occurred at the quarry, and that once reduction of the mass of the original obsidian nodule had already occurred, preforms were removed to be finished at the knappers' leisure. This did not appear to be the case at Glass Mountain. However, to some degree, antiquities collectors may be responsible for the low numbers of stage 5 fragments recovered at sites with easy public access. One project visitor pointed out a

Figure 10.9: Stage 3 biface fragment. FS 05-09-56-3042, locus 45 (not collected).

Figure 10.10: Stage 3 biface fragment. FS 05-09-56-3042, locus 59 (not collected).

Figure 10.11: Stage 3 biface fragment. FS 05-09-56-3047, locus 5 (not collected).

Figure 10.12: Stage 4 biface fragment. FS 05-09-56-3042, locus 45 (not collected).

Figure 10.13: Stage 4 biface fragment. FS 05-09-56-3044, locus 20 (not collected).

Figure 10.14: Stage 4 biface fragment. FS 05-09-56-3042, locus 40 (not collected).

Figure 10.15: Stage 5 biface fragment. FS 05-09-56-3041, no locus. Collected: FSMA #09-2012-01.

Figure 10.16: Stage 5 biface fragment. FS 05-09-56-3005, datum 1. Collected: FSMA #09-1268-03.

Figure 10.17: Hammerstone of pink rhyolite. FS 05-09-56-3003, locus 2 (not collected).

Figure 10.18: Large obsidian flake. FS 05-09-56-3003, locus 1 (not collected).

location where a large biface fragment had been observed in the past (Forrest 1999: personal communication), but after thorough searching, it was not relocated.

Hammerstones and Large Flakes: Large, rounded cobbles and boulders used as hammerstones were also recorded during survey. These hammerstones (figure 10.17) were made of non-local material including rhyolite or granite and exhibit water or glacially worn surfaces, which would not occur naturally at Glass Mountain, given its recent geologic origin. The closest possible natural occurrence of these boulders may be the Tule Lake area 20 miles to the northeast. Hammerstones all show evidence of battering, including the spall fracture clearly visible in figure 10.17. It is quite likely that hammerstones were deliberately left for future use at the Glass Mountain quarry, since they weighed up to 40 pounds and were difficult to transport. Hammerstones were likely used to remove large flakes from massive obsidian boulders in the glass flow. Large flakes were found adjacent to hammerstones and obsidian boulders (figure 10.18), though refitting to boulders in the flow was not successful. Flakes were also found as stage 1 and stage 2 biface preforms, suggesting they were part of the biface reduction process. However, it appears that bifaces were more commonly made on nodules rather than flakes, as evidenced by numerous stage 1 and stage 2 preforms which retain original nodule cortex or surface morphology.

CONCLUSION

Biface fragments in all stages of production were common on Glass Mountain sites. Interestingly, stage 5 bifaces were also recovered, suggesting that at least some bifaces were knapped to completion at the quarry, and not removed for completion elsewhere. Biface fragments were the only formed objects observed at Glass Mountain. Projectile points, projectile point preforms, knives, crescents, or other chipped stone tools were not found. This is counter to the expected assemblage if generalized retooling were performed at the quarry. Instead, it reveals that bifaces were the only objects manufactured at Glass Mountain, supporting the hypothesis that this quarry was part of a belief system that reserved particular quarries for specific types of objects.

CHAPTER 11

GEOCHEMICAL CHARACTERIZATION OF GLASS MOUNTAIN OBSIDIAN AND THE APPLICATION OF X-RAY FLUORESCENCE

INTRODUCTION

The utility of chemical characterization studies in sourcing archaeological obsidian samples has been proven many times over, and submitting obsidian artifacts for X-ray fluorescence analyses has become standard practice among archaeologists in the western United States. Yet there is an underlying prerequisite for adequate geologic fingerprinting to occur prior to and concurrently with archaeological sourcing studies. Research investigating the chemical homogeneity of obsidian sources has revealed that individual flows within rhyolite domes sometimes possess trace element chemical differentiations vast enough to warrant false assignment to distant sources (Shackley 2000: 1-4, Tykot 1998: 67-82, Hughes 1994, Hughes and Smith 1993: 79-91). As a result, despite prior studies of the composition of the Glass Mountain obsidian source (Hughes 1986, Grove et al. 1997: 205-223, Jack 1976), additional geologic specimens were collected for chemical characterization using X-ray fluorescence as part of the research conducted for this dissertation.

X-ray fluorescence studies performed in conjunction with Cultural Resource Management projects in northern California have revealed an interesting pattern of Medicine Lake Highland obsidian procurement and use during late prehistoric times. This chapter will synthesize these findings, and explore the possible explanations for minimal Glass Mountain obsidian use in the past.

X-RAY FLUORESCENCE

X-ray fluorescence is one of the most commonly employed chemical characterization methods utilized for obsidian artifacts. It is largely effective because of the unique nature of obsidian's composition, in that trace element proportions tend to vary between sources yet remain relatively homogenous within single flow events (Glascock et al. 1998: 19, Shackley 2000: 1-4, Tykot 1998: 67-82, Hughes 1994, Hughes and Smith 1993: 79-91). Trace elements are those elements present in concentrations of less than 1%. Thorough sampling is necessary to determine the homogeneity of specific geologic obsidian sources prior to definitive source assignments of archaeological specimens.

X-ray fluorescence provides the added benefit of accurate chemical characterization assessments without requiring extensive sample preparation. Objects can be placed whole inside the sample chamber, providing they are small enough to fit within the closed chamber. Every effort is made to analyze a flat surface of the sample; yet irregular surface configurations do not hinder source assignments in most cases (Davis et al. 1998: 159-180). Finally, X-ray fluorescence is a non-destructive technique, which is ideal for archaeological specimens, and analysis can be completed in mere minutes.

In X-ray fluorescence, samples are placed inside a sealed vacuum chamber and irradiated with a beam of X-rays. This irradiation displaces electrons from the inner orbitals, creating vacant holes, which are filled by electrons from the outer orbitals. When electrons from the outer orbitals move into the inner levels, energy is emitted in the form of a secondary x-ray photon. The fluorescence caused by the emitted photon is distinctive for each element, creating an energy spectrum that reveals the elemental composition of the obsidian sample.

ANALYSIS PROCEDURES AND INSTRUMENTATION

Samples for this study were analyzed on a Phillips PW 2400 Sequential Wavelength X-Ray Spectrometer in the Department of Geology and Geophysics at the University of California, Berkeley. Geologic samples were fractured to obtain a fresh surface for analysis, but archaeological samples were analyzed whole. The results are quantitative in that they are derived from "filtered" intensity values ratioed to the appropriate x-ray continuum regions through a least squares fitting formula rather than plotting the proportions of the net intensities in a ternary system (McCarthy and Schamber 1981; Schamber 1977). Data are presented in parts per million (ppm) by weight.

The Philips PW 2400 wavelength X-ray fluorescence spectrometer employs a LiF 200 crystal for all measurements. This crystal spectrometer uses SuperQ software written by Philips and automatically adjusts instrument settings for the elements of interest. Practical detection limits have not been calculated for this instrument. Sample selection is automated and controlled by the Philips software. X-ray intensity K-line data with the scintillation counter were measured for elements rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb). X-ray intensities for barium (Ba) were measured with the flow counter from the L-line. These elements were selected because they represent those elements typically used by other obsidian characterization studies for their utility in distinguishing geologic obsidian sources (Hughes 1982, Hughes 1986, Glascock et al. 1998, Shackley 1998a, Davis et al. 1998).

Trace element intensities were converted to concentration estimates by employing a least-squares calibration line established for each element from the analysis of international rock standards certified by the National Institute of Standards and Technology (NIST), the US. Geological Survey (USGS), Canadian Centre for Mineral and Energy Technology, and the Centre de Recherches Pétrographiques et Géochimiques in France (Govindaraju 1994). Specific standards used for the best fit regression calibration for elements Ti through Nb include G-2 (basalt), AGV-1 (andesite), GSP-1 and SY-2 (syenite), BHVO-1 (hawaiite), STM-1 (syenite), QLM-1 (quartz latite), RGM-1 (obsidian), W-2 (diabase), BIR-1 (basalt), SDC-1 (mica schist), TLM-1 (tonalite), SCO-1 (shale), all US Geological Survey standards, and BR-N (basalt) from the Centre de Recherches Pétrographiques et Géochimiques in France (Govindaraju 1994).

The data from the SuperQ software were translated directly into Excel™ for Windows software for manipulation and statistical analyses. In order to evaluate these quantitative determinations, machine data were compared to measurements of known standards during each run. Source standard RGM-1 was analyzed in conjunction with these specimens and elemental data for this standard ensure instrument precision and comparability (Govindaraju 1994, Hampel 1984). Trace element data are reported in parts per million (ppm), a quantitative measure by weight.

OBSIDIAN SAMPLING AND CHARACTERIZATION

Obsidian samples were collected throughout the duration of the Glass Mountain Archaeological Project. Samples were obtained from the surface and edges of the glass flow (figure 11.1); drilling or boring into the obsidian flow was not performed. Select samples were analyzed using X-ray fluorescence to assess the variability in trace element concentrations throughout the flow. As will be discussed further, sampling revealed a remarkable uniformity in trace element concentrations, which bodes well for the efficacy of X-ray fluorescence as a means of identifying Glass Mountain obsidian in the archaeological record.

Random (probabilistic) and judgmental (non-probabilistic) sampling strategies were performed. Obsidian specimens were collected using a random sampling methodology along the edge of the glass flow and on top of the flow. Obsidian specimens were also collected in a judgmental pattern, whenever surveyors observed unusual color, texture, or geographic variations in the obsidian flow. In particular, any red obsidian was sampled, as were occasional obsidian spires located away from the main body of the glass flow. Any visual or flow abnormalities were recorded at the time of collection. All obsidian specimens were mapped using the Trimble Geoexplorer 3 Global Positioning System.

Samples from Glass Mountain were analyzed on the Phillips PW 2400 wavelength X-ray fluorescence spectrometer in the Department of Geology and Geophysics at the University of California, Berkeley. Geologic source standard RGM-1 was analyzed simultaneously to ensure comparability and machine accuracy. Table 11.1 presents the published values for these standards and the results obtained during this

Figure 11.1: X-ray fluorescence geologic source sample locations.

Table 11.1 RGM-1 Concentration Values in Parts per Million (ppm)

Sample name	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Ba
RGM-1 (this study)	2727	375	18814	145	102	24	217	9	809
RGM-1 (Govindaraju 1994)	1600	279	12998	149	108	25	219	8.9	807
RGM-1 (Glascock and Anderson 1993)	1800+200	323+7	12400+300	145+3	120+10	n/a	150+7	n/a	826+31

study, showing a high degree of comparability between the values obtained here and accepted values for RGM-1 elemental concentrations.

Previous characterization studies at Glass Mountain have revealed that the trace elements Zirconium (Zr) and Strontium (Sr) are the most effective identifying elements for this source, particularly when used to distinguish Glass Mountain from other Medicine Lake Highland obsidian such as Grasshopper Flat, Lost Iron Wells, and Cougar Butte (Hughes 1982). Therefore, variability within Sr and Zr trace element concentrations within the Glass Mountain obsidian source is of the most concern in characterization analyses used as a comparative database for archaeological obsidian.

A total of 29 source samples were selected for analysis from the geologic specimens collected during the Glass Mountain Archaeological Project. Of the analyzed specimens, four were judgmentally collected samples (#10, #11, #15, #8) that were selected based on anomalies in appearance or location. Twenty-five of the analyzed specimens were selected as random grab samples from the population of specimens collected at the source using a random sampling methodology. The results of the X-ray fluorescence analysis of these specimens are presented in table 11.2. Sample numbers correlate with numbers indicated on the map in figure 11.1.

