University of Nevada, Reno

A Diachronic Study of Land-Use in the Bodie Hills, Mono County, California

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Arts in
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By

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THE GRADUATE SCHOOL

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ABSTRACT

This thesis presents the results of a study to test hypotheses related to diachronic shifts in land-use and obsidian use in the Bodie Hills region of eastern California. The Bodie Hills obsidian source is the northernmost of numerous eastern Sierra Nevada obsidian sources known to have been utilized throughout prehistory. Research at various eastern Sierra Nevada obsidian sources has revealed a production peak ~3,000 – 1,100 cal BP with a subsequent drop-off in obsidian use thereafter. For this study, I performed a records search and compiled 81 single-component sites and separated them into Early (pre-5,000 cal BP), Middle (5,000 – 1,300 cal BP) and Late (post-1,300 cal BP) periods. I then employed models of technological organization to characterize those sites and test hypotheses related to diachronic shifts in land-use and obsidian use. Additionally, I reviewed geochemical sourcing data to establish an eastern distribution of Bodie Hills obsidian in the Great Basin. Results from this study indicate that Early Period groups were far-ranging and, compared to later periods, minimally used obsidian from the Bodie Hills. Middle Period use of land and obsidian in the Bodie Hills was most intensive. Finally, obsidian use in the Bodie Hills decreased during the Late Period while subsistence pursuits increased. This study has wider applicability for the procurement and conveyance of eastern Sierra Nevada obsidian.

DEDICATION

To my Mom and Dad, for always supporting my decisions no matter what they might be and always leading me in the right direction.

To Uwe Gonder, my Opa, whose love for life was contagious. Though you are not here to experience this accomplishment with me I know you would be as excited as ever.

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CHAPTER 1

Research Goals

In this study I test multiple hypotheses related to diachronic shifts in land-use in the Bodie Hills region of central-eastern California. My analysis is focused on characterizing lithic assemblages from each site and comparing the site assemblages between cultural periods. These data are used here to test hypotheses related to land-use in the Bodie Hills. High quality obsidian from the Bodie Hills was utilized throughout prehistory and examples of each temporally diagnostic projectile point type in the western Great Basin were made from it (DeBoer et al. 2011; Halford 2001, 2008). The obsidian source sits in mixed sagebrush steppe and pinyon-juniper woodland at elevations between ~2,500 and ~2,700 m in the hills east of the Bridgeport Valley – a high elevation valley (~1,900 m) at the foot of the eastern Sierra Nevada – with alluvial deposits present down to the modern-day Bridgeport Reservoir (Figure 1.1). Bodie Hills obsidian occurs in both primary cobble exposures and secondary alluvial deposits, resulting in ~3,677 acres of terrain containing useable toolstone (Halford 2008) (Figure 1.2). Sites included in my study were recorded over multiple decades during cultural resource management (CRM) and federal agency projects, resulting in extensive cover of much of the land surrounding the obsidian source. All sites included in my study contain temporally diagnostic projectile points, which allowed me to test my hypotheses related to specific temporal periods and consider diachronic shifts.

The primary goal of this study is to test the following hypotheses related to diachronic shifts in land-use and obsidian use in the Bodie Hills:

(A) Prior to ~5,000 cal BP there was limited use of the Bodie Hills region;

(B) The most intensive use of the Bodie Hills occurred between ~5,000 and ~1,300 cal BP;

(C) After ~1,300 cal BP, obsidian use in the Bodie Hills decreased and subsistence activities increased;

(D) Conveyance of Bodie Hills obsidian into the Great Basin was most extensive prior to ~5,000 cal BP;

(E) Frequencies of Bodie Hills obsidian in the Great Basin reached a peak between ~5,000 and ~1,300 cal BP; and

(F) Frequencies of Bodie Hills obsidian in the Great Basin were lowest after ~1,300 cal BP.

To test these hypotheses, I ask two questions to assist in characterizing sites and viewing diachronic shifts:

(1) What types of artifacts and features are present at the sites; and

(2) Do artifact and feature types/frequencies vary between periods?

Addressing these questions will permit inferences about how raw material was procured and conveyed in the western Great Basin and California. Testing the above hypotheses will allow me to consider the behaviors that produced trends in the archaeological record at Bodie Hills and other eastern Sierra Nevada obsidian sources and evaluate current models of toolstone procurement and distribution in that region.

In the remainder of this chapter, I outline previous research related to prehistoric land-use studies and toolstone source use. With respect to land-use, I emphasize the various factors that affect technological organization and how studies of technological organization can inform our understanding of hunter-gatherer mobility. I also summarize studies of other eastern Sierra Nevada obsidian source use to help situate this study within a regional context. Additionally, I briefly address the potential utility of lithic quarries to contribute to broader understandings of prehistoric land-use, although the discussion is limited to those situations where changes over time have been identified.

Introduction

Prehistoric land-use studies (e.g., Binford 1977, 1979, 1980; Eerkens et al. 2008; Jones et al. 2003, 2012; Smith 2010) have been a focus in archaeology for some time. Many studies have focused on the analysis of stone artifacts in varying contexts (e.g., Bamforth 1986, 1991; Kelly 1988; Parry and Kelly 1987). X-ray fluorescence (XRF) analysis and other means of conducting source provenance studies have been employed to understand how raw materials from particular geologic sources were procured, manufactured, used, and discarded. While Hughes (2011) cautions that the geographic distances from artifacts to geologic sources alone cannot be used to identify the behaviors (e.g., direct procurement vs. exchange) responsible for the distribution of toolstone, other researchers (e.g., Eerkens et al. 2008; Jones et al. 2003, 2012; Smith 2010) have invoked toolstone distributions in discussions of prehistoric land-use strategies. Although distinguishing between exchange and direct procurement is a difficult aspect of land-use studies (Hughes 2011), identifying if and how toolstone use changed in time and space can assist in developing those models of human behavior.

While many researchers often use toolstone distributions to consider prehistoric land-use at a regional scale, some (e.g., Beck et al. 2002; Elston and Raven 1992; Gramly 1980) take a different route by studying sites at and/or near toolstone sources to explore prehistoric land-use at a local scale. Analysis of assemblages at and/or near toolstone sources can provide data similar to studies away from lithic sources. The study of technological organization has been employed to inform on myriad behaviors responsible for the formation of archaeological assemblages. Similar to source provenance studies, technological organization studies have focused on artifacts removed from lithic source areas (Andrefsky 1994, 2009; Bamforth 1986, 1991; Kelly 1988; Parry and Kelly 1987). Considering if and how technological organization has changed at lithic source areas, however, can show changes in behaviors and support or refute current behavioral models.

Research Background

Land-Use Studies

Land-use patterns can differ depending on the distributions of resources in time and space. Given the abundance of lithic detritus present at archaeological sites, raw material was clearly an important resource in prehistory. Raw material, unlike floral and faunal resources, is generally situated variably in space but not time. Presumably, then, the timing of raw material procurement was secondary to the timing of other resource procurement activities (e.g., animal migrations or plant harvesting). Negotiating the spatial and temporal incongruities in optimal resource procurement activities can be accomplished through varying mobility strategies, trade/exchange, storage, or a combination of all three.

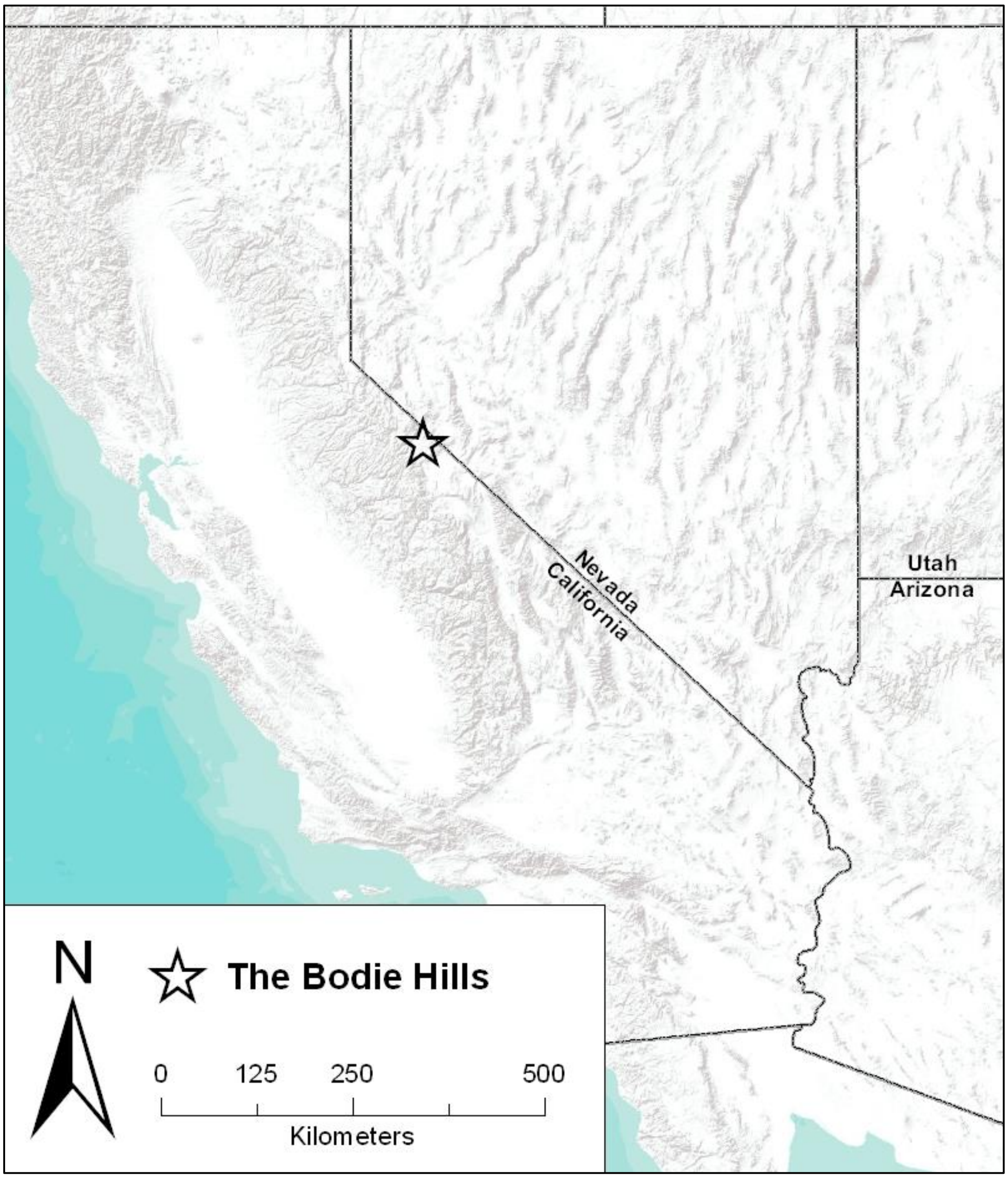

Figure 1.1. Location of project area. Image source: ESRI.

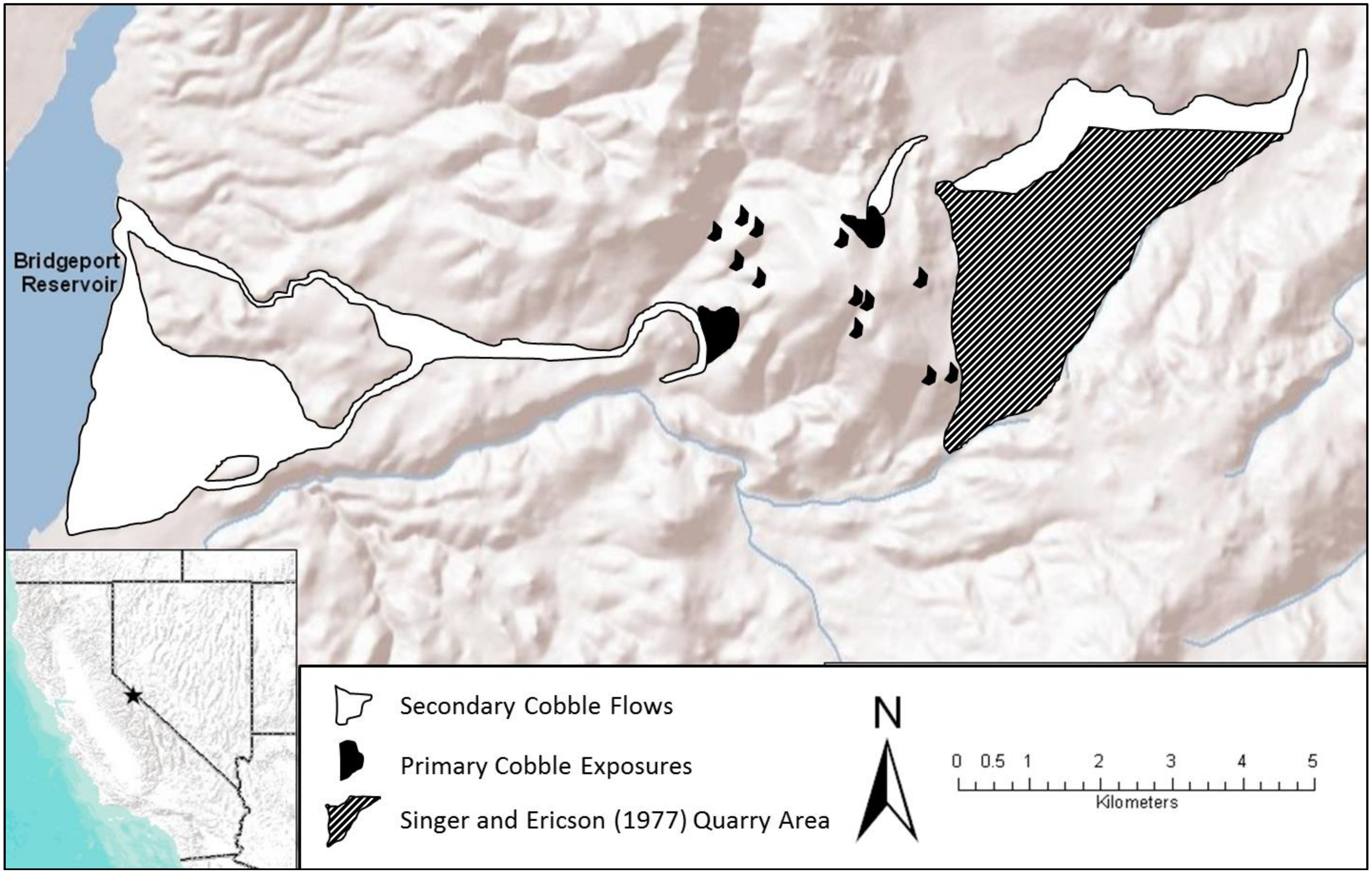

Figure 1.2. Bodie Hills obsidian source.
Adapted from Halford (2008). Image source: ESRI.

Binford (1980) was the first to tie technological organization and site character to mobility. In 1980, he introduced the forager-collector continuum, which modeled opposing mobility strategies capable of alleviating the stresses of variable resource distribution. The forager strategy is one of residential mobility where all members of a community move together to take advantage of resources differing in time and space. In contrast, the collector strategy involves logistical mobility where groups occupy a residential base for comparatively longer spans of time while task-specific forays are carried out to acquire resources to bring back to the base. In Binford's (1980) model, the archaeological remains at sites created by these different strategies might be readily distinguished, and although he suggested that these classifications are not rigid, they nevertheless serve as a starting point to explore differences in mobility. Indeed, subsequent research (e.g., Bamforth 1986, 1991; Chatters 1987; Kelly 1988, 1992; Parry and Kelly 1987; Shott 1986) has focused on establishing this link between mobility strategies and technological organization.

Such research has also shown that no single factor (e.g., settlement-subsistence strategies) can completely explain the variability seen in the archaeological record. Raw material availability is also acknowledged as having an influence on technological organization (Andrefsky 1994; Bamforth 1986; Daniel 2001). Other researchers (e.g., Bamforth 1986; Odell 1996) have added another facet to raw material availability by discussing how behaviors closely tied to Binford's (1980) opposing settlement-subsistence strategies can create raw material shortages even when raw materials are present. Similarly, the quality and size of raw material packages can also affect technological organization (Andrefsky 2009; MacDonald 2008). For example, decreasing size of secondary lag deposit cobbles at the Bodie Hills obsidian source and Coso Volcanic Field may have prompted prehistoric groups to use the primary outcrops (Gilreath and Hildebrandt 1997; Halford 2001, 2008). Research (e.g., Kuhn 1995) has also linked occupation span to raw material availability. Kuhn (1995) modeled the opposing strategies of provisioning individuals and provisioning places – where provisioning individuals occurs with shorter occupation spans and provisioning places occurs with longer occupation spans. Later researchers (Smith 2011; Surovell 2009) have used this model to link occupation span and mobility.

Despite the potential issues with confidently attributing technological organization to any one factor there remains good evidence that mobility and raw material availability – including quality and package size – affect the character of lithic assemblages (Andrefsky 1994; Bamforth 1986, 1991; Duke and Young 2007; Shott 1986). By considering if and how technological organization has changed over time, researchers (e.g., Bettinger 1982, 1989, 1991; Bouey and Basgall 1984; Parry and Kelly 1987) have evaluated which of the factors outlined above may have varied diachronically.

The effects of mobility and raw material availability on technological organization can offer insight into the kinds of tools that may be present at different types of sites. Parry and Kelly (1987) proposed that mobile hunter-gatherers employed efficient bifacial technologies while more sedentary populations employed simple core/flake technologies. Kelly (1988, but see Prasciunas 2007) suggested that bifaces were efficient for mobile populations because they were used as cores, tools, or preforms for other tools. Groups could have employed bifaces as cores and tools early in their use-lives and fashioned them into other tools (e.g., projectile points) once they were no longer useful as cores. This trend has been identified in archaeological studies (e.g., Bouey and Basgall 1984; Gilreath and Hildebrandt 1997, 2011; Hall 1983; Parry and Kelly 1987; Martinez 2009; Ramos 2000; Singer and Ericson 1977). For example, the peak in obsidian exploitation and conveyance at eastern Sierra Nevada obsidian sources during the Newberry Period (3,150 – 1,350 cal BP) was typified by biface manufacture and some researchers (e.g., Basgall 1989; Bettinger 1991; Eerkens et al. 2008) suggested that this period was represented by high mobility.

Once groups became more sedentary, there would not have been a cost-benefit to expending energy on bifacial technologies because tools no longer needed to continually be carried, making core/flake technologies just as efficient (Ericson 1982; Parry and Kelly 1987). The decision to adopt a core/flake technology is also believed to have been influenced by raw material availability. Researchers (e.g., Kelly 1988; Kuhn 1995) suggested that when raw material is high quality and locally available, groups likely employed expedient flake technologies; however, Andrefsky (1994) showed that in this instance, both formal and informal tools were produced. Therefore, being aware of the abundance and quality of raw material in a region is important for any study of technological organization.

The study of technological organization has the potential to reveal behaviors responsible for the formation of archaeological sites. While much of this research has been directed at sites farther removed from lithic sources, the application of these principles to quarry sites and the surrounding areas is generally no different. An exception is raw material availability, which can be assumed to have minimally influenced changes in site characteristics and/or assemblage structure at and near quarries. While toolstone quality varies on a source by source basis, it can be assumed that if toolstone was an impetus for the occupation of source areas, then quality should not affect site characteristics. Setting these characteristics aside, differences in mobility and site function should be as visible in quarry area sites as elsewhere.

Quarry Studies

Using large samples of sites, many researchers (e.g., Bamforth 1986, 1991; Beck et al. 2002; Jones et al. 2003; Kelly 1988; Parry and Kelly 1987; Smith 2010) have explored lithic technology and toolstone distributions to consider how different mobility strategies might be expressed in lithic assemblages in both time and space. Lithic quarries have received comparatively less attention in the archaeological literature. Although raw material procurement is an important part of the use-lives of stone tools (Andrefsky 2009, 2010), difficulties in quarry studies, both in terms of spatial extent and a lack of chronological control, deter many researchers. Chronological control at quarry sites is especially difficult because such sites were likely visited by groups throughout prehistory, creating a palimpsest of reduction detritus that is difficult to sort into specific periods. When successful, however, interpreting reduction sequences at quarries and how they may have changed over time can assist greatly in understanding patterns of technological organization and land-use.

Gramly (1980) illustrated the separation of quarry and stone tool distribution studies in his research on the Mount Jasper lithic source area in New Hampshire. There, an impressive amount of quarrying and reduction took place throughout prehistory. Due to the absence of organic remains for radiocarbon dating, the author employed temporally diagnostic projectile points for chronological control. The identification of three distinct artifact types – waste flakes, manufacture tools, and formal tools – in varying amounts allowed for study of quarrying and land-use behaviors at the Mount Jasper source. The disjunction in source profiles between flakes predominately made on the Mount Jasper source and formal tools predominately made on more distant sources led Gramly (1980) to posit that visitors to the quarry practiced dumping behavior – leaving worn out tools behind and continuing with newly produced implements – on a seasonal or yearly basis. Though his research did not consider diachronic shifts at this source, Gramly (1980) did suggest the importance of those types of studies due to the valuable information they might reveal about prehistoric behavior.

In the Great Basin, the Tosawihi opalite quarries in northeastern Nevada are some of the most studied raw material source areas in that region. Due to mining operations, large scale archaeological surveys and excavations have been carried out over an extensive area, facilitating the study of changing use of multiple quarries and the surrounding areas (Elston and Raven 1992). Chronological control was maintained through radiocarbon dating and temporally diagnostic projectile point types (Elston and Drews 1992). Both radiocarbon dates on charcoal obtained from hearths and projectile point frequencies indicate that use of the quarries increased throughout time. The most significant increase in projectile point frequencies occurred during the Middle Archaic, represented by Elko projectile points (3,250 – 1,350 cal BP), suggesting that intensive use of Tosawihi opalite began during that period and continually increased over time.

Analysis of debitage and tools indicates that biface production was the dominant technological activity at Tosawihi (Ataman and Bloomer 1992). Ataman and Bloomer (1992) indicated that Stage 3 bifaces were the most prevalent form produced and note that bifaces were both heat-treated and exported from quarry sites at that stage. Elston (1992) suggested that the overwhelming representation of Stage 3 bifaces reflects an economizing behavior aimed at exporting tools with minimal low-utility components and risk of breakage while retaining maximum potential use.

The model of economizing behavior that Elston (1992) discussed in relation to Tosawihi was applied by Beck et al. (2002) at two Paleoarchaic (Paleoindian) dacite quarries in the central Great Basin. Operating under a model of central place foraging – where hunter-gatherers venture out from a central place and bring resources back to a residential base – the authors suggested that the reduction seen at quarries should vary with distance to residential bases. Beck et al. (2002) applied this model to two dacite quarries – the Cowboy Rest Creek Quarry and the Little Smoky Quarry – by analyzing bifaces and debitage at each location. Additionally, they collected artifacts from two Paleoarchaic sites at a distance of 9 km (Knudtsen Site) from the Cowboy Rest Creek Quarry and 60 km (Limestone Peak Locality 1) from the Little Smoky Quarry to determine if lithic reduction activities varied with distance from geologic source. The central place foraging model predicted that less reduction would take place at the Cowboy Rest Creek Quarry than the Little Smoky Quarry and that prediction was supported by the data. Although Beck et al. (2002) did not explore diachronic change in reduction activity, their work serves as an example of how raw material source studies can compare reduction behaviors at sites versus quarries and how such behaviors may have changed across time. In fact, other researchers (e.g., Gramly 1980; Singer and Ericson 1977) working at quarries have suggested that the study of outlying sites containing corresponding raw materials should be undertaken to better understand prehistoric quarrying behaviors.

One of the first diachronic quarry studies was performed by Singer and Ericson (1977) at the Bodie Hills obsidian source (Figure 1.3). They offered an analysis intended to complement studies of "product consumption in the surrounding region" (Singer and Ericson 1977:171). They employed a sampling strategy consisting of 14 transects focused on ridgeline outcrops and cobble exposures. A total of 230 collection units along these transects provided lithic data: flake density; the number, type, and approximate size of tools; and presence of unworked or non-obsidian materials. Their analysis indicated that two different artifact types were produced in abundance: prismatic blades and bifaces of different sizes and morphologies. Singer and Ericson (1977) estimated the number of flakes produced per biface to infer that approximately four to eight million bifaces were produced for export. Furthermore, no evidence of habitation – a fact noted by Gramly (1980) at Mount Jasper – and minimal (<5%) retouching of artifacts was found, leading the authors to suggest that the sites were task specific locations where bifaces and blades were produced.