X-ray fluorescence analysis revealed a high degree of uniformity in Zr and Sr concentrations in the Glass Mountain source samples. Interestingly, two visually anomalous source specimens (sample #10 and #11) and a sample from an obsidian spire away from the flow (sample #15) also did not reveal any significant variation in Sr and Zr concentrations. Five specimens fell outside the first standard deviation for Zr and Sr concentrations, of these samples #8 and #9 were collected from the south side of the glass

Table 11.2 Trace Element Concentrations in Parts per Million for Glass Mountain Source Specimens

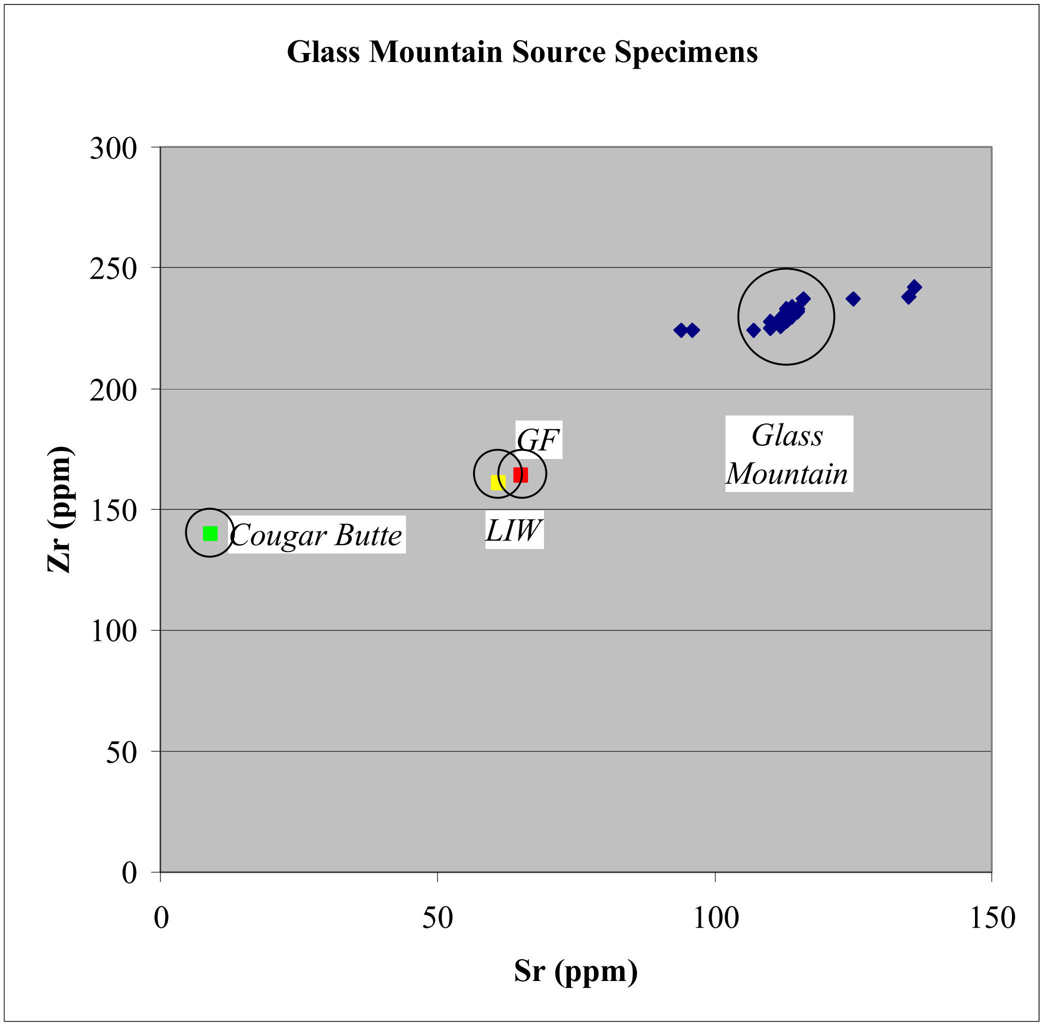
Sample	**Ti**	**Mn**	**Fe**	**Rb**	**Sr**	**Y**	**Zr**	**Nb**	**Ba**
1	2825	389	19445	149	110	25	225	10	877
2	2916	382	19770	148	112	25	226	9	814
3	3004	418	20187	158	114	26	233	10	929
4	3135	409	20380	155	116	26	237	10	917
5	2982	398	20053	154	114	26	234	9	911
6	3158	403	20769	153	114	26	231	9	915
7	3082	395	20287	151	113	26	231	9	959
8	3622	450	23568	143	135	26	238	10	870
9	3501	454	23033	146	136	26	242	10	930
10	2947	389	19796	151	112	25	228	9	876
11	3024	386	19786	151	112	25	228	9	877
12	2988	396	19978	153	110	26	228	9	912
13	2609	378	17830	158	96	25	224	9	884
14	2774	368	19170	151	112	26	229	9	820
15	2481	352	17572	157	94	26	224	9	790
16	3002	392	20079	152	113	25	229	9	881
17	3060	403	20546	153	114	26	231	9	906
18	3060	403	20355	154	115	26	232	10	922
19	3043	400	20384	154	114	26	231	10	898
20	3041	395	20126	155	115	26	233	10	946
21	2837	391	19343	150	107	25	224	10	848
22	3673	529	24611	173	125	26	237	11	1121
23	3045	387	19997	151	113	25	228	10	883
24	3029	404	20374	151	113	26	233	9	872
25	3046	398	20456	155	115	26	233	10	886
26	3028	398	20301	153	115	26	233	9	878
27	3048	403	20295	153	114	26	230	10	877
28	2909	395	19727	152	112	25	229	10	838
29	2894	390	19672	151	112	25	227	10	817
mean=	*3026*	*402*	*20272*	*153*	*114*	*26*	*231*	*10*	*892*
median=	*3028*	*396*	*20126*	*153*	*113*	*26*	*231*	*10*	*883*
Sd. Dev.=	*246*	*31*	*1406*	*5*	*8*	*0*	*4*	*1*	*60*

flow, where rhyolitic obsidian grades into coarser-grained rhyodacite. However, even these five minor outliers would be easily identifiable geochemically as Glass Mountain obsidian, based only on the Sr and Zr concentrations, when compared to other Medicine Lake Highland obsidian sources. Figure 11.2 presents a plot of Zr and Sr concentrations in parts per million for the 29 Glass Mountain specimens analyzed here. In addition, mean Zr and Sr concentrations for other Medicine Lake Highland sources are plotted for comparison. As can be seen in this figure, Glass Mountain obsidian does not overlap with any other Medicine Lake Highland obsidian source at one standard deviation.

Based on this geologic sampling and analysis of the Glass Mountain obsidian source, the source is extremely uniform in the concentrations of elements used to discriminate between Medicine Lake Highland sources. Parts per million measurements of Zr and Sr showed little variability, suggesting that there exist few erroneous source assignments in geochemical analyses of archaeological specimens. Any errors in the assignment of archaeological obsidian artifacts to the Glass Mountain source therefore are likely the result of operator error and errors in interpreting trace element concentrations, rather than due to variations in the geochemical composition of Glass Mountain obsidian.

X-RAY FLUORESCENCE IN CULTURAL RESOURCE MANAGEMENT CONTEXTS

Many of the cultural resource management (CRM) projects conducted in the northern California region contain accompanying obsidian sourcing analyses, since a large portion of the artifactual lithic material often consists of obsidian debitage and



Glass Mountain: **n=29**

Grasshopper Flat (GF): **n=20 (Hughes 1982: 177)**
Lost Iron Wells (LIW): **n=10 (Hughes 1982: 177)**
Cougar Butte: **n=20 (Hughes 1982: 177)**

Figure 11.2: Zr and Sr concentrations (ppm) for Glass Mountain source samples, and mean values for other Medicine Lake Highland sources. Circles indicate one standard deviation from the mean.

formed tools. These gray-literature data are rarely synthesized on a regional level or used to address questions of patterns in long-distance obsidian procurement and use. This study will use a sample of archaeological sites with firmly dated late-period components to ascertain the distribution of Glass Mountain obsidian artifacts in the area immediately surrounding the source.

Temporal control forms the biggest challenge to utilizing gray-literature data for Glass Mountain obsidian use patterns. Because the Glass Mountain eruption occurred only approximately 900 years ago, it is imperative that sites used for this study date to within the appropriate time frame. Many sites in northern California have been dated using diagnostic projectile point types, which is insufficient to achieve the level of temporal control needed here. Therefore, only securely dated, post-900 BP components will be included in this discussion. The sites included in this discussion were chosen based on the availability of X-ray fluorescence data and securely dated components within 50 miles of Glass Mountain. Because of the paucity of such sites in the region, all available and accessible data were used.

Site records and lithic analysis reports for sixteen sites were examined, yielding data for 1421 obsidian artifacts. Artifacts were selected only from post-900 BP components, as determined by obsidian hydration or radiocarbon dating of associated material. None of the components examined dated to the historic period. Sites were selected to cluster around Glass Mountain (figure 11.3), and all except for one are within 50 miles of the source. These sites represented a variety of prehistoric activities, and include small camp sites and larger village sites. None of the selected sites were quarry locales.

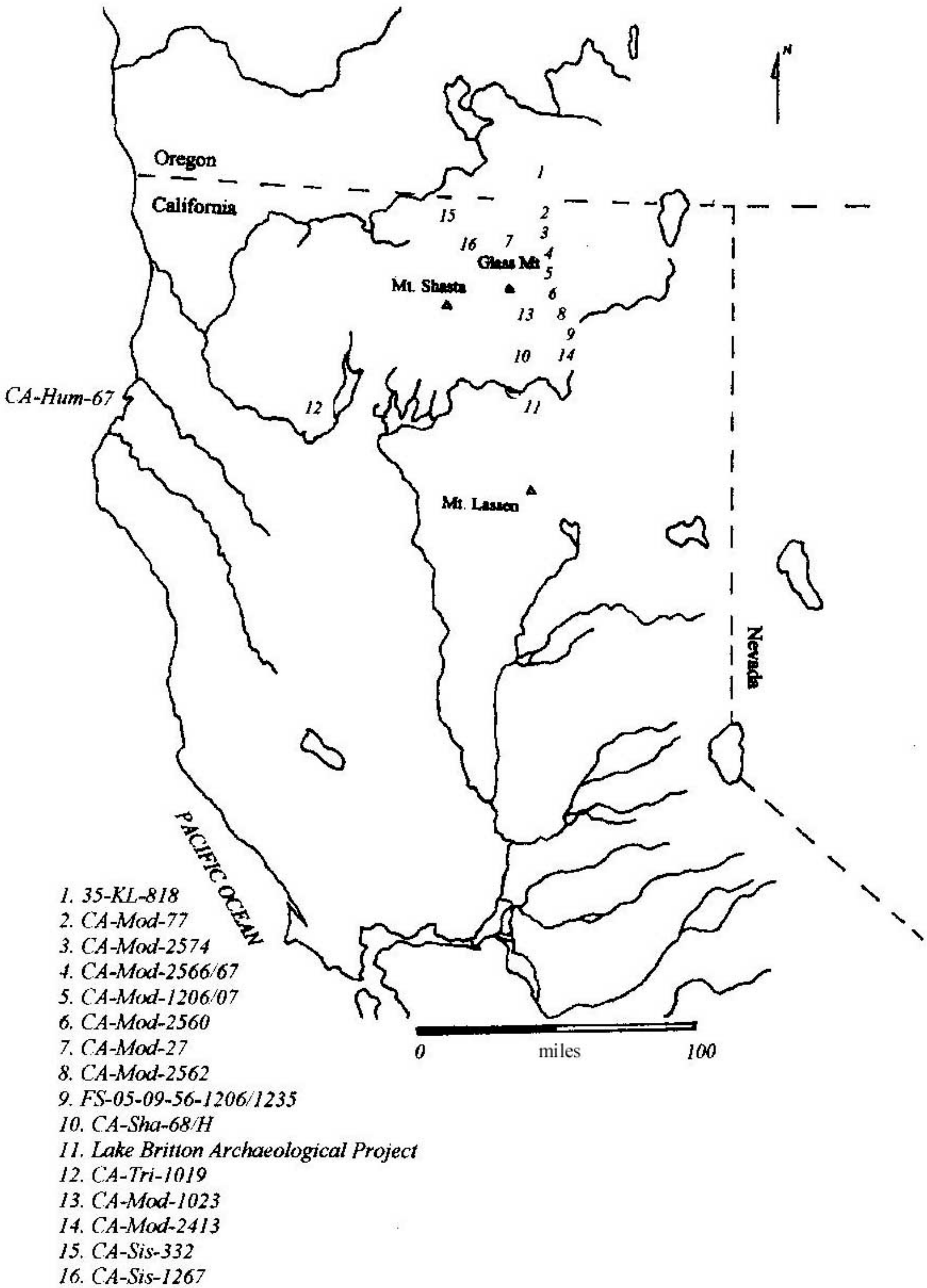


Figure 11.3: Archaeological site locations for comparative assemblages.