Although Singer and Ericson (1977) collected all diagnostic projectile points, they used obsidian hydration analysis for chronological control – a method now common in studies of obsidian in the Sierra Nevada region (Bouey and Basgall 1984; Gilreath and Hildebrandt 1997; Ramos 2000) (Table 1.1). The authors took readings from 98 artifacts using a source-specific hydration rate of 650 years per micron and identified initial use of the source ~6,000 cal BP, a peak at ~2,500 cal BP, and a steep drop-off ~1,500 cal BP.

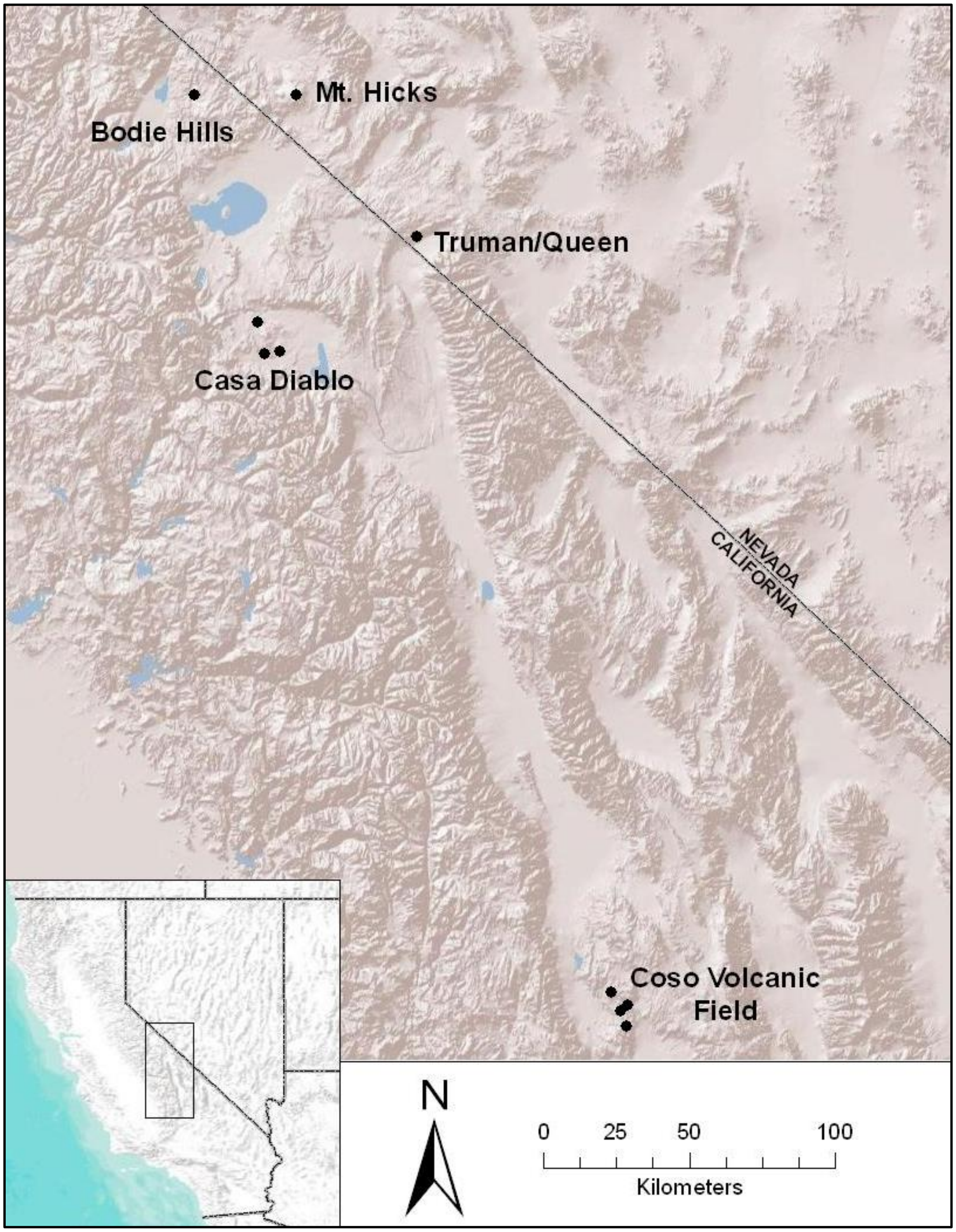

Figure 1.3. Eastern Sierra Nevada obsidian sources discussed in text. Image source: ESRI.

Table 1.1. Data on Eastern Sierra Nevada Obsidian Sources Discussed in Text.

Source	**Peak Use (cal BP)**	**Dating Method**	**Reference(s)**
Bodie Hills	[a]~6,000 – 1,500 [b]pre-5,000; ~3,500 – 1,350	Obsidian Hydration	Goebel et al. (2008) Halford (2001, 2008) Singer and Ericson (1977)
Mount Hicks	~4,000 – 1,350	Obsidian Hydration	Martinez (2009)
Truman/Queen	~3,500 – 1,300	Obsidian Hydration/ Projectile Points	Ramos (2000)
Casa Diablo	~3,500 – 1,300 (~3,000 – 650)	Obsidian Hydration	Bouey and Basgall (1984) Hall (1983) (Ramos 2000)
Coso Volcanic Field	[a]~3,500 – 1,000 [b]pre-2,300	Obsidian Hydration	Gilreath and Hildebrandt (1997)

[a] Primary
[b] Secondary

Singer and Ericson (1977) suggested that studies of sites in areas consuming Bodie Hills obsidian would add insight to the production trends revealed during their study, and decades later King et al. (2011) did so by evaluating trends in Bodie Hills obsidian exploitation by consumer populations in the western Sierra Nevada foothills and Central Valley. King et al. (2011) evaluated a number of explanations for the production peak seen at eastern Sierra Nevada obsidian sources. Some researchers (e.g., Basgall 1989; Bouey and Basgall 1984) suggested that direct/embedded procurement was responsible for the production peak, while others (e.g., Ericson 1982; Singer and Ericson 1977) posited that interregional exchange fueled the peak. By evaluating source and material profiles at various sites in consumer areas, King et al. (2011) concluded that the rise and fall of interregional exchange was likely responsible for the production peak ~2,500 cal BP.

Halford (2000, 2001, 2008) later identified extensive secondary obsidian cobble flows, or lag deposits, extending almost 10 km west of the main Bodie Hills obsidian source which showed an altogether different trend in obsidian utilization. Intensive surface collection and testing of two sites (CA-MNO-3125/H and CA-MNO-3126 [Goebel et al. 2008]) on the western periphery of these secondary cobble flows produced a Great Basin Concave Base point and Great Basin Stemmed Series varieties – projectile points diagnostic of the early Holocene in the Great Basin (Beck and Jones 2009). A sample of 68 tools and 132 pieces of debitage submitted for obsidian hydration analysis indicated extensive pre-6,000 cal BP use of the lag deposits with a subsequent drop-off once the initial use of the primary outcrops began. Halford (2001) suggests that this change was due to the depletion of obsidian cobbles of sufficient size to produce flaked stone tools in the secondary deposits (*sensu* Andrefsky 2009). Interestingly, Halford (2001) also identified a later increase in the use of the secondary cobble flows following the decrease in use of the primary outcrop noted by Singer and Ericson (1977) and posited that this was due to scavenging of previously flaked toolstone packages. Halford (2008) later reevaluated the obsidian hydration data and showed that the previously discussed bimodal production curve for the secondary cobble flow showed continued use ~3,500 – 1,100 cal BP with no increased use later in time (see Table 1.1).

Approximately 20 km east of the Bodie Hills lies the Mt. Hicks obsidian source, recently studied by Martinez (2009) (see Figure 1.3). Using obsidian hydration analysis, Martinez (2009) identified production trends broadly similar to those previously observed at the Bodie Hills and other regional sources (discussed below) with biface production peaking ~4,000 – 1,350 cal BP. Martinez (2009) also identified an apparent emphasis on simple flake tools prior to ~4,000 cal BP which he attributes to the availability of high quality raw material in the region (*sensu* Andrefsky 1994). In addition to identifying diachronic shifts in obsidian use, Martinez (2009) separated the Mt. Hicks source into four environmental zones – upper desert scrub, pinyon-juniper, lower desert scrub, and lacustrine – to evaluate changes in obsidian use by zone. He found that there was variability in the use of obsidian by zone and that the pinyon-juniper zone exhibited a production curve most similar to that seen at other regional sources.

South of the Mt. Hicks source and east of the Bodie Hills along the Nevada-California border at the Truman/Queen obsidian source, research by Ramos (2000) has indicated a similar peak in production to that what Singer and Ericson (1977) saw at the primary Bodie Hills obsidian outcrop (see Figure 1.3, Table 1.1). Using obsidian hydration analysis calibrated against temporally diagnostic projectile points, Ramos (2000) showed that a peak in utilization of the Truman/Queen obsidian source ~3,500 – 1,300 cal BP was typified by biface production, a phenomenon that generally tracks the trends noted at the Bodie Hills obsidian source. Additionally, Ramos (2000) noted temporal and spatial differences between lowland and upland quarry and off-quarry locales. In terms of pure numbers, upland quarry and off-quarry sites contain more artifacts than do the lowland quarry and off-quarry sites. Finally, use of the upland zone appears to have persisted after ~1,300 cal BP, possibly due to the continued exploitation of other resources (e.g., pinyon) there (Ramos 2000:165). As noted above, bifaces were the primary tools produced during the peak in Truman/Queen obsidian use, and while cores are less well-represented than bifaces, they follow the same temporal trajectory with a peak between ~3,500 and ~1,300 cal BP and a subsequent drop-off. This is interesting in light of some models (e.g., Ericson 1982; Parry and Kelly 1987) which suggest that a shift from biface technology to core/flake technology occurred with increased sedentism later in time.

South of the Bodie Hills and southwest of Truman/Queen, the Casa Diablo obsidian source has received much attention (see Figure 1.3). There, researchers (e.g., Bouey and Basgall 1984; Ericson 1982; Hall 1983) have also noted trends in the production and apparent collapse of biface manufacture similar to those seen at the Bodie Hills obsidian source (see Table 1.1). Ericson (1982) produced a production curve nearly identical to that observed at the Bodie Hills source using a source-specific hydration rate of 1,000 years/micron. Hall (1983) found less than satisfactory results using this rate when he compared hydration data to temporally diagnostic projectile point data and formulated a slower hydration rate more compatible with the known age ranges of diagnostic point types. Furthermore, he posited that the Bodie Hills hydration rate used by Singer and Ericson (1977) is ~500 – 700 years too slow if the production peaks at Bodie Hills and Casa Diablo occurred at roughly the same time (Hall 1983:213). Bouey and Basgall (1984) agreed with Hall (1983), suggesting that a similar peak occurred between ~3,500 and ~1,300 cal BP at Casa Diablo; however, Ramos (2000) proposed a different overview of diachronic use of Casa Diablo obsidian. Drawing from published obsidian hydration data comprised of 1,361 readings from sites near Casa Diablo, Ramos (2000) found that obsidian use peaked ~3,000 to ~650 cal BP and not ~3,500 to ~1,300 cal BP as previously suggested by Hall (1983) and Bouey and Basgall (1984). Regardless of the hydration rate applied, it is apparent that biface production at Casa

Diablo peaked sometime after ~3,500 cal BP, although the terminus of this fluorescence is debated.

Further south along the eastern Sierra Nevada, the Coso Volcanic Field has received some of the most extensive research of the regional sources (Gilreath and Hildebrandt 1997, 2011). The Coso Volcanic Field represents the southernmost eastern Sierra Nevada obsidian source while Bodie Hills represents the northernmost source (see Figure 1.3). Extensive survey, mapping, and excavation at Coso have identified spatial and temporal variability in obsidian procurement and land-use. Obsidian hydration constitutes the primary dating method of sites in and around the source. Once again, a peak in use of the primary obsidian outcrops typified by biface production is apparent between ~3,500 and ~1,000 cal BP (see Table 1.1); however, research has also identified substantial changes within that period (Gilreath and Hildebrandt 1997). Although a peak in obsidian use occurred between ~3,500 and ~1,000 cal BP, it appears that most utilization took place between ~2,300 and ~1,275 cal BP. During this time, off-quarry loci focused on biface reduction outnumbered primary quarries by a ratio of 2.2 to 1 (Gilreath and Hildebrandt 2011), a trend also noted by Ramos (2000) at the Truman/Queen obsidian source.