Map Number	Site	Reference	Glass Mountain	Total Obsidian	Percent Glass Mtn.	Other Medicine Lake	Percent Other Medicine Lake	Object Type
1	35-KL-818	Site record on file at Modoc NF	1	52	1.9	0	0.0	Flake Tool
2	CA-Mod-77	Site record on file at Modoc NF	4	73	5.5	0	0.0	Debitage
3	CA-Mod-2574	Site record on file at Modoc NF	18	44	40.9	15	34.1	Debitage
4	CA-Mod-2566/2567	Site record on file at Modoc NF	3	129	2.3	0	0.0	P.P./Deb.
5	CA-Mod-1206/1207	Site record on file at Modoc NF	29	90	32.2	52	57.8	Debitage
6	CA-Mod-2560	Site record on file at Modoc NF	19	155	12.3	126	81.3	Debitage
7	Nightfire Island (CA-Mod-27)	Hughes 1986, Sampson 1985	0	34	0.0	27	79.4	P. Points
8	CA-Mod-2562	Site record on file at Modoc NF	1	179	0.6	0	0.0	Multiple
9	OTH-B (05-09-56-1206, 05-09-56-1235)	Busby et al. 1990	2	45	4.4	31	68.9	P. Point
10	CA-Sha-68/H	Site record on file at Modoc NF	1	169	0.6	0	0.0	Debitage
11	Lake Britton	Kelly et al. 1987	2	387	0.5	271	70.0	P. P./Deb.
12	CA-Tri-1019	Nilsson 1990	0	15	0.0	9	60.0	Debitage
13	CA-Mod-1023	Gates 1991	1	1	100.0	0	0.0	P. Point
14	05-09-56-2413	Gates et al 2000	0	16	0.0	16	100.0	Debitage
15	CA-Sis-332	Shackley 1987	1	7	14.3	6	85.7	Multiple
16	CA-Sis-1267	McAlister 1988	0	25	0.0	25	100.0	Multiple
		Total:	82	1421	5.8		46.1	
		Mean:	*5.1*	*88.8*	*13.5*	*36.1*	*46.1*	
		Median:	*1.0*	*48.5*	*2.1*	*12.0*	*58.9*	
		Std. Dev.:	*8.7*	*99.1*	*26.1*	*70.3*	*40.0*	

Table 11.3: Cultural Resource Management X-ray fluorescence data summary.

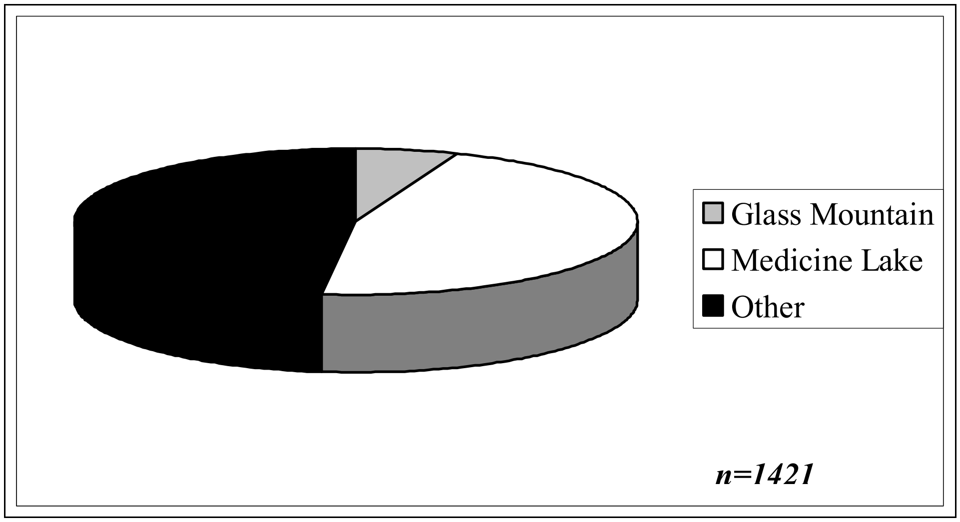


Figure 11.4 Glass Mountain vs. Medicine Lake Highland and Other Obsidian in Selected Late Prehistoric Archeological Sites within 50 miles of Glass Mountain.

X-ray fluorescence data reveal that 5.8% of the obsidian debitage and tools are made up of Glass Mountain obsidian. Meanwhile, other obsidian sources in the Medicine Lake Highland such as Grasshopper Flat/Lost Iron Well/Red Switchback, Cougar Butte, and East Medicine Lake comprise 46.1% of these same assemblages. The remaining obsidian sources represented include sources in the Warner Mountains (Buck Mountain or South Warners), Blue Mountain, or other northern California and southern Oregon sources (Busby et al. 1990, Kelly et al. 1987, Hughes 1986, Sampson 1985, Nilsson 1990, McAlister 1988, Gates 1991, Shackley 1987, Gates et al. 2000).

The paucity of Glass Mountain obsidian in these sites is unexpected, given the size, accessibility, and quality of Glass Mountain obsidian available after 900 BP. Interestingly, the Medicine Lake Highland sources that comprise a majority of the obsidian assemblage at these same sites are located only a short distance from Glass Mountain. This implies that northern California peoples were obtaining obsidian in the Medicine Lake Highland near Glass Mountain. Yet Glass Mountain was effectively ignored as a major obsidian source for local peoples during this time. In fact, the true percentage of Glass Mountain obsidian in post-900 B.P. sites in the region may actually be lower than that represented here. Some sites that did not contain Glass Mountain obsidian were excluded from this study due to questionable chronological assessments based on diagnostic projectile point types or stratigraphic associations.

X-RAY FLUORESCENCE OF VALUE OBJECTS

The most comprehensive obsidian sourcing study of large ceremonial bifaces in northern California was conducted twenty-five years ago (Hughes 1978). This study performed rapid scan semi-quantitative X-ray fluorescence analysis on thirteen bifaces and biface fragments, as well as twenty-eight projectile points and drills, all from burial contexts from site CA-Hum-67.

CA-Hum-67 is a late-prehistoric and ethnographic period site, also known as *Dulawo't,* located on Gunther Island near the city of Eureka on the northwest coast of California. L. L. Loud (1918) of the University of California, Berkeley excavated twenty-two burials from the site in 1913. Chronological estimates suggest that the burials date to approximately 600 years ago, based on a radiocarbon date from the basal peat layer of 1050±200 B.P. and a relatively constant rate of sedimentation (Hughes 1978: 56, Heizer and Elsasser 1964: 35, Elsasser and Heizer 1966: 2). Occupation by the Wiyot continued until historic times, and the site was abandoned around 1860 (Nomland and Kroeber 1936).

Hughes's analyses of the obsidian artifacts from the burials excavated by Loud at CA-Hum-67 were conducted using rapid scan semi-quantitative X-ray fluorescence analysis on a Norelco/Phillips Universal Vacuum Spectrograph in the Department of Geology and Geophysics at the University of California, Berkeley (Hughes 1978: 62). His analyses were sensitive enough to discriminate obsidian source groups, such as Medicine Lake and Warner Mountains, yet were not able to distinguish individual Medicine Lake sources, such as Glass Mountain, Grasshopper Flat/Lost Iron Wells/Red Switchback, or Cougar Butte (Hughes 2001: personal communication).

Despite the technological limitations at the time and the very small sample size of black obsidian bifaces (n=5), these analyses revealed that black bifaces in the assemblage were comprised of three different obsidian source groups: 40% from Medicine Lake in

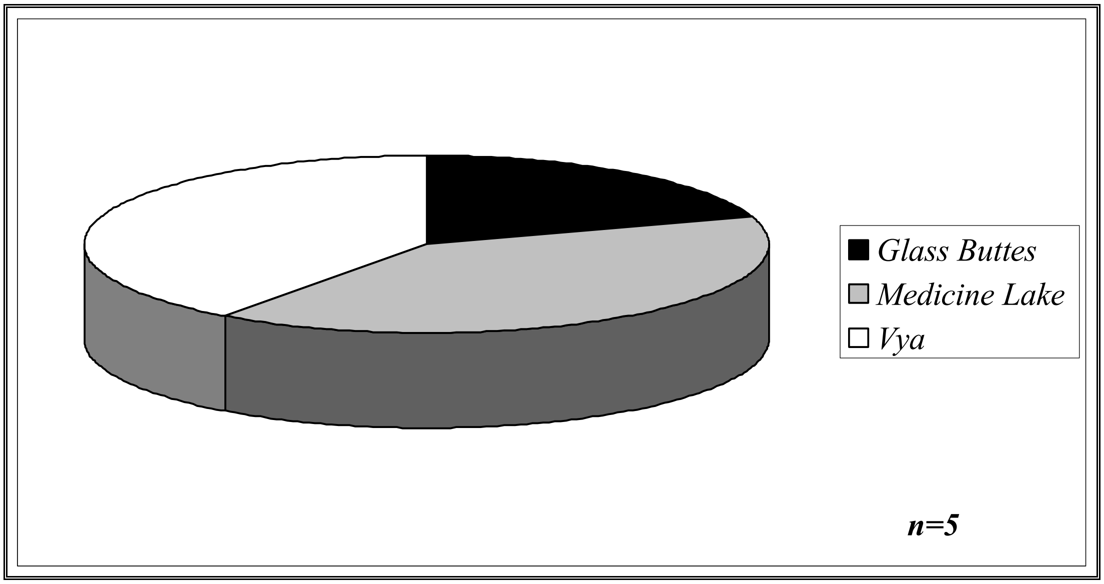


Figure 11.5 Geologic Source Assignments for Black Obsidian Bifaces at CA-Hum-67 (Hughes 1978).

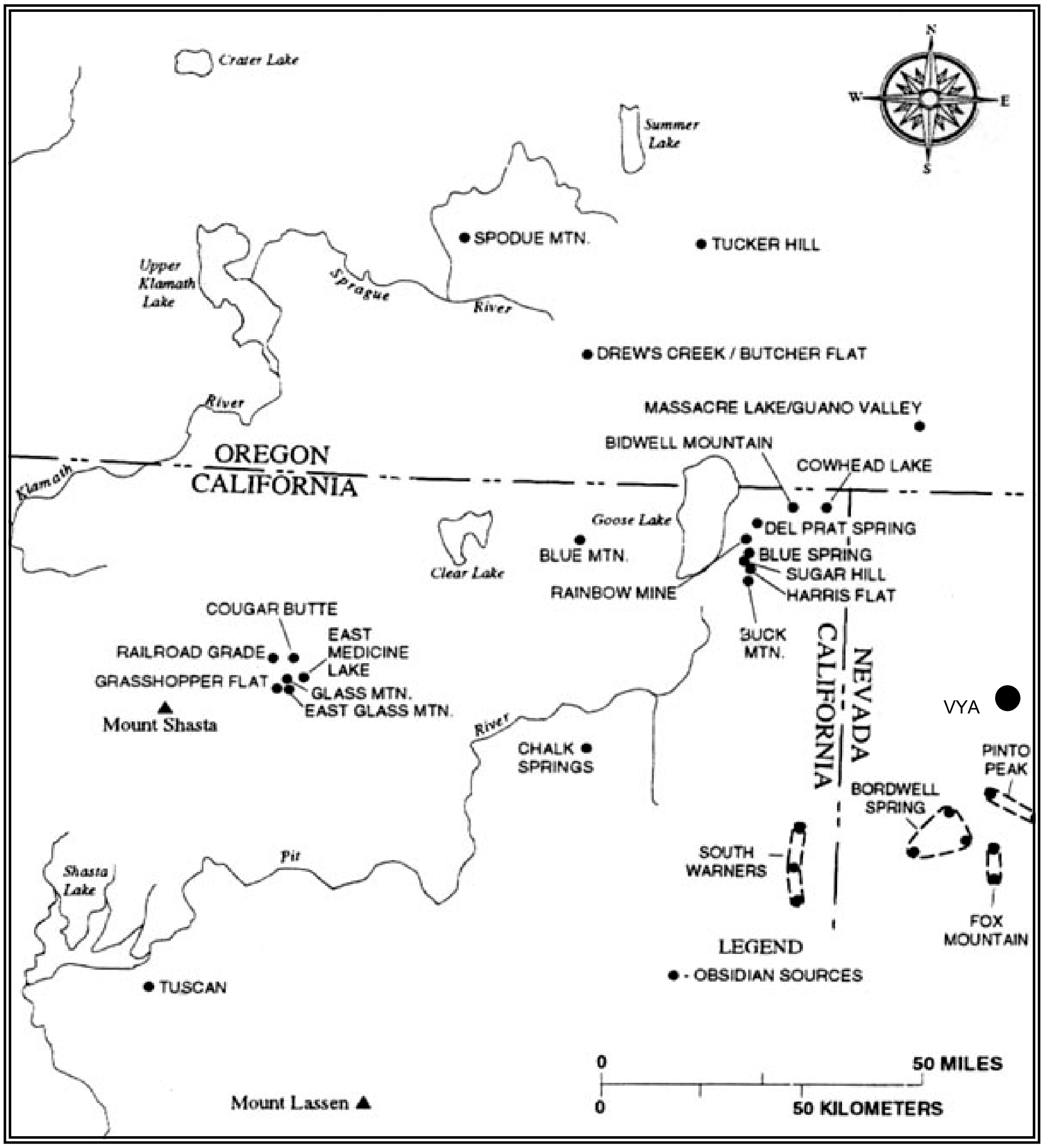


Figure 11.6: Northern California, Western Nevada, and Southern Oregon Obsidian Sources (Schalk 1995).

northeastern California, 40% from Vya in Western Nevada, and 20% from Glass Buttes in South-central Oregon. The red obsidian bifaces in the assemblage were traced exclusively to the Warner Mountains of northeastern California, one of the few sources of large red obsidian nodules.