Gilreath and Hildebrandt (1997) also documented diachronic shifts in land-use at Coso. Following the fluorescence in obsidian exploitation from ~2,300 to ~1,275 cal BP, there was a marked drop-off in use of the area for both toolstone and subsistence resources. Around 650 cal BP, use of the Coso Volcanic Field increased; however, it was limited to subsistence activities (e.g, pinyon [see Hildebrandt and Ruby 2006]) and not obsidian quarrying. A similar trend was identified by Ramos (2000) at the

Truman/Queen source immediately following the decline in obsidian biface production ~1,300 cal BP. Ramos (2000) viewed the decline in biface production as a direct result of a decreased emphasis on butchering activities in favor of intensive pinyon nut harvesting at Truman/Queen. In contrast, Gilreath and Hildebrandt (1997) perceive the intensification of seed and nut resources as a later manifestation not involved with the collapse of obsidian biface production and conveyance.

Although research at these toolstone sources is limited compared to broader studies of prehistoric land-use, it is clear that quarry studies can provide insight into raw material procurement and other decisions related to lithic technological organization. The information gained from such studies has wider applicability to both surrounding and more distant sites. For example, Gramly (1980) showed that raw materials were likely procured as part of seasonal or yearly rounds that included retooling activities, and he suggested including studies of sites outside of quarries to situate quarrying behavior within a broader context. As illustrated by the Tosawihi research, there was indeed variation between reduction activities at toolstone sources and sites further removed from sources (Elston 1992). Beck et al. (2002) elaborated on this spatial variation by applying a central place foraging model to quarries and related sites to show that decisions related to lithic reduction at quarries were influenced by distance to a residential base. Singer and Ericson (1977) provided an overview of the Bodie Hills obsidian source and suggested that other sources and outlying sites should be studied to create a more complete understanding of quarrying behavior. Other researchers followed, demonstrating that similar peaks and drop-offs at other eastern Sierra Nevada obsidian sources occurred between ~3,500 and ~1,000 cal BP.

Some of these studies (e.g., Bouey and Basgall 1984; Elston and Raven 1992; Gilreath and Hildebrandt 1997; Ramos 2000) incorporated land-use patterns into interpretations of raw material procurement and utilization. Not surprisingly, many such studies have also documented concomitant increases in subsistence activities in raw material source areas late in time coupled with an apparent increase in sedentism. Other researchers focused on eastern Sierra Nevada obsidian sources (e.g., Bouey and Basgall 1984; Gilreath and Hildebrandt 1997) suggested that major changes in subsistence-settlement organization were associated with a regional drop-off in obsidian biface production, while Ramos (2000) suggested that the change from hunting to seed and nut processing was directly responsible for the decline in biface production due to a decreased necessity for such tools.

The aforementioned cases demonstrate that studies of technological organization can reveal patterns of land-use and how they may have varied across time. Mobility is an important topic in any study of technological organization as differing mobility strategies represent behavioral adaptations designed to exploit resources situated variably in time and space. Furthermore, since raw material was an important resource in prehistory, the study of mobility carries with it the potential to improve our understanding of raw material procurement. I review several relevant approaches to the study of technological organization and general land-use trends, and how these might effectively be applied to quarry-area research, below.

Potential for Quarry Area Land-Use Studies

Evaluating of technological organization – inevitably intertwined with mobility (Binford 1980) – at quarry areas can be accomplished through characterizing sites in and around lithic sources and identifying diachronic shifts in how such locations were used. Lithic source area research provides the unique ability to hold raw material availability constant (but see Bamforth 1986; Odell 1996) as a source of change in technological organization. Quarry areas also present an opportunity to study diachronic shifts because many of them were utilized for relatively long periods of prehistory and quarrying raw materials likely involved varying degrees of occupation, depending on the intensity of toolstone extraction. Any change in quarrying behavior would presumably be represented in the archaeological record of the surrounding region. Considering if and how use of these regions changed across time can lead to more elaborate models of human behavior. In the case of the Bodie Hills, the opportunity to compare the archaeological record of surrounding sites to previous studies (e.g., Goebel et al. 2008; Halford 2001; Singer and Ericson 1977) of the obsidian source allows for a more informed discussion on the behaviors responsible for the varying intensity of exploitation. This study has wider applicability to records at other eastern Sierra Nevada obsidian sources and the mechanisms involved in the parallel peaks and declines in obsidian use there.

CHAPTER 2

Materials – The Bodie Hills

Modern Climate and Biota

The Bodie Hills lie along the eastern Sierra Nevada mountain range on the western fringe of the Great Basin. While they sit in the orographic rain shadow of the Sierra Nevada, their proximity to the range greatly influences weather in the region and annual precipitation in the Bodie Hills is high compared to the rest of the Great Basin (Halford 2008:10). The Bodie Hills region receives an average annual precipitation of 32.33 cm, most of which occurs during the fall (November) and winter months (December – March). Average annual snowfall for the region is 243.07 cm (Western Regional Climate Center [WRCC] 2013). The modern biotic environment of the Bodie Hills is typical of the western Great Basin and is composed of two altitudinally defined zones: pinyon-juniper woodland and sagebrush steppe (Halford 2008:10). These two zones overlap from ~1,524 to ~2,438 m and sagebrush steppe continues up to ~3,048 m (DeBoer et al. 2011:2-2; Halford 2008:10). The sagebrush steppe zone is composed of mesic species such as sagebrush, rabbitbrush, and manzanita; woodlands are composed of pine, juniper, firs, and aspen (DeBoer et al. 2011:2-2, 2-3; Halford 2008:10).

Paleoenvironment

There is a lack of climatic data specific to the Bodie Hills region from the terminal Pleistocene/early Holocene (TP/EH); however, nearby areas provide proxies for climate in the Bodie Hills. Pinyon-juniper woodlands in the western and southwestern Great Basin had a more southerly distribution prior to ~14,000 cal BP. Warming and drying occurred in Owens Valley ~15,000 cal BP and sagebrush began to replace Juniper woodland on the valley floor (Mensing 2001). Pinyon disappeared in the Mojave Desert by ~13,850 cal BP[1]. Woodrat midden studies in the Volcanic Tablelands south of the Bodie Hills indicate that juniper was present by ~11,250 cal BP[1]. Woodrat middens in the White Mountains south of the Bodie Hills show that pinyon was present by at least ~9,600 cal BP[1] and plant communities there during the TP/EH were roughly similar to those found today (Jennings and Elliot-Fiske 1993:214-216).

During the middle Holocene (~8,000 – 5,000 cal BP), rapid warming drastically changed environmental conditions in the Great Basin (Grayson 2000, 2011; Lindström 1990; Mensing et al. 2004; Schmitt et al. 2002). In general, this period was much warmer and drier than the early Holocene. Lakes receded – many to the point of desiccation – and marsh systems followed (Grayson 2011:245; Lindström 1990; Mensing et al. 2004; Schmitt et al. 2002). In the White Mountains, pinyon retreated ~250 m upslope (Jennings and Elliot-Fisk 1993:216) and the lower limit of bristlecone pine moved upslope ~150 m (LaMarche 1973). Woodrat midden studies in the Dry Lakes Plateau in the northeastern Bodie Hills indicate that pinyon was present by ~4,980 cal BP (Grayson 2011:256; Halford 1998:155, 2008:13).

[1] Dates provided in radiocarbon years before present and converted to calendar years before present using Appendix A in Grayson (2011) for consistency.

The late Holocene (~5,000 cal BP – present) has been a highly variable but general movement toward current conditions (Bacon et al. 2006; Briggs et al. 2005; Grayson 2011; LaMarche 1973, 1974; Stine 1990, 1994), with many fluctuations in temperature and precipitation occurring especially within the last 1,500 years. Stine's (1990, 1994) work on Mono Lake's fluctuations ~20 km south of the Bodie Hills and submerged tree-stumps in Tenaya Lake and the Walker River ~30 km northwest of the Bodie Hills have added important paleoenvironmental data regarding late Holocene conditions in the region. Submerged stumps are evidence of intense drought during the Medieval Climatic Anomaly (~1,100 – 600 cal BP) (Stine 1990, 1994) and the variable levels of Mono Lake after this period are evidence of continued climatic variation.

Geology and Hydrology

As part of the hydrographic Great Basin, water in Bridgeport Valley has no outlet to the ocean and the East Walker River is the only permanent flowing water that exits the valley, supplying Walker Lake via Walker Canyon. The valley averages ~1,981 m in elevation and is situated in a generally north-south trending direction (California Department of Water Resources [CDWR] 2004:1).

Geology of the Bodie Hills has received much attention in the past due to significant gold bearing deposits in the region. Tertiary volcanics are responsible for the formation of the Bodie Hills (Halford 2008:9) and local geology consists mainly of Mesozoic granite and post-batholith volcanic rock that occur as Pliocene andesite and lahars (United States Department of Agriculture, Forest Service [USDA] 1994). An ancient volcanic center known as the “Big Alkali” caldera lies at the eastern edge of the Bodie Hills (Zuber 1995:9). Sediment in the Bodie Hills often consists of silt and clay deposits with clodding prevalent from 10 to 30 cm below the surface and hard pan clayey substrates from 20 to 30 cm below surface (Halford 2008:9). At ~50 cm below the surface a silica rich duripan layer that predates Holocene deposits occurs (Halford 2008:33). Halford (2008) noted obsidian cobbles embedded in this layer and coupled with an absence of cultural material, this corroborates the old age of these deposits.

Previous Research

In January of 2013, I visited the California Historic Resources Information System (CHRIS), Eastern Information Center (EIC) in Riverside to conduct a records search. From maps housed at the EIC, I obtained a comprehensive list of inventory reports, archaeological sites, and isolated cultural resources within ~12 km of an arbitrary center-point of the Bodie Hills obsidian source. A majority of the land surrounding the Bodie Hills obsidian source is managed by two different government agencies: the Bureau of Land Management (BLM) and the Humboldt-Toiyabe National Forest (HTNF). The obsidian source and much of the terrain to the south and east – save for several small blocks of private land – lie on BLM land. With the exception of the private Bridgeport Valley and various other private and state blocks, all land north and west of the obsidian source is managed by the HTNF. A large majority of the archaeological fieldwork undertaken in the Bodie Hills region has occurred on land managed by the BLM. Although there remains a dearth of archaeological data from HTNF and private land to the north and west of the obsidian source, my study represents the most comprehensive compilation of recorded archaeological resources in the area to date (Figure 2.1).

The first systematic archaeological fieldwork in the region was carried out by Clement Meighan in 1953 (Meighan 1955). This cursory survey identified a number of sites throughout the Bodie Hills and adjacent areas. In the 1960s, Emma Lou Davis completed extensive archaeological studies in the Bodie Hills region (Davis 1964). As noted in Chapter 1, Singer and Ericson (1977) were the first to study and map the primary obsidian outcrop in the Bodie Hills. Subsequent studies were undertaken by cultural resource management (CRM) companies under contract by government agencies and through graduate research. The first extensive CRM work took place during the late 1970s and early 1980s as multiple Class I and II surveys (e.g, Busby et al. 1979; Hall 1980; Kobori et al. 1980). Bieling's (1992) graduate research in northwest Bridgeport Valley explored land-use strategies using obsidian hydration analysis of artifacts from a sample of sites. Halford (2000, 2001, 2008) provided extensive information on the secondary cobble flows. More recent CRM projects have been carried out within the current project area in 2010 and 2011 (e.g., DeBoer et al. 2011; King 2010).

I excluded sites recorded in the 1950s and 1960s (e.g., Meighan [1955] and Davis [1964]) due to inadequate site recording standards during that period. For example, Meighan (1955) and Davis (1964) only recorded the locations of archaeological sites and not the amounts of debitage, number of tools, or types and/or number of habitation features. A number of the sites recorded by Meighan (1955) and Davis (1964) were updated during more recent surveys and I have included those updated sites. In the absence of data from these early projects, the majority of information in my study comes from CRM and government agency projects completed between the 1970s and present. These are briefly summarized below.