Based on visual inspection of the black bifaces assigned to the Medicine Lake source group by Hughes, it appears that they are likely made of Glass Mountain obsidian. Glass Mountain obsidian is one of the few sources that occurs in nodules large enough to be knapped into extravagant bifaces, which can approach one meter in length (Heflin 1982: 124). Glass Mountain obsidian also generally appears as a dusky black with gray swirling bands of varying thickness and opacity, which is distinctive from the clearer black with occasional parallel banding found in other Medicine Lake Highland sources. Visually, the bifaces sourced to the Medicine Lake Highland source group appear to be manufactured from Glass Mountain obsidian[1].

According to the ethnographic record, obsidian used in bifaces for the Hupa White Deerskin Dance came from outside the region: "red obsidian that presumably comes from the south, and a black obsidian that comes from the Shasta region in

[1] Ideally, it would be possible to re-analyze the obsidian bifaces from CA-Hum-67 using more precise, modern X-ray fluorescence technology to determine if they are indeed Glass Mountain obsidian. In addition, a larger sample size could be obtained through re-analysis. However, as burial items, bifaces are subjects of NAGPRA legislation and at this time are the objects of consultation and repatriation. The descendant Native American representatives have requested that no bifaces be re-analyzed for this study, and their wishes will be respected here. Therefore, Hughes's data and visual examination provide the only available source information. For this same reason, bifaces from other California sites in the collections at the Phoebe A. Hearst Museum of Anthropology and Archaeology at the University of California, Berkeley, have also not been analyzed using geochemical techniques.

northeastern California" (Goldschmidt and Driver 1940: 120). X-ray fluorescence and visual sourcing data strongly support the hypothesis that Glass Mountain was a significant source for large, ceremonial bifaces used by coastal Nations. It is also apparent from the ethnographies that at least in historic times, these artifacts were being exchanged as finished bifaces, rather than as nodules or preforms. The archaeological evidence also supports this, in that Glass Mountain obsidian is only minimally represented in the debitage assemblages of late-prehistoric archaeological sites in northern California, yet makes up 40% of the black biface assemblage at CA-Hum-67.

CONCLUSION

An intriguing dichotomy is revealed by the geochemical characterization data from archaeological sites in the vicinity of Glass Mountain and large ceremonial bifaces recovered from burial contexts at CA-Hum-67. On one hand, Glass Mountain obsidian makes up only approximately 5% of the obsidian assemblage in sites close to the source. Yet on the other hand, it has a significant presence in the biface assemblage from CA-Hum-67 along the northwestern California coast. From these data, it is apparent that Glass Mountain obsidian was utilized in the past, albeit very selectively. What is most remarkable however, is the fact that Glass Mountain was effectively ignored for utilitarian purposes in the immediate vicinity of the source while other Medicine Lake Highland obsidian was preferred for utilitarian things.

There exist few economic explanations for the lack of Glass Mountain obsidian in utilitarian assemblages in the sites within 50 miles of the quarry, particularly given that it is a high quality, easily procured obsidian. Indeed, prehistoric flintknappers traveled to nearby obsidian sources in the Medicine Lake Highland to obtain their toolstone, as evidenced by the 73% proportion of other Medicine Lake Highland obsidians in late-prehistoric assemblages. These data indicate that cultural factors held a substantial role in influencing the procurement and use of Glass Mountain obsidian in late prehistory. There was a pattern of selection of Medicine Lake Highland obsidian for a multitude of uses, yet Glass Mountain obsidian, arguably the largest and most spectacular obsidian flow in the Medicine Lake Highland, was neglected for utilitarian purposes. Instead, Glass Mountain obsidian was used for large, ceremonial bifaces. As such, the archaeological record strongly supports the hypothesis that Glass Mountain was a special obsidian source, reserved for the production of ceremonial and high value objects, and deemed inappropriate for the manufacture of utilitarian tools.

CHAPTER 12

OBSIDIAN HYDRATION

INTRODUCTION

Obsidian hydration offers one means for calculating chronological estimates in obsidian quarry situations such as that at Glass Mountain. Obsidian hydration directly dates an obsidian artifact, and therefore does not rely on stratigraphic association with other materials for chronologies. However, due to inherent problems with this technique, which will be discussed in further detail below, obsidian hydration is often not the preferred method for achieving temporal control. Despite this, because associated organic materials were not observed at Glass Mountain, and temporally diagnostic formed tools were not recovered, obsidian hydration provided the most appropriate available method to determine the time period when Glass Mountain sites were created.

Obsidian hydration dating entails the measurement of a thin hydration rind on the surface of archaeological obsidian. Calendar dates are based on rind thickness calibrated to additional factors such as obsidian chemistry, relative humidity, and ambient temperature. Despite the utilization of this technique for over 40 years in archaeology (Friedman and Smith 1960, Friedman and Long 1967), there are still questions and problems with its implementation. However, in situations where other methods of dating are unavailable, it offers one potential source of chronological information.

Obsidian hydration occurs in nature in the presence of liquid water and water vapor, though most moisture occurs as the latter (Stevenson et al. 1998: 183). Water vapor creates a thin molecular layer of water on the surface of the obsidian, which is

Figure 12.1: Obsidian hydration rim as seen under polarizing microscope (Northwest Research Obsidian Studies Laboratory 2002).

continually replenished through interaction with the surrounding matrix. Two processes occur when a fresh surface of obsidian is exposed to water: first, water slowly diffuses into the obsidian, creating a hydration rind, and second, the glass actively dissolves until silica saturation of the water layer is achieved. Obsidian hydration is possible because the rate at which water is absorbed by the obsidian occurs at a faster rate than the dissolution of the obsidian. However, obsidian hydration is both a physical and a chemical process. As the obsidian matrix absorbs molecular water, hydronium ions replace mobile cations, such as sodium, in the obsidian (Stevenson et al. 1998: 183). These processes create a birefringence layer visible under a polarizing microscope, and it is this layer that is measured in obsidian hydration dating (figure 12.1).

METHODOLOGY

Fifty-eight samples were collected and analyzed using obsidian hydration for the Glass Mountain Archaeological Project. Of these, 54 were flakes, and only 4 were biface fragments. A random sampling strategy was employed to collect flakes from the surface of loci in sites along the base of the glass flow. Simple random sampling within each locus was selected for this exercise. “Simple random sampling is a method of generating samples such that every sample of size *n* has exactly the same probability of selection” (Thomas 1986: 126). This strategy was carried out through the use of the same 20x20 cm square template used for debitage analysis. This template was randomly tossed within the boundaries of a locus. The sample was then collected from within the template wherever it fell, consisting of a grab sample of two flakes. No effort was made to obtain specific types of debitage, so biface thinning flakes, core reduction flakes, and shatter were all represented in the sample assemblage. The only criteria for collection was a flake size large enough to be held safely while it was cut for hydration measurement, and generally this dictated that the collected specimen be at least two centimeters in diameter. In order to obtain the 54 debitage specimens for hydration analysis, all collected debitage was placed in a large bag, and individual samples were pulled blindly from the bag. The first 54 pulled from the bag were analyzed. Only four biface fragments were analyzed, due to Native American concerns about artifact collection and the damage caused to these objects by obsidian hydration. Two of the biface fragments were paired halves of a single biface.

Obsidian samples were prepared and analyzed with the assistance of Tom Origer at Sonoma State University and the offices of Origer and Associates in Rohnert Park, California. Preparation was performed at Sonoma State University and at the Archaeological Research Facility, University of California, Berkeley.

Each sample was first examined macroscopically to identify an appropriate surface for cutting and analysis. Flake edges with acute angles, little edge-damage, and minimal surface accretions were selected whenever possible. Two parallel cuts oriented roughly perpendicular to the flake edge were made on the selected margin of each specimen using a diamond-impregnated, 4 inch diameter circular saw blade mounted on a lapidary saw. This isolated an approximately 1mm wide sample, which was removed and mounted on a heated glass slide using Lakeside thermoplastic cement. After the cement cooled and formed a strong bond, the mounted sample was manually ground on a glass plate using a slurry of #500 grade optical-quality silicon carbide abrasive. This first grinding reduced the thickness of the sample by approximately one-half, which removed any flaws or striations resulting from the cutting process. The slide was then reheated on a hot plate to melt the Lakeside cement, and the sample was flipped over. The second grinding smoothed the second surface and reduced the specimen to its desired thickness of approximately 30-50 microns. The correct section thickness was determined by touch, and double-checked by Tom Origer prior to hydration measurement. A protective cover slip was applied and permanently affixed over the specimen, resulting in a lasting thin section of the artifact surfaces.

The prepared slides were examined using a petrographic microscope under 45x magnification. Edges of the specimen were scanned to identify the hydration rim and to select the most appropriate sections for measurement. Readings were taken using a 10x filar micrometer eyepiece. At least four measurements were taken for each specimen at different locations along the surface of the sample, and the mean measurement calculated for each. It should be noted that hydration band measurements have a standard error factor of +/- 0.2 microns due to the limitations of the equipment.

ANALYSIS

Hydration rim readings for the 58 Glass Mountain specimens yielded a mean of 1.1 microns, with a median of 1.06 microns, and a standard deviation of 0.18. Three samples had a diffuse hydration rim, which was unreadable, and one had no visible hydration band at all. A graph of the measurements revealed a normal distribution, though slightly skewed towards the higher end. Low outliers were non-existent, likely due to the limits of the measuring equipment in accurately discerning smaller hydration rind. The graph of hydration measurements implies that Glass Mountain was utilized

Hydration Lab Number	FSMA Number	Provenience (Site Number)	Locus Number	Measurement #1	Measurement #2	Measurement #3	Measurement #4	Mean	Source	Notes
CD-1	2016-05a	05-09-56-3042	34	1.1	1.2	1.4	1.1	1.2	GM	
CD-2	2016-05b	05-09-56-3042	34	1.1	1.5	1.3	1	1.225	GM	
CD-3	2025-01a	05-09-56-3049	2	1.3	1.4	1.5	1	1.3	GM	
CD-4	2025-01b	05-09-56-3049	2	1.5	1.1	1.1	1.1	1.2	GM	
CD-5	2021-01a	05-09-56-3045	10	1	1	1	1.2	1.05	GM	
CD-6	2021-01b	05-09-56-3045	10	1	1.1	1.1	1.1	1.075	GM	
CD-7	1969-01	05-09-56-3039	3	n/a	n/a	n/a	n/a	n/a	GM	DH/w
CD-8	2016-12a	05-09-56-3042	53	0.8	0.7	1	1.1	0.9	GM	
CD-9	2016-12b	05-09-56-3042	53	n/a	n/a	n/a	n/a	n/a	GM	DH/w
CD-10	2016-07a	05-09-56-3042	8	0.7	0.8	0.7	1.1	0.825	GM	
CD-11	2016-07b	05-09-56-3042	8	1.5	1.5	1.3	1.1	1.35	GM	
CD-12	2020-03a	05-09-56-3044	2	2	1.1	1.4	1.3	1.45	GM	
CD-13	2020-03b	05-09-56-3044	2	1.3	1.3	1.3	1.1	1.25	GM	
CD-14	2016-06a	05-09-56-3042	19	1.1	1.5	1.6	1.3	1.375	GM	
CD-15	2016-06b	05-09-56-3042	19	1.5	1.3	1	1.2	1.25	GM	
CD-16	2016-08a	05-09-56-3042	30	1.9	1.6	1.5	1.6	1.65	GM	
CD-17	2016-08b	05-09-56-3042	30	1.3	1	1.3	1.1	1.175	GM	
CD-18	2016-03a	05-09-56-3042	37	1.2	1.1	1.1	1.1	1.125	GM	
CD-19	2016-03b	05-09-56-3042	37	1.1	0.9	1	1.1	1.025	GM	
CD-20	2016-11a	05-09-56-3042	44	1.3	1.1	1.3	1.2	1.225	GM	
CD-21	2016-11b	05-09-56-3042	44	1.2	1.1	1	1.2	1.125	GM	
CD-22	1969-02	05-09-56-3039	2	0.8	1	1	0.9	0.925	GM	
CD-23	1991-01a	05-09-56-3040	7	1	0.7	0.8	1	0.875	GM	
CD-24	1991-01b	05-09-56-3040	7	0.8	0.9	0.8	1.1	0.9	GM	
CD-25	2016-13a	05-09-56-3042	16	1.2	1	0.9	0.9	1	GM	
CD-26	2016-13b	05-09-56-3042	16	n/a	n/a	n/a	n/a	n/a	GM	DH/w
CD-27	2012-02a	05-09-56-3041	11	1.1	1	1	1.1	1.05	GM	
CD-28	2012-02b	05-09-56-3041	11	1.1	1.1	1.3	1.1	1.15	GM	
CD-29	1969-03	05-09-56-3039	1	1	1	1	1	1	GM	
CD-30	1991-02	05-09-56-3040	1	0.8	0.9	1	1.3	1	GM	
CD-31	2016-04a	05-09-56-3042	13	1	1.4	1.3	1.2	1.225	GM	
CD-32	2016-04b	05-09-56-3042	13	1.1	1.1	1.1	0.9	1.05	GM	

Table 12.1: Glass Mountain Hydration Measurements (page 1 of 2)

Hydration Lab Number	FSMA Number	Provenience (Site Number)	Locus Number	Measurement #1	Measurement #2	Measurement #3	Measurement #4	Mean	Source	Notes
CD-33	2016-02a	05-09-56-3042	75	1.3	1.3	1.5	1	1.275	GM	
CD-34	2016-02b	05-09-56-3042	75	0.8	1	1.2	0.8	0.95	GM	
CD-35	2016-10a	05-09-56-3042	22	1.1	0.8	1.1	1	1	GM	
CD-36	2016-10b	05-09-56-3042	22	1.1	1.2	1.1	0.9	1.075	GM	
CD-37	2016-09a	05-09-56-3042	68	1.3	1.5	1.2	1.1	1.275	GM	
CD-38	2016-09b	05-09-56-3042	68	1.9	1.6	1.5	1.4	1.6	GM	
CD-39	2017-01a	05-09-56-3043	9	0.9	0.8	0.8	1.1	0.9	GM	
CD-40	2017-01b	05-09-56-3043	9	1.1	1.4	1.3	1	1.2	GM	
CD-41	2020-01a	05-09-56-3044	12	1.4	1.4	1.3	1.1	1.3	GM	
CD-42	2020-01b	05-09-56-3044	12	0.8	0.9	0.8	1	0.875	GM	
CD-43	2020-02a	05-09-56-3044	6	1	1.1	1.2	1.2	1.125	GM	
CD-44	2020-02b	05-09-56-3044	6	0.8	0.9	0.8	0.9	0.85	GM	
CD-45	2022-01a	05-09-56-3046	1	1	1.1	1	1.2	1.075	GM	
CD-46	2022-01b	05-09-56-3046	1	1.3	0.9	1	1.2	1.1	GM	
CD-47	2023-01a	05-09-56-3047	3	1	0.8	0.9	1.4	1.025	GM	
CD-48	2023-01b	05-09-56-3047	3	0.8	1	1	1.1	0.975	GM	
CD-49	2023-02a	05-09-56-3047	22	1.1	1	1	1.1	1.05	GM	
CD-50	2023-02b	05-09-56-3047	22	0.8	0.8	0.7	1.2	0.875	GM	
CD-51	2023-03a	05-09-56-3047	10	1.2	1.1	1	1.1	1.1	GM	
CD-52	2023-03b	05-09-56-3047	10	1.1	0.9	0.9	1.2	1.025	GM	
CD-53	2024-01a	05-09-56-3048	1	0.8	0.9	1	1.2	0.975	GM	
CD-54	2024-01b	05-09-56-3048	1	1	1.1	0.8	1.1	1	GM	
CD-55	2012-01	05-09-56-3041	none	0.8	1	0.8	0.9	0.875	GM	
CD-56	2016-01a	05-09-56-3042	59	0.9	1	1.1	1.1	1.025	GM	
CD-57	2016-01b	05-09-56-3042	59	1	0.8	1	1.2	1	GM	
CD-58	672-03	05-09-56-1028	none	n/a	n/a	n/a	n/a	n/a	GM	no H
			mean:	*1.11*	*1.09*	*1.09*	*1.11*	*1.101*		
			median:	*1.10*	*1.05*	*1.00*	*1.10*	*1.063*		
			Std. Dev.	*0.28*	*0.23*	*0.23*	*0.14*	*0.18*		
			minimum:	*0.70*	*0.70*	*0.70*	*0.80*	*0.825*		
			maximum:	*2.00*	*1.60*	*1.60*	*1.60*	*1.65*		

Table 12.1: Glass Mountain Hydration Measurements (page 2 of 2)

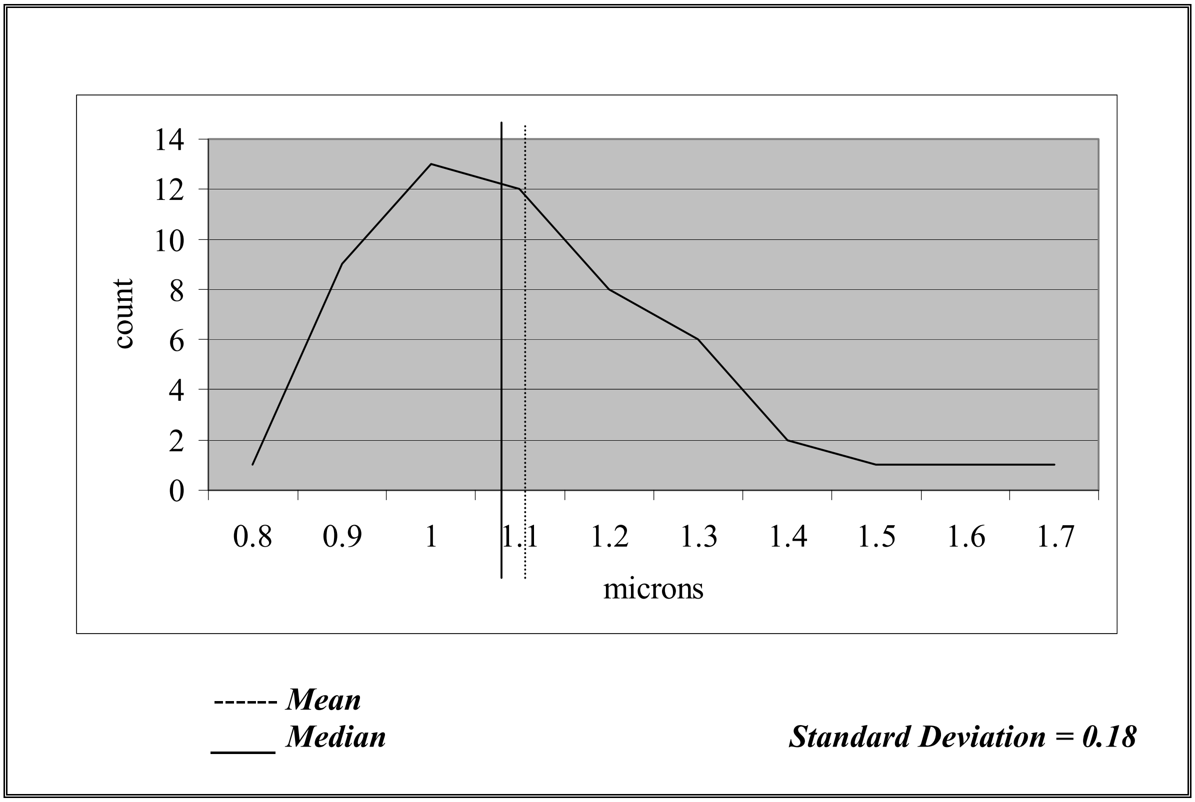


Figure 12.3: Glass Mountain hydration measurements (n=54).

primarily during a single time period. This graph does not indicate an extended period of use or multiple peaks.

Hydration measurements were then used to calculate a calendar date for Glass Mountain utilization. Because a number of factors come into play in affecting the hydration of obsidian, it was first necessary to correct for such things as ambient temperature and hydration rate for Glass Mountain obsidian. These factors were calibrated to the Napa Glass Mountain obsidian source, because extensive experimentation has yielded an effective formula for the hydration of Napa Glass Mountain obsidian and this has become the standard for obsidian hydration in northern California (Origer 2001: personal communication, Hull 2001b: personal communication).

Glass Mountain obsidian hydrates at a rate of 90% of that of Napa Glass Mountain obsidian (Origer 2001: personal communication). This is presented as a ratio or comparison constant, which converts the hydration reading for one source into the equivalent reading for another source with a known hydration rate (Tremaine and Fredrickson 1988). Therefore, the hydration measurements for Glass Mountain obsidian were corrected to the Napa Glass Mountain rate by an increase of 10%.

To adjust the hydration measurements for temperature, it was necessary to calculate the effective hydration temperature (EHT) for Glass Mountain. Glass Mountain is located at an elevation of between 5500 and 7500 feet above sea level, so temperatures tend to be fairly cool, with much of the annual precipitation falling as snow. Mean annual and monthly temperatures were calculated from data published for Medicine Lake and the Pit River Basin by the California Department of Water Resources, Division of Flood Management. Temperature data include hourly air temperature readings at an elevation of 6,700 feet above sea level, which should be comparable to temperatures at Glass Mountain, located within 3 miles of Medicine Lake. Temperature readings spanned fifteen years, between 1985 and the present. The following formula was used to calculate the Effective Hydration Temperature:

$$Ta = - 1.2316 + 1.0645\ Te - 0.1607\ Rt$$

Ta = mean annual air temperature (degrees Celsius)
Te = effective hydration temperature in degrees Celsius (EHT)
Rt = temperature range of annual monthly means (degrees Celsius)

For Glass Mountain:

Ta = 4.892°C
Te = 6.329°C
Rt = 3.819°C

In order to again calibrate to the Napa Glass Mountain source, the Effective Hydration Temperature (EHT) of Glass Mountain was compared to that of Napa. Napa has an EHT of 16.1°C while Glass Mountain has an EHT of 6.329°C. Therefore the hydration measurements for Glass Mountain obsidian samples must be adjusted down exponentially by 0.6 per degree difference, which in this case is 9.8 degrees. This final step calibrates hydration rim measurements between Glass Mountain samples and Napa Glass Mountain, the source for which the hydration formula was created. Once these calculations were completed, calibrated hydration rim measurements were used in the following formula to calculate age of the specimen in number of years before present.

$$x^2\ k^2 = \text{years BP}$$

k = hydration rate at a particular temperature
x = hydration rim measurement (in microns)

The following formula yields the age of Napa Glass Mountain obsidian, and therefore is used for calibrated Glass Mountain specimen measurements:

$$M^2 (153.4) = \text{years BP}$$

M = calibrated hydration rim measurement (microns)

For the 58 Glass Mountain samples analyzed, the above calculations yielded a mean date of 114 BP +/- 15. The minimum date obtained for this assemblage was 62.2 BP +/- 15 and the maximum was 249 BP +/- 15. As will be discussed in the next section, there are potential problems with these obsidian hydration calculations, which may have resulted in a younger date than expected.

DISCUSSION

Hydration rim measurements suggest that use of the Glass Mountain obsidian source was comparatively recent, spanning the late prehistoric and historic periods, yet there are potential problems with the obsidian hydration calculations. Hydration dates cluster around 114 BP and display a relatively normal distribution, which can be interpreted to indicate that Glass Mountain was utilized for a 150 year span of time beginning in the late prehistoric. However, the historic period in this area began relatively late, since earliest white contact in the northeastern California region occurred in the late 1820's, and consistent and repeated interactions did not occur until the late 1840's.