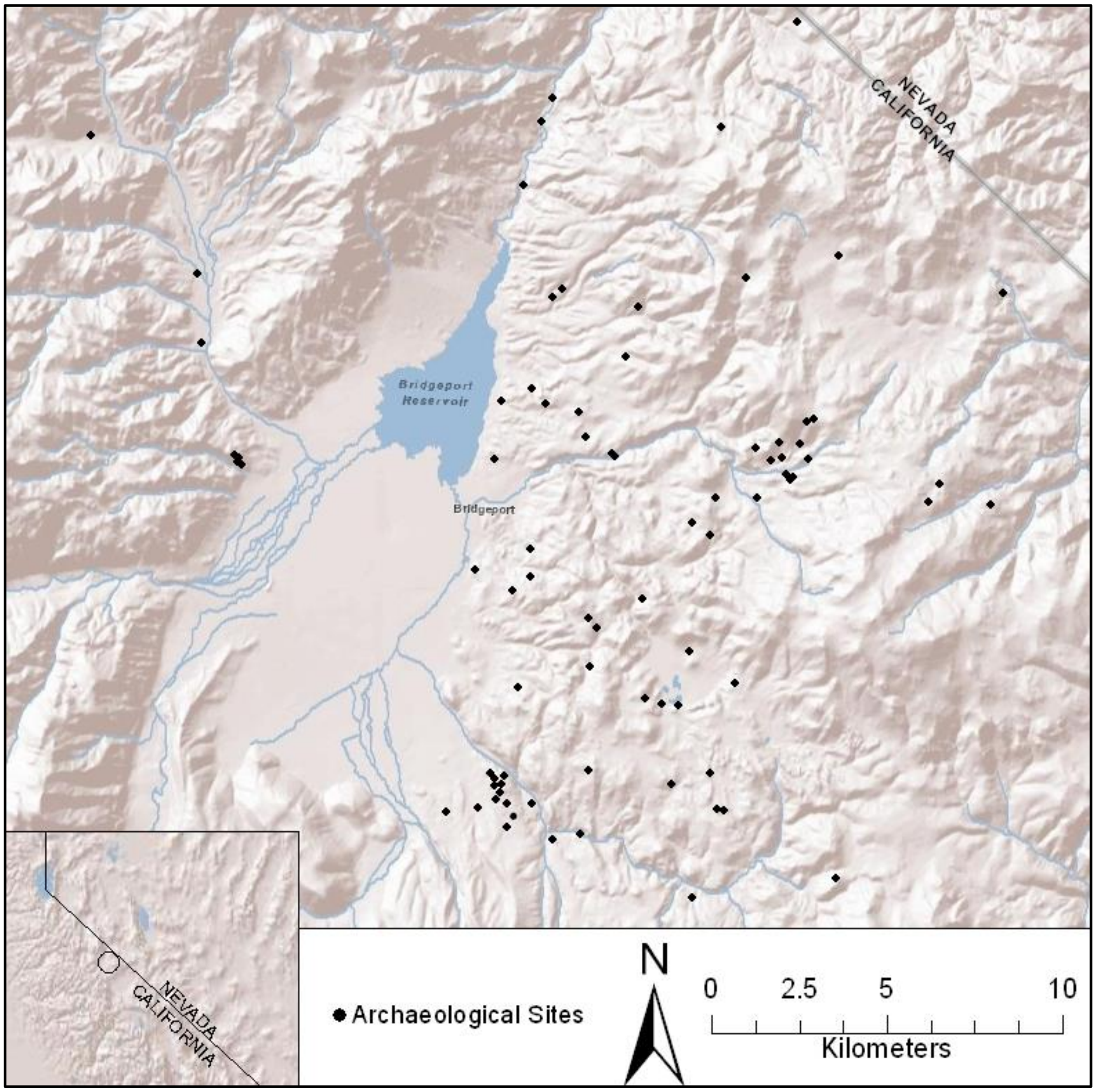

Figure 2.1. Location of sites included in this study. Image source: ESRI.

The earliest sites included in my study were recorded during the mid-1970s for the Bridgeport Indian Housing Project. In 1979, surveys were completed by Kobori

(1980) and Hall (1980) in the Bodie Hills and surrounding areas. Rusco (1991) conducted research on the prehistoric resources of the Bodie Mining District. Two small surveys were undertaken for the Bridgeport Gunclub Recreation and Public Purposes (Christian 1994; Halford and Christian 1993) and the Bodie Hills Recreational Vehicle Park (Farrell and Burton 1996). Halford (1997) conducted research for the Bridgeport Landfill Project and later surveyed and recorded sites at the Travertine Hot Springs, south of the obsidian source (Halford 1998b). Halford (2000, 2001) conducted data recovery at two sites (MNO-3125/H and MNO-3126) west of the Bridgeport Reservoir. Goebel et al. (2008) advanced Halford's (2000, 2001) work at MNO-3126. Most recently, King (2010) and DeBoer et al. (2011) completed extensive survey within the Bodie Hills obsidian source and outlying regions.

From site forms recorded during the aforementioned studies, I collected information to test my hypotheses related to diachronic shifts in land-use. For each site, I noted the presence, type, and quantity of projectile points, bifaces, flake tools, and cores. This information is relevant because these artifacts can assist in studies of technological organization. I also collected information on the debitage density, presence of milling equipment, and presence and number of features (e.g., rock rings, hearths, etc.) from each site. These aspects can provide information about occupation span and mobility and add further data with which to infer technological organization strategies. Due to differences in the methods of site recording as well as the nature of lithic assemblages, not all of the aforementioned information was obtained for all sites. Table 2.1 summarizes the information obtained for each of the sites included in this study.

Table 2.1. Information Collected for Sites Included in this Study.

Site Number	Debitage Amount	TOOLS [a]PPT	[b]UD	[c]BIF	[d]FT	[e]O	[f]BI	[g]FTI	Milling	Features
MNO-265	+	+		+			+			
MNO-276	+	+	+	+	+	+	+	+		
MNO-303	+	+	+			+				
MNO-1118	+	+	+	+	+	+	+	+	+	
MNO-1146	+	+		+			+			
MNO-1155	+	+								
MNO-1161	+	+	+	+			+			
MNO-1165	+	+								
MNO-1166	+	+	+							
MNO-1175	+	+								
MNO-1191	+	+		+						
MNO-1284	+	+	+	+		+	+		+	
MNO-1333	+	+								
MNO-1339	+	+								
MNO-1348	+	+	+	+		+	+		+	+
MNO-1349	+	+	+	+		+	+			+
MNO-1374	+	+	+							
MNO-1382	+	+	+	+			+		+	
MNO-1395	+	+	+	+		+	+			
MNO-1400	+	+		+		+	+			
MNO-1427	+	+		+					+	+
MNO-1451	+	+		+						
MNO-1457	+	+		+			+		+	
MNO-1479	+	+		+			+			
MNO-1537	+	+	+	+	+	+	+			
MNO-1543	+	+								
MNO-1546	+	+								
MNO-1549		+	+	+		+	+			
MNO-1554	+	+				+				
MNO-1555	+	+		+			+			
MNO-1573		+								
MNO-1576	+	+	+	+	+		+			
MNO-1605	+	+		+						
MNO-1606	+	+	+							
MNO-1640		+								
MNO-1947	+	+		+	+	+	+		+	
MNO-2471	+	+								
MNO-2474	+	+	+	+			+			
MNO-2476	+	+								
MNO-2749	+	+	+	+		+				
MNO-2750	+	+		+						
MNO-3103	+	+	+	+			+			
MNO-3114/H	+	+			+	+	+		+	+
MNO-3116/H	+	+	+	+	+	+	+		+	
MNO-3121	+	+		+					+	
MNO-3122	+	+		+	+				+	
MNO-3131	+	+		+		+				
MNO-3858	+	+	+	+	+		+		+	
MNO-3861	+	+	+	+	+	+	+		+	
MNO-3863	+	+		+		+	+			
MNO-3864	+	+		+	+		+			

Site	Debitage	TOOLS								
Number	**Amount**	**[a]PPT**	**[b]UD**	**[c]BIF**	**[d]FT**	**[e]O**	**[f]BI**	**[g]FTI**	**Milling**	**Features**
MNO-3866	+	+	+	+	+	+	+			
MNO-3867	+	+		+	+	+	+		+	
MNO-3868	+	+	+	+	+		+		+	
MNO-3870	+	+		+	+		+			
MNO-3997	+	+		+	+		+			
MNO-4001	+	+		+		+			+	
MNO-4003	+	+		+	+	+	+		+	+
MNO-4375	+	+		+			+		+	
MNO-4523/H	+	+		+					+	+
MNO-4530	+	+		+		+	+			
MNO-4549	+	+		+	+	+	+		+	
MNO-4552	+	+		+		+	+			
MNO-4553	+	+		+	+	+	+	+		
MNO-4556	+	+		+			+			
MNO-4558	+	+		+			+			
MNO-4559	+	+		+			+			
MNO-4560	+	+		+			+		+	
MNO-4572	+	+	+	+		+	+		+	
MNO-4581	+	+		+			+			
MNO-4583	+	+		+						
MNO-4585	+	+								
MNO-4790	+	+		+			+			
MNO-4795	+	+		+					+	+
MNO-4796	+	+								
MNO-4826	+	+		+			+			
MNO-4832	+	+		+		+	+			
MNO-4835	+	+	+	+			+		+	+
MNO-4914	+	+	+	+	+		+	+		
MNO-4915	+	+		+			+			
MNO-4971	+	+								

[a] PPT – Projectile point
[b] UD – Undiagnostic projectile point
[c] BIF – Biface
[d] FT – Flake tool
[e] O – Other
[f] BI – Biface index
[g] FTI – Flake tool index

Chronological Control

Chronological control is essential in diachronic studies. Unfortunately, most surface sites lack organic material suitable for radiocarbon dating. As such, researchers in the Great Basin generally use diagnostic projectile points to establish the age of sites at which they are found in a method known as typological cross-dating. While typological cross-dating lacks the resolution of radiocarbon dating, it nevertheless provides coarse-grained (e.g., century- or millennium-scale) age estimates for sites.

Obsidian hydration is a relative dating technique that can be applied when obsidian artifacts are present at a site even when diagnostic projectile points are absent. Obsidian hydration has been employed by researchers (e.g., Gilreath and Hildebrandt 1997, 2011; Goebel et al. 2008; Halford 2001, 2008; Ramos 2000; Singer and Ericson 1977) at the Bodie Hills and other regional quarries to identify peaks and troughs in obsidian exploitation. Obsidian hydration is based on the principle that obsidian adsorbs water at the surface which then diffuses into the interior at a constant rate. A diffusion front develops on a freshly flaked surface and the distance between the surface and the front (thickness of the rim) can be measured and compared to the rate of adsorption to provide an approximate age for the artifact being studied (Friedman and Smith 1960). Critics of obsidian hydration (e.g., Anovitz et al. 1999, Ridings 1996) cite a variety of factors (e.g., geochemical composition, effective temperature, etc.) that can affect the rate at which water adsorbs and diffuses inward as evidence against its efficacy. While the effectiveness of obsidian hydration as an absolute dating technique has yet to be clearly established, there is evidence that obsidian hydration is useful as a relative dating technique (Rogers 2007).

Researchers (e.g., Bieling 1992; Goebel et al. 2008; Halford 2001, 2008; Singer and Ericson 1977) have largely depended on obsidian hydration for chronological control in the Bodie Hills. Hydration readings are calibrated with radiocarbon dates from other regions, providing ages in years before present (Halford 2008). Furthermore, dates provided by obsidian hydration analysis generally, if loosely, match the known age ranges of diagnostic projectile points (Halford 2008). Although obsidian hydration analysis has been applied in many eastern Sierra Nevada quarry studies, my study depends on diagnostic projectile points for chronological control. The results of obsidian hydration analyses undertaken by previous researchers in the Bodie Hills (e.g., Bieling 1992; Halford 2008), however, are essential for establishing the age ranges of certain projectile points (e.g., Humboldt, Elko) used in this study. Furthermore, any useful comparison between the results of my study and previous studies of eastern Sierra Nevada obsidian sources depends on the effectiveness of using either diagnostic projectile points or obsidian hydration analysis for chronological control of archaeological sites. Diagnostic projectile points, their associated ages, and their role in my study are outlined below.

Projectile Points

Projectile points are often used as chronological markers at surface lithic scatters. The dating of organic materials in association with projectile points in stratified contexts has led to exceptional clarity on the ages of many projectile point types. The temporal spans of projectile point types range from thousands of years (e.g., Great Basin Stemmed Series) to less than a millennium (e.g., Rosegate and Desert series). Therefore, projectile points can provide coarse- to fine-grained age estimates for sites at which they are found.

Various regional studies have established chronologies for California and the Great Basin. General chronologies and typologies developed by Beck and Jones (2009) and Thomas (1981) were used in some cases for projectile point descriptions and ages here. Point chronologies specific to the western and southwestern Great Basin (Bettinger and Taylor 1974; Hildebrandt and King 2002; Sutton et al. 2007) were also used to establish ages of sites in the study area (Table 2.2). Humboldt, Elko, Rosegate, and Desert series points are the most common styles found in the Bodie Hills. Great Basin Fluted (GBF), Great Basin Stemmed Series (GBSS), and Pinto/Little Lake Series projectile points occur in lesser frequencies. The descriptions and age ranges of these projectile points in the Bodie Hills are as follows:

Table 2.2. Cultural Chronology Used in this Study.