It is interesting that according to the hydration data, Glass Mountain obsidian does not appear to have been used significantly prior to 249 BP, even though it was

Hydration Lab Number	FSMA Number	Provenience (Site Number)	Locus Number	Mean Hydration Measurement	Years BP	Calendar Year
CD-1	2016-05a	05-09-56-3042	34	1.32	132	1818
CD-2	2016-05b	05-09-56-3042	34	1.35	137	1813
CD-3	2025-01a	05-09-56-3049	2	1.43	155	1795
CD-4	2025-01b	05-09-56-3049	2	1.32	132	1818
CD-5	2021-01a	05-09-56-3045	10	1.16	101	1849
CD-6	2021-01b	05-09-56-3045	10	1.18	106	1844
CD-7	1969-01	05-09-56-3039	3	n/a	n/a	n/a
CD-8	2016-12a	05-09-56-3042	53	0.99	74	1876
CD-9	2016-12b	05-09-56-3042	53	n/a	n/a	n/a
CD-10	2016-07a	05-09-56-3042	8	0.91	62	1888
CD-11	2016-07b	05-09-56-3042	8	1.49	167	1783
CD-12	2020-03a	05-09-56-3044	2	1.6	192	1758
CD-13	2020-03b	05-09-56-3044	2	1.38	143	1807
CD-14	2016-06a	05-09-56-3042	19	1.51	173	1777
CD-15	2016-06b	05-09-56-3042	19	1.38	143	1807
CD-16	2016-08a	05-09-56-3042	30	1.82	249	1701
CD-17	2016-08b	05-09-56-3042	30	1.29	126	1824
CD-18	2016-03a	05-09-56-3042	37	1.24	116	1834
CD-19	2016-03b	05-09-56-3042	37	1.13	96	1854
CD-20	2016-11a	05-09-56-3042	44	1.35	137	1813
CD-21	2016-11b	05-09-56-3042	44	1.24	116	1834
CD-22	1969-02	05-09-56-3039	2	1.02	78	1872
CD-23	1991-01a	05-09-56-3040	7	0.96	70	1880
CD-24	1991-01b	05-09-56-3040	7	0.99	74	1876
CD-25	2016-13a	05-09-56-3042	16	1.1	91	1859
CD-26	2016-13b	05-09-56-3042	16	n/a	n/a	n/a
CD-27	2012-02a	05-09-56-3041	11	1.16	101	1849
CD-28	2012-02b	05-09-56-3041	11	1.27	121	1829
CD-29	1969-03	05-09-56-3039	1	1.1	91	1859
CD-30	1991-02	05-09-56-3040	1	1.1	91	1859
CD-31	2016-04a	05-09-56-3042	13	1.35	137	1813
CD-32	2016-04b	05-09-56-3042	13	1.16	101	1849

Table 12.2: Obsidian Hydration Calendar Date Calculations (page 1 of 2).

Hydration Lab Number	FSMA Number	Provenience (Site Number)	Locus Number	Mean Hydration Measurement	Years BP	Calendar Year
CD-33	2016-02a	05-09-56-3042	75	1.4	149	1801
CD-34	2016-02b	05-09-56-3042	75	1.05	83	1867
CD-35	2016-10a	05-09-56-3042	22	1.1	91	1859
CD-36	2016-10b	05-09-56-3042	22	1.18	106	1844
CD-37	2016-09a	05-09-56-3042	68	1.4	149	1801
CD-38	2016-09b	05-09-56-3042	68	1.76	234	1716
CD-39	2017-01a	05-09-56-3043	9	0.99	74	1876
CD-40	2017-01b	05-09-56-3043	9	1.32	132	1818
CD-41	2020-01a	05-09-56-3044	12	1.43	155	1795
CD-42	2020-01b	05-09-56-3044	12	0.96	70	1880
CD-43	2020-02a	05-09-56-3044	6	1.24	116	1834
CD-44	2020-02b	05-09-56-3044	6	0.94	66	1884
CD-45	2022-01a	05-09-56-3046	1	1.18	106	1844
CD-46	2022-01b	05-09-56-3046	1	1.21	111	1839
CD-47	2023-01a	05-09-56-3047	3	1.13	96	1854
CD-48	2023-01b	05-09-56-3047	3	1.07	87	1863
CD-49	2023-02a	05-09-56-3047	22	1.16	101	1849
CD-50	2023-02b	05-09-56-3047	22	0.96	70	1880
CD-51	2023-03a	05-09-56-3047	10	1.21	111	1839
CD-52	2023-03b	05-09-56-3047	10	1.13	96	1854
CD-53	2024-01a	05-09-56-3048	1	1.07	87	1863
CD-54	2024-01b	05-09-56-3048	1	1.1	91	1859
CD-55	2012-01	05-09-56-3041	n/a	0.96	70	1880
CD-56	2016-01a	05-09-56-3042	59	1.13	96	1854
CD-57	2016-01b	05-09-56-3042	59	1.1	91	1859
CD-58	672-03	05-09-56-1028	n/a	n/a	n/a	n/a
			Mean:	*1.21*	*114*	*1836*
			Median:	*1.17*	*103*	*1847*
			Std. Dev.:	*0.20*	*39*	*39*
			Min.:	*0.91*	*62*	*1701*
			Max.:	*1.82*	*249*	*1888*

Table 12.2: Obsidian Hydration Calendar Date Calculations (page 2 of 2).

available as early as approximately 900 BP. There are several possible interpretations for this that will be explored in this section. First, date calculations based on hydration rim measurements may be incorrect due to a variety of complicating environmental factors. Second, given that sampling was confined to surface collection, the data may represent a biased sample of Glass Mountain debitage. Third, the data may be correct and other factors may have prohibited use of Glass Mountain earlier than 249 BP. These three potential explanations will be discussed further below.

First, date calculations based on hydration rim measurements may be incorrect due to an incomplete understanding of the hydration process, environmental factors such as fire or excessive heat, or measurement errors resulting from inaccurate temperature data, imprecise equipment, or operator error.

Hydration processes and equations are constantly being refined, and it has been suggested that the equations currently in use are merely crude tools for estimating approximate dates and should by no means be viewed as accurate assessments of chronological data (Anovitz et al. 1999: 735). However, accelerated hydration experiments have been used as one means for refining and re-evaluating hydration equations (Origer et al. 1997). Accelerated hydration, essentially subjecting obsidian specimens to pressure, heat, and steam for varying periods of time, is used to calculate hydration rate differences between and among obsidian sources. These data are used to refine hydration equations used to compute calendar dates from hydration measurements. Given this, date calculations based on hydration measurements for Glass Mountain samples were conducted with the most current available data in mind. If this is a source for error in assessing Glass Mountain dates, it is unavoidable at this time.

Environmental factors such as fire and excessive heat are known to affect the hydration rim thickness of obsidian specimens (Origer et al. 1997, Anderson and Origer 1997, Loyd 1999). Experimental heating has shown that hydration rims disappear or become indistinct following burning, even at relatively low temperatures (Anderson and Origer 1997, Soloman 1999). However, accelerated hydration of burned samples have resulted in hydration rims similar to those which formed on previously unhydrated specimens during the same period of accelerated hydration (Origer et al. 1997). This could obviously pose potential problems in environments that burn periodically or in those situations where the burning history of the area is unknown (Skinner and Weatherspoon 1999). If burning took place in the past, it would effectively reset the hydration rim at the zero point, resulting in a much younger calendar date for the obsidian specimen. At Glass Mountain, evidence of burning was not directly observed, yet burning frequently occurs in this area and likely impacted archaeological sites in the past. If so, hydration rim measurements may provide a younger date than expected and would not accurately reflect the amount of time that has passed since the flakes were created.

Another potential issue linked to the experimental work just described is the effect of heat caused by solar radiation. To my knowledge, no research has been conducted to specifically address this issue, however experiments dealing with the effects of fire on hydration rim measurements have questioned the lowest temperature thresholds at which hydration rims are altered and found that temperatures as low as 150°C can result in diffuse hydration rinds, particularly in situations of extended durations of heat exposure (Deal and McLemore 1999). Therefore, excessive heat caused by solar radiation on a daily basis could potentially alter the hydration rim of archaeological obsidian samples.

At Glass Mountain during the summer months, exposed obsidian becomes hot enough to cause first-degree burns when touched on an almost daily basis. Temperature readings were not obtained from hot obsidian samples, but probably reached 90°C. Essentially, like the known effects of fire on obsidian hydration measurements, solar radiation could result in an incorrect calendar date for the obsidian specimen. Because heat resets the obsidian hydration process, samples may appear younger than is actually the case. This may warrant future study as yet another issue complicating the use of obsidian hydration for archaeological specimens. Imprecise temperature data, including differences in surface and subsurface temperatures, microclimates, or shaded areas can also affect hydration rates and calculations. Small-scale, regionally-specific climatic data, including surface and subsurface temperatures, may be necessary for calculating age estimates from hydration rim measurements (Hull 2001a).

The chemical composition of obsidian is also a variable factor in the hydration of archaeological specimens. Above all, intrinsic water strongly affects hydration rate. Compositional variability between sources is accounted for to some degree in the hydration formula, which is specific to a particular source. However issues of chemical variability *within* a single source are rarely addressed in hydration analyses, though it is now recognized that structural water content is variable within sources (Stevenson et al. 2000: 225). Geochemical characterization studies have also revealed that compositional variability is a major issue in the identification and sourcing of archaeological specimens (Shackley 2000: 1-4), and by extension, may be a factor in hydration studies as well. If obsidian flows are extremely variable in chemistry and water content, compositionally specific hydration rate formulas may be necessary for accurate assessment of chronological data. Glass Mountain is relatively homogenous in trace element composition, however it contains varying percentages of intrinsic water (Grove et al. 1997, Donnelly-Nolan et al. 1990), which can affect the hydration rate and as a result, can affect the calculated date for archaeological specimens.

Finally, operator or equipment error is yet another factor that can have drastic effects on the date assignments for hydration specimens. Comparative studies of the hydration rim measurements obtained by independent operators on the same specimens have shown that there is a wide range of variation (Jackson 1984, Stevenson et al. 1989). New methodologies for detecting and measuring hydration thicknesses are increasingly gaining popularity, though they may add higher costs to a traditionally low-cost and low-tech dating technique. Experimental use of secondary ion mass spectrometry (Riciputi et al. 2000) and infra-red photoacoustic spectroscopy (Stevenson et al. 2001) for detecting and measuring hydration rims has shown some success, but has yet to gain widespread use in archaeology. In this study, obsidian hydration rim thicknesses were measured using the standard filar micrometer eyepiece. In order to avoid excessive operator error, measurements were read by both Tom Origer and myself. Though we were still constrained by the limitations of the equipment, it is hoped that measurements by two individuals more accurately represent the true hydration rim thickness.

A second potential interpretation for the recent date of Glass Mountain archaeological specimens involves possible bias in sample collection. Given that specimens used for obsidian hydration as part of the Glass Mountain Archaeological Project were obtained through surface collection, it is possible that this has created a biased sample of obsidian artifacts, and by extension, a biased sample of obsidian hydration dates. Stratigraphically, in undisturbed conditions, more recent archaeological material would be expected to comprise the uppermost levels. Glass Mountain sediments appear remarkably undisturbed, with little evidence of bioturbation or human activity. As a result, environmental conditions such as snow, ice, wind, and rain are responsible for almost all of the stratigraphic disturbance, though even this appears extremely minimal. However, test excavations at site 05-09-56-3001/H revealed that archaeological material was purely a surface manifestation. Over 99% of the artifacts recovered during test excavation originated in the top 10cm level. Therefore, surface collection of specimens for obsidian hydration should include a representative sample of the material contained in the assemblage. Admittedly, test excavations were not performed in all loci or sites, due to prohibitive costs and Native American concerns, though examination of surface conditions indicates a complete lack of soil development and minimal organic material. Thus it is assumed that archaeological samples collected for hydration analyses should include specimens from all components.

A third potential interpretation for obsidian hydration data suggests that the hydration results are an accurate representation of the variability present at Glass Mountain. Despite an unexpected lack of earlier dates for Glass Mountain hydration samples, the data may be fully correct in pointing towards a brief, late prehistoric utilization of this obsidian source. A sample of 54 hydration rim measurements from specimens collected using a probabilistic, random sampling strategy should provide a representative sample of the utilization of Glass Mountain obsidian. Obviously, as sample size increases, the sample will begin to approach the configuration of the population as a whole. However, I suggest that this sample size provided a fairly good representation of the hydration rim measurements for Glass Mountain debitage. Even though the sample may accurately represent the obsidian hydration rim thicknesses at Glass Mountain sites, additional complications such as environmental factors, may have resulted in thinner hydration rims overall, and therefore false recent hydration dates.

Archaeological data from non-quarry sites where Glass Mountain artifacts have been found are consistent with a late prehistoric utilization of Glass Mountain obsidian, yet suggest that Glass Mountain obsidian was used prior to the 114 BP mean date obtained through obsidian hydration analysis. The Gunther Island site (CA-Hum-67) contained two bifaces that were assigned to the Medicine Lake Highland sources, and upon visual inspection appear to be of Glass Mountain obsidian. This site was occupied until the 1860's and was historically known as *Dulawo't*, though its earliest occupation may have been 900 years ago (Hughes 1978: 53-66). Bifaces of this type were manufactured at Glass Mountain, based on debitage and production analyses conducted as part of this research. Debitage recovered during the PGT-PG&E pipeline project also shows a concentration of Glass Mountain obsidian during the late prehistoric. In two selected regions, Dobie Flat and the Modoc Uplands, 96.1% of Glass Mountain obsidian flakes were recovered from late prehistoric contexts (Schalk 1995: 8-16). Other sites, including CA-Sha-68/H, CA-Mod-2574, CA-Mod-1206/07, CA-Mod-2560, and CA-Mod-2562 also contained Glass Mountain artifacts dating to the late prehistoric (site records on file at Modoc National Forest).

It must be assumed that Glass Mountain was used after 900 BP, since the source was unavailable prior to that time. Furthermore, Glass Mountain may have remained hot and contained active fumaroles for centuries after the glass-forming eruption in 900 BP.

Therefore, access to the source could have been dangerous for many years. It is also possible to speculate that prehistoric peoples were hesitant to collect and use Glass Mountain obsidian soon after the eruption, even once the danger of heat, earthquakes, and poisonous gasses dissipated. People may have been fearful of this mountain, given the impact of its massive eruption, and avoided the source for several generations. Over time, however, fear may have given rise to reverence of Glass Mountain as a special place, ultimately culminating in its use for high value and ceremonial objects. In sum, the lag between obsidian availability and utilization may be yet another indication of the prehistoric belief systems relating to the exploitation and use of specific obsidian sources for particular categories of objects.

CONCLUSION

Hydration rim measurements from the Glass Mountain Archaeological Project yielded dates ranging from a minimum of 62.2 BP +/- 15 and a maximum of 249 BP +/- 15, with a mean date of 114 BP +/- 15. This indicates that use of the Glass Mountain obsidian quarry spanned only an approximately 150 year period in the late prehistoric and early historic, despite its availability since approximately 900 BP. This pattern of late prehistoric use of this source may indicate that cultural factors influenced the utilization of Glass Mountain obsidian. Or, alternatively, environmental impacts, sampling biases, or technological limitations may have caused the very recent obsidian hydration dates recovered from these archaeological specimens, and in fact indicate that they do not accurately represent the true antiquity of Glass Mountain obsidian procurement and use.

Despite the many criticisms and problems with using obsidian hydration dating for archaeological specimens, in the case of Glass Mountain, obsidian hydration provided the only feasible technique for dating these quarry sites. Since there was a complete absence of organic material, other more reliable methods were unavailable. As a result, obsidian hydration was used for the Glass Mountain samples, but the results were questioned for their accuracy. Unknown environmental conditions, such as the occurrence of fire and heat due to solar radiation, could have altered the hydration rims resulting in spurious, younger obsidian hydration dates. As always, when relying on analytical methods it is essential to know and understand the limitations of the technology, and the effectiveness of obsidian hydration analyses continues to be debated among both archaeologists and archaeometrists (Anovitz et al. 1999, Hull 2001a, Origer et al. 1997, Lloyd 1999, Deal and McLemore 1999, Anderson and Origer 1997, Skinner and Weatherspoon 1999, Soloman 1999, Stevenson et al. 1989).

CHAPTER 13

SYNTHESIS AND CONCLUSIONS

In the year 1050 A.D. the earth shook with a tremendous roar. It started slowly, stealthily, with a shallow ripple that caused the incense cedar to tremble as though it were cold. The ground squirrels cocked their ears at the unusual mumblings within the earth, and frowned at the cascade of soft soil that collapsed into their burrows. But they continued their busy-busy nervous activity. Until the world exploded.

At first it was just a rumble; a shaking, rattling, rumble within the ground. Waves appeared to race towards the shores of placid Medicine Lake, only to be confused by waves traveling in the opposite direction. Smoke seeped up through the trees, carrying with it a biting smell of sulfur and foreboding. The people stared, curious but not yet afraid for the Elders have told of similar events on the Highland in the remembered past. Quickly the rumblings increased, louder and ferocious like a great beast preparing to strike. The ground broke with a sudden blast, sending a giant cloud into the sky. The people saw the explosion before they heard the boom – more a feeling than a sound, like a physical blow. Now, they were afraid.

Unnatural night engulfed the land, and gray ash fell like warm snow. The people huddled in what shelter they could find and waited for the earth to cease its convulsions. After ten days, the gray snow stopped falling and the people emerged from their places of refuge. The night was clear, and they could see the beast on the Highland glowing in the darkened sky. Lightning illuminated the clouds over the newly formed mountain, while *burning forests illuminated the ground. The people watched with awe and reverence, but the nightly fireworks diminished over time. They could see the new mountain sparkling in the midst of barren pumice and ashfall, and they stayed away from this dangerous place for many generations.*

Finally, a brave young person tired of the Elders' stories about the rumbling beast that created the sparkling flow on the Highland, and decided it was time to explore the new mountain. A group of three friends prepared themselves for a trek across unknown terrain, through unknown perils, certain in their intelligence and ability. They set off across the desert, over the vast hills of new pumice, and up-up-up to the sparkling cliff on the Highland. They knew already of the black and red stones which were used for tools and arrows, for this material was common in the region. But there, before them, as far as they could see, flowed a special gift from the spirit-monster within the mountain. Obsidian.

Early descriptive studies of prehistoric quarries have provided a foundation for further research into the role of quarry locales in past cultures. However, preconceived ideas about the utilitarian function of quarries in the past have obscured the cultural context of these important sites. Archaeological studies of lithic material procurement and use have traditionally focused on raw material quality and proximity to source as sole indicators for selection of particular materials for stone tool manufacture. Yet this effectively denies the role of human agency in the choice of lithic materials. The Glass Mountain obsidian quarry provides evidence for integration of prehistoric belief systems into toolstone procurement and use patterns, and the selective use of Glass Mountain obsidian for ceremonial and value objects.

THE GLASS MOUNTAIN ARCHAEOLOGICAL PROJECT

Fieldwork conducted at Glass Mountain revealed a singular pattern of raw material procurement and production at the quarry. Field reconnaissance, surface sampling, and subsurface testing indicated that biface production was the primary activity performed at Glass Mountain. High percentages of identifiable biface thinning flakes as well as biface fragments in all stages of production attest to this fact. In addition, retooling activities were conspicuously absent in the debitage and tool assemblages at the sites recorded along the base of the Glass Mountain obsidian flow. Though a handful of utilized flakes were found, no projectile points, projectile point fragments, knives, formed scrapers, drills, or other formed tools were observed. The only formalized objects recorded were large bifaces and biface fragments.

Not surprisingly, obsidian assemblages for the area surrounding Glass Mountain are consistent with the production patterns observed at the source. Glass Mountain obsidian is extremely rare in late-prehistoric components, comprising only approximately 5% of the debitage and formed tools. Interestingly, other obsidian sources from the Medicine Lake Highland, including Grasshopper Flat/Lost Iron Well, Cougar Butte, and East Medicine Lake, are common. Any prohibition against utilizing Glass Mountain obsidian for utilitarian objects obviously did not extend to other obsidian sources in the immediate vicinity. Such patterning suggests that cultural and ideological, rather than purely economic, factors influenced the use of Glass Mountain obsidian in prehistory.

Archaeological evidence from northwestern California provides an additional piece of the Glass Mountain puzzle. Large ceremonial bifaces from burial contexts were geochemically characterized (Hughes 1978) and macroscopically analyzed to determine the geologic source for the black and red obsidian. Though only a small sample of black bifaces was analyzed (Hughes 1978), it appears that 40% of the black bifaces may have originated from Glass Mountain. Though other black obsidian sources were also exploited for large ceremonial bifaces, Glass Mountain obsidian was a significant portion of this assemblage, and provides evidence for a cross-cultural value and belief system emphasizing particular obsidian sources as appropriate for the manufacture of specific types of objects.

Such a unique pattern of lithic material utilization does not occur within a cultural vacuum. A variety of factors must come into play in the transformation and translation of value and belief across cultural, temporal, and geographic boundaries. In northern California, exchange, territoriality, and culture contact all profoundly influenced the creation, transport, and continuation of value and value items in the past. Furthermore, the experiential element of recent geologic phenomena that created the Glass Mountain obsidian flow cannot be ignored. As witnesses of the large, explosive, pyroclastic eruptions that occurred on Glass Mountain, local populations were instrumental in the creation of an aura of value and 'sacredness' which surrounds this particular quarry. By designating the Glass Mountain quarry as a significant quarry, to be used exclusively for the manufacture of value objects, people actively created and reinforced a continuing belief system that upheld appropriate behaviors and uses for the Glass Mountain obsidian source. As such, the Glass Mountain source was imbued with a special status, which it bestowed on the objects created from this material. In this sense, the quarry itself gave value to things.

Value:

Value in this case was intertwined ultimately with both the object and the source. Large obsidian bifaces were value objects and were made from Glass Mountain obsidian, which was reserved as a 'special' obsidian source. This cycle of value between object and source only served to further reinforce the value and status of the other. Thus the cultural context of obsidian use was an essential factor in the value of both source and object.

The Glass Mountain obsidian source retained a special place in the worldview of local peoples. It was perceived as a location for the production of ceremonial and high value objects, yet cultural prohibitions prevented its use for utilitarian tools. Given the recent date for the eruption of Glass Mountain obsidian, it is highly likely that local peoples witnessed this eruption and the formation of the obsidian flow. Stories of the eruption entered into oral histories and legends, and contributed to the special status of this obsidian source in the local cosmology. Glass Mountain obsidian was thus used exclusively for ceremonial and high status objects, such as large bifaces, and neglected for utilitarian purposes. The Glass Mountain obsidian quarry provides evidence for integration of prehistoric belief systems into toolstone procurement and use patterns, through the selective use of Glass Mountain obsidian for ceremonial and value objects. Thus the cultural context of the prehistoric belief system and oral histories about Glass Mountain underlie selective procurement and use of this obsidian source. The Glass

Mountain quarry serves as an active agent in the creation and transformation of value for large bifaces made from this source.

Coastal Nations revered large bifaces, such as those made from Glass Mountain obsidian, as high status and wealth objects as well as important regalia used in the White Deerskin Dance. The value of a biface may have differed for coastal and inland peoples, yet there is little doubt that these stylized objects retained an important status within the cultures of all northern California peoples. Biface value was intertwined with numerous factors of production, exchange, use, and cultural context.

It is possible to speculate that bifaces, as large, concentrated sources of otherwise relatively rare raw material, were a type of wealth regardless of the associated ceremonial system. Obsidian, particularly that from distant sources, was a very rare and valuable commodity. It could serve utilitarian functions, as effective cutting tools. In that sense a biface could conceivably be knapped into points, knives, or flake tools. Perhaps the innate value of a biface is in some degree a measure of the *possible* other tools it could be made into. A large biface was effectively a large piece of raw material. However, these bifaces were not made into utilitarian tools. Instead they were retained as personal property and wealth. In this way, a biface can be viewed as a type of conspicuous consumption. It was a large cache of potentially useful raw material that was, in effect, *not* used. Instead it just *was.* It existed as wealth and was incorporated into the ceremonial world renewal system, and thus took on a more important significance, verging on sacred (Kroeber 1905: 691).

The value of large bifaces was closely linked with their role as ceremonial objects for the White Deerskin Dance. As ceremonial regalia, bifaces were prominently displayed throughout the dance, and biface owners increased both personal status and fortuitous social connections by including their bifaces and other regalia in the ceremony. The almost sacred significance of bifaces and white deerskins was further reinforced through the context of ceremony and ritual. The value of these objects was transformed through the social context of ceremony and the wealth culture of northwest California Nations.

Territoriality:

Territories and territoriality strongly influenced the use and exchange of Glass Mountain obsidian. Glass Mountain is located within ethnographically recorded Modoc territory, and the Modoc maintained a reputation for aggressiveness and hostility towards neighbors, according to the ethnographic record (Murray 1959). Archaeological evidence also indicates that individual bands of the Modoc retained almost exclusive use of obsidian sources within their territories (Luhnow 1997), and it is possible to project that restrictions on obsidian procurement by outsiders would be even more extreme. Furthermore, obsidian exchange networks traversed the territorial boundaries of other northern California Nations including the Shasta, Wintu, and Karok, suggesting that mechanisms of territorial control and defense may have influenced obsidian procurement and exchange at Glass Mountain.

Instead of Karok obsidian procurement and biface manufacture as recorded during ethnographic interviews, the Modoc may have been knapping bifaces within their own territory, and then trading them to the Shasta or directly to the Karok, who then exchanged the bifaces with coastal peoples like the Yurok or Hupa. The archaeological evidence suggests that the knappers spent a considerable length of time at the quarry, and reveals that they did not feel threatened in Modoc territory. In addition, bifaces of this type are found, though rarely, at other sites within the ethnographically recorded territorial boundaries of the Modoc (Sampson 1985).

The suggestion that the Modoc, and not the Karok, manufactured obsidian bifaces at Glass Mountain is contrary to the ethnographic reports. Due to the Modoc's reputation for hostility and aggression, it is likely the Karok would have been reluctant to spend extended periods of time at Glass Mountain. Instead, we would expect the Karok to reduce obsidian nodules to manageable-size preforms and take them away to be completed elsewhere. This behavior is not represented at Glass Mountain. Instead, bifaces were knapped to the final stages of manufacture at the quarry. Over 230 large bifaces and biface fragments were observed during surface reconnaissance, and biface thinning flakes make up a relatively large percentage of the obsidian debitage found at the quarry.