Date (cal BP)	Cultural Complex	Diagnostic Points
Terminal Pleistocene		
12,000 – 10,000	Paleoarchaic (Paleoindian	[a]GBSS, [b]GBF, [c]GBCB
Early Holocene		
10,000 – 8,000	Mohave	GBSS, Pinto (from ~9,000 cal BP)
Middle Holocene		
8,000 – 4,000	Little Lake/Pinto	Pinto, Elko (from ~5,000 cal BP)
Late Holocene		
4,000 – 1,300	Newberry (starting at 3,500 cal BP)	Elko, Humboldt
1,300 – 650	Haiwee	Rosegate
650 – Historic (A.D. 1850)	Marana	Desert Side-notched, Cottonwood

Note: Adapted from Bettinger and Taylor (1974) and Sutton et al. (2007)
[a] GBSS – Great Basin Stemmed Series
[b] GBF – Great Basin Fluted
[c] GBCB – Great Basin Concave Base

Great Basin Fluted Projectile Points. Great Basin fluted points have similarly been termed Clovis Points; however, use of the term Clovis implies that the adaptations of people who used fluted points in the Great Basin were the same as those in other parts of the country, which has not been conclusively shown (Beck and Jones 1997; Grayson 2011:289-292). Therefore, the term Great Basin Fluted (GBF) is employed here to imply no specific behavior or adaptation. GBF points are lanceolate in profile and possess concave bases and diagnostic "fluting" near their bases on one or both faces. Fluted points are less securely dated in the Great Basin than in other parts of North America, but they are associated with the Paleoarchaic period (Beck and Jones 2009).

Great Basin Concave Base Projectile Points. Great Basin Concave Base points are unfluted variants of GBF projectile points (Beck and Jones 2009). Alternately referred to as Black Rock Concave Base points (Clewlow 1968), GBCB points are lanceolate in shape and exhibit concave bases with basal thinning (Beck and Jones 2009).

Great Basin Stemmed Series Projectile Points. Great Basin Stemmed points include many different subtypes found throughout the Great Basin. Debates on the attributes and distribution of these subtypes have led some researchers (e.g., Tuohy and Layton 1977:2) to suggest that they be lumped into a Great Basin Stemmed Series (GBSS). Beck and Jones (2009) revisited the original definition of points lumped into the GBSS designation and emphasize the usefulness of separate typologies, specifically in terms of function. As the separation of these projectile points is based primarily on style rather than differences in age, I retain the GBSS designation for all stemmed points in this study.

GBSS points are lanceolate in shape and may be shouldered with basal and lateral edge-grinding (Beck and Jones 2009). They are coarse-grained temporal markers because they were used over thousands of years, from the TP/EH transition to ~8,000 cal BP (Beck and Jones 2009; Grayson 2011:294; Sutton et al. 2007). GBSS projectile points are associated with the Paleoarchaic period and saw continued use through the

Mohave Period in the southwestern Great Basin (Bettinger and Taylor 1974; Sutton et al. 2007).

Pinto Series Projectile Points. Alternately known as the Little Lake Series in the southwestern Great Basin (Bettinger and Taylor 1974), Pinto points provide coarse-grained temporal estimates for sites. They persisted from ~9,000 cal BP – overlapping with the Mohave Period – to approximately 5,000 cal BP (Jenkins and Warren 1984). Originally defined by Amsden (1935), these points are shouldered with bifurcated or indented basal elements. The Pinto/Little Lake Period is typified by Pinto Series projectile points.

Humboldt Series Projectile Points. Humboldt Series points vary in size but are generally ≥4 cm in length. They are lanceolate in profile with concave bases or basal notches/indentations (Thomas 1981:17). Dates for Humboldt projectile points vary widely in the Great Basin. Thomas (1981) noted the wide variability in Humboldt point morphology and suggested that the type ranges from ~5,000 to ~1,300 cal BP. While there is general agreement on the discontinued manufacture of Humboldt points after ~1,300 cal BP, their initial emergence varies widely by region, from ~6,000 cal BP in the northern Great Basin (Oetting 1994) to ~3,500 cal BP along the Sierra/Cascade front (Hildebrandt and King 2002). Gilreath and Hildebrandt's (1997) obsidian hydration analysis at the Coso Volcanic Field indicates that Humboldt points occupy a narrow time range from ~3,000 to just after 1,300 cal BP. In the Bodie Hills region, Bieling's (1992) obsidian hydration work in the Bridgeport Valley suggests that Humboldt points fit securely within the Newberry Period (3,500 – 1,300 cal BP). Finally, Halford's (2008) research indicates that Humboldt Series points subjected to obsidian hydration analysis exhibit smaller rim values on average than do Elko Series projectile points, which are generally thought to exhibit a shorter period of use than Humboldt points in the western and southwestern Great Basin (Bettinger and Taylor 1974; Sutton et al. 2007). In line with hydration data in the Bodie Hills region, I adopt Hildebrandt and King's (2002) estimate, which places Humboldt Series projectile points between 3,500 and 1,300 cal BP.

Elko Series Projectile Points. Elko projectile points exhibit a great deal of morphological variation. They were initially separated into four categories: Side-notched, Corner-notched, Eared, and Contracting-stem (Heizer and Baumhoff 1961; Heizer et al. 1968). Thomas (1981:22) suggested dropping the side-notched variant from the typology and incorporating the contracting-stem variant into his then newly created Gatecliff Series, which he suggests dates from ~5,000 to ~3,300 cal BP. Elko Series points are shouldered projectile points with corner-notched basal elements. The corner-notched form is generally flat to slightly convex and the eared form exhibits a bifurcated base (Thomas 1981:20-22).

Age estimates for the Elko Series vary greatly by geographic area. Thomas (1981) securely dated Elko Series points in Monitor Valley to 3,300 – 1,300 cal BP; however, in the eastern Great Basin they have been found in pre-8,000 cal BP contexts, suggesting a much earlier initial use in that region (Aikens 1970; Holmer 1986). Hildebrandt and King (2002) proposed that initial use of Elko Series points along the Sierra/Cascade Front occurred ~4,500 cal BP. Recent obsidian hydration analyses of Elko points in the southwestern Great Basin have identified a temporal distinction between thick (>6.5 mm) and thin (≤6.5 mm) Elko points (Gilreath and Hildebrandt

1997:71, 84). Thick Elko points exhibit larger hydration rim values than do thin Elko points, suggesting that they were used earlier than thin specimens. While it is my opinion that this issue stems from the misclassification of Pinto projectile points as Elko points (see Basgall and Hall 2000), this issue has negative implications for any study using temporally diagnostic projectile points for chronological control. However, if we assume that the ages of particular projectile point types form a normal distribution as they were adopted, reached a peak in popularity, and were gradually replaced by other styles (*sensu* Oetting 1994:43), then *most* sites with Elko points likely date to between ~4,500 and ~1,300 cal BP (Hildebrandt and King 2002). My assignment of Elko points to the Newberry Period (3,500 – 1,300 cal BP) is in line with other studies (e.g., Bieling 1992; Halford 2008) in the Bodie Hills and surrounding regions.

Rosegate Series Projectile Points. Rosegate Series points are assumed to reflect the introduction of the bow-and-arrow to the Great Basin (Allen 1986; Yohe 1998). They are small corner-notched points with expanding stems measuring <10 mm in width (Thomas 1981:19). The temporal range of Rosegate points varies across the Great Basin. Their initial use is suggested as anytime from post-2,000 cal BP to 1,230 cal BP in the western Great Basin (Smith et al. 2013). Thomas (1981:19) suggested that their entry into the archaeological record of the central Great Basin occurred ~1,250 cal BP. Bettinger and Taylor (1974) also suggested a late appearance of these points in the southwestern Great Basin ~1,300 cal BP. My study assumes a late entry (~1,300 cal BP) of Rosegate points to the Bodie Hills region and their discontinued use ~650 cal BP following Bettinger and Taylor (1974). These points are the sole temporal marker of the Haiwee Period (1,300 – 650 cal BP).

Desert Series Projectile Points. These points include Desert Side-notched and Cottonwood Triangular/Leaf-shaped points. Desert Side-notched points are small with high margin-notches and concave or notched bases. Cottonwood Triangular/Leaf-shaped points are small, unnotched triangular or leaf-shaped points. Desert Series points weigh <1.5 grams (Thomas 1981:15-16). Sutton et al. (2007) suggested that Desert Series points postdate ~900 cal BP in the southwestern Great Basin, while Hildebrandt and King (2002) posited that their appearance postdates ~200 cal BP further north. I use the temporal range of ~650 cal BP to contact times, suggested by Thomas (1981) and other researchers (e.g., Bettinger and Taylor 1974) and as such, Desert Series points are associated with the Marana Period (650 cal BP – contact).

Summary

Data in my study were gathered from various CRM and government agency projects. From site forms, data related to technological organization were extracted. Chronological control of sites was established using temporally diagnostic projectile points. The projectile points and their associated age ranges discussed above allow for the assignment of sites into cultural periods to facilitate comparison of sites between periods to test my hypotheses related to diachronic shifts in land-use in the Bodie Hills region. In the next chapter, I establish methods for characterizing sites used in my study based on the data obtained from site forms and outline a series of expectations related to the hypotheses outlined in Chapter 1.

CHAPTER 3

Methods

In this study, I characterize sites in the Bodie Hills region to test hypotheses related to diachronic shifts in land-use through the study of technological organization. In this chapter, I describe the methods employed to characterize my sample of sites. I include discussions on the use of projectile point typologies defined in the preceding chapter and how I quantified site attributes. Additionally, I describe the methods used to establish projectile point frequencies for the region. I also use the distribution of Bodie Hills obsidian in the Great Basin to test my hypotheses related to diachronic shifts in Bodie Hills obsidian use and conveyance; therefore, I outline the methods used to acquire and evaluate data related to the eastern distribution of that material. Finally, I restate my hypotheses and outline related expectations based on previous research of technological organization and eastern Sierra Nevada obsidian procurement and conveyance for each cultural period.

Defining Cultural Periods

Sites included in my study are separated by cultural period based on the presence of temporally diagnostic projectile points. This necessarily means that the absence of temporally diagnostic projectile points at sites precluded their inclusion in this study.

Isolated projectile points were excluded from the sample of sites but I return to them later to further evaluate the prehistoric use of the Bodie Hills.

Since the purpose of this study is to test the hypotheses related to diachronic shifts in land-use, only single-component sites were included. Single-component sites are defined as sites containing only one temporally diagnostic projectile point type or a greater proportion of one temporal type if multiple types are present; I assume that greater numbers of projectile points from any given period indicate greater use of a site during that period. Using the diagnostic projectile point types outlined in the previous chapter, I assigned sites to one of three time periods: (1) the Early Period (pre-5,000 cal BP); (2) the Middle Period (5,000 – 1,300 cal BP); and (3) the Late Period (post-1,300 cal BP) (Table 3.1). Characteristics of these periods, including associated diagnostic projectile point types and proposed activities – considering both studies of technological organization, quarries, and subsistence – are outlined below:

Early Period (pre-5,000 cal BP)

Diagnostic projectile points from the Early Period include the GBF, GBCB, GBSS, and Pinto/Little Lake Series types. The temporal division at 5,000 cal BP between the Early and Middle periods was based on the small number of single-component sites prior to the Middle Period (defined below) and that prior to ~5,000 cal BP there was low level use of eastern Sierra Nevada obsidian sources (e.g., Bodie Hills and Coso). Therefore, given the small sample of sites, further division of the Early Period would have created samples unsuitable for statistical comparisons.

Following the organization of technology models summarized in Chapter 1, the Early Period is generally characterized by high mobility (Jones et al. 2003, 2012; Smith 2010) and an emphasis on bifacial technology (Kelly 1988; Parry and Kelly 1987). Studies (e.g., Bouey and Basgall 1984; Gilreath and Hildebrandt 1997; Goebel et al. 2008; Halford 2001; Martinez 2009; Ramos 2009) have shown that Eastern Sierra Nevada obsidian sources were minimally exploited prior to ~5,000 cal BP. Researchers (e.g., Gilreath and Hildebrandt 1997; Goebel et al. 2008; Halford 2001) have suggested that at the Bodie Hills and Coso Volcanic Field, secondary deposits of obsidian cobbles were utilized prior to ~3,000 cal BP. These secondary deposits were likely exploited "by groups using an expansive, highly mobile settlement-subsistence system" (Gilreath and Hildebrandt 1997:iii). Subsistence pursuits during this time are believed to have been generalized (Jones et al. 2003). Halford (2008:21) suggests that secondary obsidian cobble flows in the Bodie Hills were used by mobile groups exploiting the wetland resources of the East Walker River.

Middle Period (5,000 – 1,300 cal BP)

The Middle Period is typified by Humboldt and Elko Series projectile points. Although the chronology outlined in the previous chapter placed the initial emergence of Elko Series projectile points at ~4,500 cal BP in the Bodie Hills, incorporating Elko Contracting-stem variants to the Gatecliff Series (5,000 – 3,300 cal BP) (Thomas 1981:22) created issues with some sites. A small number of site forms reported Elko subtypes (some of which were contracting-stem variants) while some reported only the

Elko designation. Additionally, the thick-thin Elko issue discussed in Chapter 2 suggests that reported Elko Series points may date much earlier than is generally accepted (3,500 – 1,350 cal BP) in the southwestern Great Basin. Once again, if projectile point types form a normal distribution within an established time-frame, then most Elko points should date to after 5,000 cal BP. Therefore, I set the start of the Middle Period at 5,000 cal BP.

Researchers working in the southwestern Great Basin (e.g., Basgall 1989; Eerkens et al. 2008) suggest that the Middle Period was typified by continued high residential mobility; however, others (e.g., McGuire and Hildebrandt 2005:706) have alternatively suggested that the Middle Period may have been the pinnacle of residential stability in the Great Basin. This period is also associated with an emphasis on bifacial technology as evidenced by increased biface production at eastern Sierra Nevada obsidian sources. Hildebrandt and McGuire (2002) suggest that subsistence pursuits were focused on high-ranked resources (i.e., large game) from ~4,000 – 1,000 cal BP with a switch to an emphasis on low-return resources (e.g., nuts and seeds) (see Hildebrandt and Ruby 2006) after that time.

Late Period (Post-1,300 cal BP)

Diagnostic projectile points from the Late Period include Rosegate and Desert Series points. The beginning of this period signaled the decline in obsidian utilization and biface production at eastern Sierra Nevada obsidian sources (Bouey and Basgall 1984; Gilreath and Hildebrandt 1997; Hall 1983; Martinez 2009; Ramos 2000; Singer and Ericson 1977). Ericson (1982) proposed that at the Casa Diablo obsidian source, this decline was due to a switch from the production of luxury bifaces for trade to a blade/flake technology for more utilitarian purposes. Ericson (1982) suggested that this switch was brought about by the introduction of the bow-and-arrow into the southwestern Great Basin after ~1,500 cal BP (Allen 1986; Yohe 1998). Concomitantly, there was an apparent shift in subsistence strategies that included intensified processing of low-ranked resources (e.g., seeds and nuts) (Bettinger and Baumhoff 1982; Hildebrandt and Ruby 2006; Ramos 2000).

Table 3.1. Designated Periods and their Cultural and Temporal Correlates.

Period (cal BP)	**Cultural Complex**	**Temporal Markers**
Early (Pre-5,000)	Paleoarchaic, Mohave, Little Lake/Pinto	[a]GBF, [b]GBSS, [c]GBCB, Pinto
Middle (5,000 – 1,300)	Newberry	Elko, Humboldt
Late (Post-1,300)	Haiwee, Marana	Rosegate, [d]DSN, [e]CT

[a] GBF – Great Basin Fluted
[b] GBSS – Great Basin Stemmed Series
[c] GBCB – Great Basin Concave Base
[d] DSN – Desert Side-notched
[e] CT – Cottonwood Triangular

Characterization of Sites

Debitage

A majority of site forms presented debitage density as light, medium, or heavy; in such cases, these designations were retained. When site forms did not list debitage amounts in this manner, estimates of the total number of flakes at each site – as indicated on site forms – were divided by site area to establish the number of flakes per square meter (#/m^2). To accomplish this, the site dimensions (L x W) provided on site forms were entered into a Microsoft Excel spreadsheet and an oval shape was assumed for each site. The area of an oval was calculated as:

$$(L \times 0.5) \times (W \times 0.5) \times \pi = \textit{site area}$$

This equation was entered into the spreadsheet and used to obtain site area when required. Sites with densities of $\geq 4/m^2$ were counted as heavy, $3/m^2$ as medium, and $\leq 2/m^2$ as light. These arbitrary numerical distinctions were based on designations present on a number of site forms. Debitage density was not calculated for sites with insufficient data (e.g., no total flake estimates).

Tools

All researchers reported tool types and numbers of tools present on site forms. Tool types were tallied for each site in the following manner:

Projectile Points. Projectile points were tallied for each site regardless of style. For this study, the types of points present at sites were only used to assign sites to the time periods outlined above. Individual point styles from the sample of sites in this study were later separated to calculate projectile point frequencies (defined below) for each time period. Undiagnostic points were tallied separately and site forms that reported uncertainty in projectile point identification were not included.

Bifaces. Bifaces were tallied regardless of stage or shape. Projectile points, though technically bifaces, were excluded from biface counts because I assume that they represent finished tools and not bifaces produced for transport to be finished at a later time.

A simple count of bifaces provides no indication of the relative importance of bifaces at a given site. For example, while a larger site might contain a higher number of bifaces than a smaller site, bifaces at the smaller site may comprise a greater proportion of tools, suggesting a greater emphasis on bifacial technology there. Therefore, I calculated a biface index (BI) for all sites containing bifaces to consider the relative importance of bifaces at each location. BI values were calculated as:

$$\text{BI} = \frac{\#\ \textit{Bifaces}}{\Sigma\ \textit{chipped stone tools}}$$

I did not calculate BI values for sites with less than four total tools because values could vary widely and potentially overemphasize the importance of bifaces simply due to small samples. The BI was averaged for sites from each period to present a mean BI for each period.

Flake Tools. Researchers reported flake tools using terms such as utilized flakes, edge-modified flakes, and formed-flake tools. For this study, I combined these categories and tallied them simply as flake tools. I grouped these categories together because they essentially refer to the same artifact class.

Several site forms only reported that “numerous” utilized flakes were present, suggesting that either there were too many to accurately count or that no effort was made to quantify their abundance. Sites without exact counts of flake tools were not included in flake tool tallies. Additionally, BI values were not calculated for these sites as these values are calculated by dividing bifaces by the total number of flaked stone tools, including flake tools, reported at a site.

Similar to the BI, I calculated a flake tool index (FTI) to consider the relative importance of flake tools at sites in my study. Following the method outlined above for BI values, I used the following equation to calculate FTI values:

$$\text{FTI}=\frac{\#\ \textit{Flake tools}}{\Sigma\ \textit{chipped stone tools}}$$

As with BI values, I did not calculate FTI values for sites with less than four flaked stone tools. FTI values were added and divided by the number of sites in each period to establish a mean FTI value.

Other Tools. Any stone tools included on site forms that did not fall into the above categories (e.g., choppers, cores, drills, unifaces, etc.) were tallied and designated as “other”. These tools were not tallied separately because they were present at very few sites and their inclusion in individual categories would not have added any insight to the study. They were not excluded from tool tallies, however, because their presence at sites affects the BI and FTI values defined above.

Habitation Debris

Attributes designated as habitation debris in this study include milling implements, rock rings/structures, and hearth features. All researchers reported these attributes on site forms. Milling implements were tallied separately from rock rings/structure debris and hearth features, which were tallied together. Handstones (i.e., manos), although technically milling implements, were not considered habitation debris when reported alone because handstones are portable and can presumably be used for purposes other than milling (e.g., percussion flaking or other hammering activities). While milling slabs can be transported, I assume in this study that they represent non-portable implements.

On many site forms, researchers reported the number of milling fragments but not the number of total milling implements. Therefore, in this study milling equipment was only listed as present if reported on site forms so that this attribute is not unduly overemphasized at sites.

Projectile Point Frequencies

I used projectile point frequencies to test my hypotheses related to diachronic shifts in land-use in the Bodie Hills. For this part of my study, I included isolated projectile points and multicomponent sites containing more than one temporally diagnostic projectile point type. Projectile point frequencies can present a differing view of land-use because projectiles – often associated with hunting – can occur in isolated contexts as well as at more substantial sites. As mentioned previously, hunting appears to have increased in the region during the Middle Period (~4,000 – 1,000 cal BP) (Hildebrandt and McGuire 2002). If this was the case, then presumably it would result in an increased number of isolated Humboldt and Elko projectile points.

Mobility is often related to population density (see Bettinger 1991; Kelly 1992, 2007). High mobility is generally associated with small populations, while reduced mobility is often related to larger populations (Hughes 2011; Jones et al. 2003). I use projectile point frequencies here as a proxy for population density (*sensu* Bettinger 1999, but see Surovell et al. 2009), and assume that more projectile points on the landscape indicates higher population densities in the region. Since the length of each temporal period varies (i.e., GBSS points span >4,000 years, while Rosegate points span <700 years), the number of years representing the temporal span of each projectile point type was divided by the number of projectile points of that type recovered. Doing so provides the number of years elapsed between the discard of each projectile point within a given period and allows frequencies between cultural periods to be compared, regardless of the number of projectile points reported (*sensu* Bettinger 1999).

The Eastern Conveyance of Bodie Hills Obsidian

To test my hypotheses related to the eastern distribution of Bodie Hills obsidian, I compiled published and unpublished geochemical data related to raw material use from previous work in the Great Basin. While the conveyance of Bodie Hills obsidian into central California has been well established through previous work (e.g., Jackson 1974;

King et al. 2011; Moratto 2002), the conveyance of this obsidian eastward into the obsidian-poor central Great Basin is less understood.

Data Acquisition

Geochemical sourcing data, both published and unpublished, were utilized to identify when and where Bodie Hills obsidian was conveyed into the Great Basin. I sought reports instead of site forms because geochemical sourcing does not take place in the field when artifacts are recorded or collected. Visual sourcing of raw materials may take place in the field (e.g., Bettinger 1982, but see Andrefsky 2009:77-78), but this technique is not considered here due to the subjectivity and potential errors involved. Therefore, only reports including geochemical sourcing data performed using conventional methods (e.g., X-ray fluorescence [XRF], instrumental neutron activation analysis [INAA], etc.) are included. Central and southern Nevada are of primary interest here as those regions are situated directly east and southeast of the Bodie Hills obsidian source and are less well-represented in research on the conveyance of that obsidian.

Evaluating Data

While the data exist, there is no current synthesis on the eastward conveyance of Bodie Hills obsidian. Bieling's (1992) graduate research (see Chapter 2) includes a brief discussion on the distribution of Bodie Hills obsidian. My study builds on Bieling's (1992) work and synthesizes data to evaluate expectations on the eastward conveyance of

Bodie Hills obsidian. I expect the literature review outlined below to identify an approximate distance eastward at which Bodie Hills obsidian is either minimally present or completely absent.

Hypothesis and Expectations

My hypotheses related to diachronic shifts in land-use in the Bodie Hills are as follows:

(A) Prior to ~5,000 cal BP there was limited use of the Bodie Hills region;

(B) The most intensive use of the Bodie Hills occurred between ~5,000 and ~1,300 cal BP; and

(C) After ~1,300 cal BP, obsidian use in the Bodie Hills decreased and subsistence activities increased.

I developed these hypotheses by examining previous research at eastern Sierra Nevada obsidian sources, which has identified a production peak between ~3,000 and ~1,300 cal BP. To test these hypotheses, I developed expectations for my sample of sites (Table 3.2). Assuming that the previous identification of production trends at eastern Sierra obsidian sources (e.g., Bouey and Basgall 1984; Gilreath and Hildebrandt 1997; Hall 1983; Martinez 2009; Ramos 2000; Singer and Ericson 1977) holds true for sites in and around the Bodie Hills obsidian source, I formulated expectations of what lithic assemblages should look like for each of the periods defined above.

My hypotheses related to diachronic shifts in Bodie Hills obsidian use and conveyance in the Great Basin are as follows:

(D) Conveyance of Bodie Hills obsidian into the Great Basin was the most spatially extensive prior to ~5,000 cal BP;

(E) Frequencies of Bodie Hills obsidian in the Great Basin reached a peak between ~5,000 and ~1,300 cal BP; and

(F) Frequencies of Bodie Hills obsidian in the Great Basin were lowest after ~1,300 cal BP.