The evidence indicates that Modoc flintknappers manufactured bifaces at Glass Mountain. It seems unlikely that the Karok were making bifaces as suggested ethnographically, but instead appears they were only the final middlemen in a long, down the line exchange system that served to transport Glass Mountain bifaces from the Modoc producers, across territorial boundaries, to Coastal Nation consumers. The ethnographic reference to Karok biface production may merely be an artifact of early 20th Century fieldwork practices, including interviews with coastal nation Elders.

Territoriality, as a means to control access to the Glass Mountain obsidian source, may also have influenced the valued status of Glass Mountain obsidian. As was the case with shell beads in California, access to high status objects inflates the value of these items (Brumfiel and Earle 1987: 7). Shell bead exchange from the Channel Island Chumash was controlled by elites (Arnold 1991), and this may have limited the accessibility of these objects, further reinforcing their value. Territoriality functioned as a mechanism for controlling access to the Glass Mountain obsidian source, and thus may have increased the value of objects made from it. Furthermore, territoriality and access restrictions may also help explain the lack of Glass Mountain obsidian in other contexts, particularly if Glass Mountain was the only source where territorial boundaries were enforced.

Exchange:

Exchange linked northeastern California obsidian production to northwestern California obsidian consumption, yet the obsidian bifaces that were one subject of this exchange maintained a valued status across cultures and territorial boundaries. However, this is not to say that bifaces retained the same kind of value. Instead, obsidian biface value was transformed through interaction and exchange across diverse cultural and geographic settings.

There is no evidence to suggest that coastal peoples practiced direct procurement of Glass Mountain obsidian. Instead, a mechanism of exchange and interaction occurred to transport Glass Mountain obsidian bifaces from the source to the consumers. Exchange thus had to traverse the territorial boundaries of the Modoc, Shasta, Karok, and Wintu, despite cultural, linguistic, and political differences. Based on ethnographic and archaeological data, a down-the-line exchange system is the most likely candidate for a mechanism of prehistoric obsidian biface exchange. Hupa informants claim to have witnessed Karok flintknappers making bifaces (Goldschmidt and Driver 1940: 120), though there are discrepancies with this record. Instead, this may represent an artifact of the ethnographic interview process in which Elders were asked who made the bifaces used in the White Deerskin Dance. The Karok are more likely merely the final leg in a long down-the-line exchange system which transported bifaces to the coast. Furthermore, archaeological evidence to support biface manufacture in Karok territory is non-existent. To date, Glass Mountain obsidian is extremely rare in the debitage assemblages west of Glass Mountain. Instead, Medicine Lake Highland obsidian is represented by Grasshopper Flat/Lost Iron Wells sources (Baker et al. 1990, Bevill and Nilsson 1996).

Exchange served economic functions, but also occurred within a specific social and cultural context. As a result, investigations of prehistoric exchange networks must look at the big picture and move beyond merely tracing patterns of things across the landscape. Obsidian bifaces consistently represented value and status through exchange across cultural and geographic boundaries. Nevertheless, the value inherent in these obsidian objects varied in different contexts and different cultures. Bifaces may have been valuable as products from a culturally significant obsidian source, as large caches of raw material, as wealth, as exotic items, and as ceremonial objects. However, what is central to this argument is the position of obsidian bifaces as valued items across northern California. As such, they served as a uniting force through the contact and interaction of down-the-line exchange. The value of an obsidian biface was transformed as it passed between individuals and disparate cultures in exchange.

Culture Contact:

Use of the Glass Mountain obsidian source overlapped with initial European contact in northern California. This period was a time of drastic change for Native peoples, resulting in demographic, religious, cultural, and economic upheavals. Direct contact impacted coastal Nations first, while northeastern California groups remained relatively isolated until the 1800's. However, once contact did occur, disease, warfare, and cultural turmoil soon followed.

The direct effects of contact on the use of Glass Mountain obsidian and obsidian bifaces are most obvious in the apparent dichotomy between archaeological and ethnographic records of biface use in the past. Archaeologically, obsidian bifaces are found in burial contexts in northwestern California (Hughes 1978, Goldschmidt and Driver 1940, Heflin 1982). However, ethnographic records indicate that bifaces are not buried with their owner upon death, but instead passed down as heirlooms within a family (Kroeber 1925, Rust 1905). One possible explanation for this dichotomy suggests that during prehistoric times, personal property such as bifaces were in fact truly personal property, to be buried with the owner upon their death, and this may have been the ultimate act of conspicuous consumption, in effect raising the status of the deceased. By burying bifaces with the deceased, descendants may be enhancing the status of their dead ancestor and as a result, enhancing their own status as well.

After the demographic and social upheavals associated with contact, the traditional pattern of burying bifaces ceased. Previously, the memory of a prestigious ancestor would remain in the oral histories and stories of a society, however, with the vast population decline associated with European diseases, there was no guarantee that a high-status ancestor would be remembered. Therefore, it became necessary to retain possession of obsidian bifaces and other status and wealth objects as tangible evidence of a family's prestige. Thus bifaces became family heirlooms and symbols of status for a family line.

Furthermore, it is possible that demographic upheavals may have disrupted the obsidian supply network and reduced Glass Mountain obsidian availability. Alternatively, declining population densities with European contact may have relaxed territorial controls and potentially increased access to the Glass Mountain obsidian source. Immigration by way of the Applegate Trail brought white settlers into northeastern California, and introduced smallpox to an already weakened population. Records indicate that a smallpox epidemic between 1847 and 1849 provided settlers with a reprieve from Modoc raids along the Applegate Trail (Murray 1959: 17). It is therefore likely that territorial defense also decreased during this time, and access to Glass Mountain may have been more open in the mid-1800's than during any previous time period.

Contact had a significant effect on the economic systems of northern California peoples through the introduction of European goods and horses. In southern California, European goods replaced traditional prestige items such as shell beads. Once the Spanish arrived, glass beads became the primary form of payment and exchange, replacing the shell beads previously used in Chumash trade networks. Other European items such as clothes, blankets, and metal objects were also highly desired, and these new goods quickly disrupted traditional exchange networks (Johnson 1998). In northern California, where exchange networks were vital to the wealth systems of Coastal peoples, European goods may have disrupted the value systems there as well, however there exists scant evidence for any particular object truly replacing obsidian bifaces as wealth and prestige objects in the White Deerskin Dance.

Among the tribes of northeastern California, European contact also increased raiding and exchange capability through the introduction of the horse, which may have occurred as early as the late seventeenth century (Layton 1981: 128). Use of horses permitted increased mobility and allowed northern California people to participate in the trading systems of the Pacific-Plateau (Columbia River) and Middle-Missouri. Potentially, the horse could have vastly increased the range of northern California exchange systems, and allowed for direct procurement of valuable materials such as Glass Mountain obsidian.

CONCLUSION

Ultimately, the root of differential use of the Glass Mountain obsidian quarry lies in the context of cultural beliefs, which hold Glass Mountain as a special source, to be used exclusively for the production of valued objects. Certainly Glass Mountain is not the only source utilized for value objects, but it is unique in that procurement from this source was almost entirely for non-utilitarian things, while other nearby obsidians were exploited for utilitarian objects. The cultural context of Glass Mountain obsidian utilization varies across and within territorial and geographic boundaries, yet despite cultural differences, the concept of value is intricately linked with Glass Mountain obsidian and the large bifaces made from it. Prehistoric people actively created and reinforced a continuing belief system which upheld appropriate behaviors and uses for the Glass Mountain obsidian source. As such, the Glass Mountain source was imbued with a special status, which it bestowed on the objects created from this material. In this sense, the quarry was in itself also an active agent, which gave value to things.

Descriptive studies of prehistoric quarries provided a useful background for further research into the role of quarry locales in past cultures. Yet, the archaeological studies of lithic material procurement and use have traditionally focused on raw material quality and proximity to source as sole indicators for selection of particular materials for stone tool manufacture. As illustrated here, there is room for research into the role of human agency in the choice of lithic materials. The Glass Mountain obsidian quarry provides evidence for integration of prehistoric belief systems into toolstone procurement and use patterns through the selective use of Glass Mountain obsidian for ceremonial and value objects.

CHAPTER 14

DIRECTIONS FOR FUTURE RESEARCH

Situations of differential use of stone tool raw material sources are certainly not confined solely to the Glass Mountain obsidian source, yet few archaeologists have attempted research specifically aimed at investigating the underlying cultural and ideological systems that provide a context for lithic material procurement, use, and discard. Preconceived ideas about the utilitarian function of lithic materials in the past have blinded us to the cultural context of these important objects, and the quarries from which they were obtained. Future research integrating questions of individual and cultural belief provide a new line of inquiry for archaeological investigations.

As demonstrated in this dissertation, the geologic and geographic environment influenced the utilization of specific raw material sources in unexpected ways. Such information prompts the question: are there parallel situations to the events that occurred at Glass Mountain in late prehistory? Mono Glass Mountain, located near the California and Nevada border, south of Lake Tahoe, provides an almost identical geological and geographic setting to that of Glass Mountain. Mono Glass Mountain is a large, tool-quality obsidian source that formed in late prehistory. It displayed similar eruptive phenomena, and would have been witnessed by Native American peoples. Yet despite potential variations in obsidian use in the region, and multiple obsidian sources nearby, Mono Glass Mountain does not appear to display a differential use pattern similar to that at Glass Mountain (Basgall 1989). Further research into both use of the Mono Glass Mountain obsidian source, and other obsidian sources of late prehistory, may demonstrate that either patterns of differential use for ceremonial contexts were the norm, *or* that Glass Mountain was a unique example in prehistory.

Despite the apparent geochemical and geographic advantages to conducting this type of research on obsidian, rather than on other raw material types, cryptocrystalline silicates such as cherts, jaspers, and chalcedonies, may also hold potential for elucidating patterns of differential use in the past. With the data becoming available through large-scale Cultural Resource Management projects, regional syntheses of lithic material use are possible. Furthermore, quarry studies, including those of *all* raw material types, have been notably lacking with regard to issues of prehistoric belief and ideology, in both Cultural Resource Management and academic publications. In particular, the role of individual actors and their decision-making processes within a cultural context must be made explicit in studies of lithic quarries and raw materials.

Beyond discussions of lithic materials, value and value transformation in prehistory offers yet another direction for future research. Applying the theoretical and philosophical perspectives discussed in this dissertation to value and value objects adds an alternative dimension to the traditional archaeological interpretations of value, namely a strict correlation between value and distance to source. There is obviously much more to value than merely distance and labor, including such issues as exotic origins, ceremonial importance, gifting, use, economy, desire, ownership, and exchange. The research conducted for this dissertation links anthropological and economic theories of value and status to the archaeological record, with a particular emphasis on objects found in contexts that demonstrate their valued status. Such dialogue presents new avenues of investigation and interpretation for archaeological data.

The issues presented in this dissertation also include discussions of exchange. Traditionally, exchange is considered a means by which objects and ideas were transported from one place to another. However, it is impossible to separate the economic from the social contexts for exchange. Already there are many ways in which exchange has been used to understand prehistoric societies. Exchange linked individuals and groups across geographic and cultural boundaries, and involved the trade of goods as well as information. As more archaeological data becomes available and analytic techniques are perfected, there will be more opportunities to study and interpret exchange as it occurred in the past. However, exchange research should not stop there. Exchange served economic functions, but also occurred within a specific social and cultural context. As a result, investigations of prehistoric exchange networks must look at the big picture and move beyond merely tracing patterns of things across the landscape, and it is the cultural component that makes exchange such an exciting and potentially revealing part of archaeological research.

Finally, in this dissertation, archaeological obsidian data used to analyze patterns in obsidian distribution were obtained solely from late prehistoric components. None of the data were from protohistoric or historic period components. However, research investigating changes in obsidian procurement patterns across the prehistoric-historic divide may reveal a great deal about the processes of culture contact and their effects on mechanisms of exchange and territoriality. In this dissertation, changes in obsidian use patterns were examined solely for obsidian bifaces and their position in prehistoric and historic period cultures. A broad survey of northern California obsidian procurement and exchange in early historic times has yet to be completed and offers yet another direction for future studies in the region.

In conclusion, multiple lines of inquiry are possible using this dissertation as an important starting point. As more analytic techniques become available for use in archaeology, our population of potential questions will only further increase. However, despite the many tools we may have in our toolbox, they are useless without a theoretical base from which to begin. As such, archaeologists must begin to ask questions that incorporate a wider range of issues, rather than focusing merely on documentation and description for its own sake. By approaching the archaeological record with the understanding that artifacts represent the past activities of both *cultures* and *individual actors*, perhaps we may begin to more thoroughly investigate not only prehistoric behaviors, but also prehistoric beliefs.

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