I developed these hypotheses based on previous research at the Bodie Hills which has shown that obsidian conveyance into central California was most intense during the Middle Period (5,000 – 1,300 cal BP) with a sharp drop-off during the Late Period (post-1,300 cal BP). If the use of Bodie Hills obsidian was most intense during the Middle Period – as previous work has shown – and decreased sharply during the Late Period, then I expect that the conveyance of Bodie Hills obsidian into the Great Basin during those periods will roughly follow the trend seen in central California. The Early Period (pre-5,000 cal BP) conveyance of Bodie Hills obsidian is much less understood; however, if Early Period groups in the Great Basin were mobile (*sensu* Jones et al. 2003, 2012; Smith 2010), then I expect that conveyance of that obsidian in the Great Basin was most extensive during that time.

Early Period (pre-5,000 cal BP) Sites

If use of eastern Sierra Nevada obsidian sources was minimal prior to ~3,500 cal BP relative to later times, then I expect fewer Early Period sites than either Middle or Late period sites in and around the Bodie Hills obsidian source. During the Early Period, if groups were as mobile as many researchers (e.g., Jones et al. 2003, 2012; Smith 2010) have suggested, then I expect that occupation span at sites were short. Short occupation spans should be reflected by an absence of habitation debris, as the construction of structures generally indicates investment in place and intent to remain at a site for a considerable amount of time (Kelly 1992). Additionally, if exploitation of secondary obsidian cobble flows at the Bodie Hills and Coso Volcanic Field was by mobile groups, as suggested by Gilreath and Hildebrandt (1997) and Halford (2001), then debitage density at Early Period sites should generally be light.

Table 3.2. Summary of Expectations by Cultural Period.

Measure	Early Period	Middle Period		Late Period
		Model 1	Model 2	
Debitage Density	Light	Heavy	Heavy	Light
Biface Index Values	High	High	High	Low
Flake Tool Index Values	Low	High	Low	High
Milling	Rare	Common	Rare	Common
Features	Rare	Common	Rare	Common
Projectile Point Frequencies	Low	High	Low	High

As discussed in Chapter 1, there should be an emphasis on bifacial technology within a mobile settlement system (Kelly 1988; Parry and Kelly 1987). If Early Period groups were highly mobile, then I expect BI values to be high. In contrast, I expect FTI values to be low because researchers (e.g., Ericson 1982; Parry and Kelly 1987) have demonstrated that the switch from biface technology to flake technology accompanied increased sedentism. While Andrefsky (1994) suggested that when toolstone is abundant and high quality – as it is in the Bodie Hills – groups should have produced both formal and informal tools (e.g., flake tools), Bamforth (1986) argued that high mobility in and of itself likely created raw material shortages, making toolstone scarce even when sources are nearby. In such a case, I expect that groups provisioned individuals (*sensu* Kuhn 1995) with bifaces and not flake tools. Finally, as discussed above, mobility is often linked to population density (Bettinger 1991; Kelly 1992, 2007). Since high mobility is associated with small populations, and researchers (e.g., Gilreath and Hildebrandt 1997; Halford 2001) have suggested that Early Period groups were highly mobile, I expect that Early Period projectile point frequencies will be low.

Middle Period (5,000 – 1,300 cal BP) Sites

Based on previous research at eastern Sierra Nevada obsidian sources, I generated two separate sets of expectations for sites in the Middle Period. Both of these models can be used to test the hypothesis that the Bodie Hills were most intensively used during the Middle Period. The first set of expectations is based on models that have suggested the peak in obsidian use at eastern Sierra Nevada sources was due to the production of bifaces for exchange, specifically with consumer populations in the western Sierra foothills and southern California (Ericson 1982; Gilreath and Hildebrandt 1997; King et al. 2011; Singer and Ericson 1977). The second set of expectations follows other models which have proposed that the regional peaks in obsidian use were due to direct procurement by western Sierra foothill populations (Bouey and Basgall 1984) and/or local eastern Sierra groups (Basgall 1989; Martinez 2009; Ramos 2000).

Model 1: Production for Exchange. The production of bifaces for interregional exchange has been proposed for the Bodie Hills (King et al. 2011; Singer and Ericson 1977), Casa Diablo (Ericson 1982), and the Coso Volcanic Field (Gilreath and Hildebrandt 1977). Gilreath and Hildebrandt (1997) suggested that the large volume of quarrying activity at the Coso Volcanic Field ~3,500 – 1,300 cal BP exceeded the needs of local populations, indicating that exchange was likely the impetus for biface production. The presence of Coso Volcanic Field obsidian in the western Sierra Nevada foothills and southern California may support their argument. Ericson (1982) suggested that the production of luxury bifaces for exchange with western foothill populations was the cause of the peak at the Casa Diablo obsidian source. In that case, it was simply the presence of Casa Diablo obsidian in the western foothills that led Ericson (1982) to posit that exchange was more likely than direct procurement (but see Bouey and Basgall 1984).

Singer and Ericson (1977) also proposed that the peak in biface manufacturing at the Bodie Hills obsidian source ~3,500 – 1,100 cal BP was due to production for exchange. Although their study only focused on the primary obsidian source, they suggested that studies of outlying sites were necessary to obtain a more complete picture of Bodie Hills obsidian use. King et al. (2011) took up this call three decades later and compiled a dataset of sites at which Bodie Hills obsidian is found in the western Sierra Nevada foothills, Central Valley, and Yosemite/Mono region. Additionally, they evaluated three separate models that have been proposed for the peak and collapse in obsidian biface production: (1) embedded procurement of obsidian within a mobile system (Basgall 1989; Ramos 2000); (2) production for exchange with a post-Archaic collapse (Gilreath and Hildebrandt 1997); and (3) production for exchange with a post-

Archaic expansion (Ericson 1982). Citing obsidian source and raw material profiles from sites in California, King et al. (2011:165) concluded that the production of bifaces for exchange with a subsequent post-Archaic collapse was the most parsimonious explanation for the rise and fall of Bodie Hills obsidian use and conveyance.

If production of bifaces for exchange was responsible for the peak in obsidian use in the Bodie Hills, then I expect at least seasonally stable populations to have been present in the area to enable the mass production of bifaces. Stable populations, although uncharacteristic of this period (~5,000 – 1,300 cal BP) in the western and southwestern Great Basin (see Basgall 1989; Eerkens et al. 2008), have been cited by Gilreath and Hildebrandt (2011:182-183) as possibly controlling the Coso Volcanic Field source, limiting direct access by other groups and thereby necessitating exchange. In contrast to other researchers (e.g., Basgall 1989; Bettinger 1999), McGuire and Hildebrandt (2005) suggested that groups during the Middle Period may have been more residentially stable than later populations. If populations were stable, then I expect habitation debris (e.g., milling and features) to be common among Middle Period sites. Similarly, I expect that with sedentary populations there would be an increase in the occurrence of flake tools, especially when located at a high-quality obsidian source. Additionally, since large-scale biface production was the main activity that took place during this period at the Bodie Hills source, I expect debitage densities to be heavy and BI values to be high. Finally, if there were stable populations in the Bodie Hills during the Early Period, then populations should be larger than previous times and projectile point frequencies should be high.

Model 2: Direct Procurement for Consumption. Expectations for this second model largely follow those of the preceding Early Period. If populations during the

Middle Period were mobile and practiced direct or embedded procurement of obsidian, then groups should have employed bifacial technologies and BI values should be high. Similarly, flake tool counts should be generally low. Intensive biface production during this period should also have resulted in heavy debitage densities. If populations were mobile, similar to the Early Period, then I expect that groups would not have put effort into developing site furniture (*sensu* Binford 1979); therefore, habitation debris should be rare. Finally, the presence of mobile groups suggests low population density, so projectile point frequencies should also be low.

Late Period (post-1,300 cal BP) Sites

Regional studies at multiple eastern Sierra Nevada obsidian sources suggest that there was a drop-off in obsidian use after ~1,300 cal BP (Gilreath and Hildebrandt 1997; Halford 2008; Hall 1983; Martinez 2009; Ramos 2000; Singer and Ericson 1977). Some researchers (e.g., Gilreath and Hildebrandt 1997; Ramos 2000) have identified an increase in subsistence activities – specifically pinyon nut harvesting and processing – at source areas concomitant with the apparent decline in obsidian quarrying. Many researchers (e.g., Bouey and Basgall 1984; Gilreath and Hildebrandt 1997; Hildebrandt and McGuire 2002; Hildebrandt and Ruby 2006; Ramos 2000) have suggested that increased sedentism related to growing populations and a switch in focus from animal to plant resources was at least partially responsible for the collapse in obsidian use.

If there was a decline in the use of eastern Sierra Nevada obsidian sources for obsidian procurement, quarrying, and biface production, then I expect debitage densities to be low during the Late Period. Similarly, I expect that BI values will be low. With increased sedentism, I expect an increase in the occurrence of flake tools in Late Period assemblages. Additionally, habitation debris (e.g., millingstones) related to seed/nut processing and features (e.g., rock rings and hearths) accompanying prolonged occupations should be common. Finally, if population density increased during this period, then I expect that projectile point frequencies will be high.

Summary

The expectations that I have outlined in this chapter will be used to test my hypotheses related to diachronic shifts in Bodie Hills obsidian conveyance and land-use. My expectations for the three cultural periods are based on previous studies of technological organization and prehistoric use of the Bodie Hills obsidian source. To evaluate my expectations, I have outlined methods for the characterization of sites and the eastern distribution of Bodie Hills obsidian. In the next chapter, I present the results from the characterization of sites and statistical comparisons between cultural periods.

Chapter 4

RESULTS

In this chapter, I present the results from the characterization of archaeological sites using the methods outlined in Chapter 3 (Table 4.1). Results show variation both within and between cultural periods. Additionally, I present the results of a search of published source provenance data to establish the eastern conveyance of Bodie Hills obsidian in the Great Basin in both time and space. The results show that in contrast to the situation to the west in California, Bodie Hills was minimally conveyed eastward into the Great Basin.

Sample of Sites

I compiled a sample of 81 single-component sites in and around the Bodie Hills obsidian source suitable for inclusion in this study. The Early Period (pre-5,000 cal BP) sample contains the fewest number of sites of any period (n=11). In contrast, the Middle Period (5,000 – 1,300 cal BP) represents the largest sample of sites of any period (n=36); however, the Late Period (post-1,300 cal BP) sample is only slightly smaller (n=34). Below, I highlight general trends in my sample of sites from each cultural period.

Variables Used to Characterize Sites

Debitage Density

Debitage densities can provide information on the intensity and/or duration of occupation at single-component sites (Chatters 1987; Surovell 2009). Following models of technological organization, occupation span should relate to the degree of mobility of groups (Smith 2011; Surovell 2009); therefore, debitage densities should reflect overall mobility. Debitage densities are generally light Early Period sites (n=11; 73%) (Table 4.2). While somewhat skewed toward light densities, Middle Period sites (n=36) show more of an even distribution between light and heavy densities than Early Period sites. Finally, debitage densities for Late Period sites (n=34) are highly skewed toward light densities. Sites with medium debitage densities are the next most abundant, with heavy density sites representing less than 15 percent (n=5) of the Late Period sample. When all time periods are combined, sites in the sample trend toward light densities (44 of 81 sites; 54%).

Debitage Densities Across Time. Sample sizes for the Early Period were too small to include in a chi-square test; therefore, I used a Fisher's exact test better suited for small sample sizes to compare frequencies of debitage densities across time. Results show that there is no statistically significant difference in the frequency of different debitage densities between cultural periods (p = .380) (see Table 4.2).

Table 4.1. Summary of Site Characteristics by Cultural Period.

Site	Debitage Amount			Tools								
Number	[a]L	[b]M	[c]H	[d]PPT	[e]UD	[f]BIF	[g]FT	[h]O	[i]BI	[j]FTI	Milling	Features
Early Period												
MNO-1146	x	–	–	1	–	3	–	–	.750	–	–	–
MNO-1155	–	–	x	1	–	–	–	–	–	–	–	–
MNO-1175	x	–	–	1	–	–	–	–	–	–	–	–
MNO-1339	–	x	–	1	–	–	–	–	–	–	–	–
MNO-2474	x	–	–	1	1	2	–	–	.500	–	–	–
MNO-3121	x	–	–	1	–	1	–	–	–	–	Y	–
MNO-4530	–	x	–	1	–	3	–	1	.600	–	–	–
MNO-4552	x	–	–	1	–	5	–	1	.714	–	–	–
MNO-4553	x	–	–	2	–	7	2	2	.539	.154	–	–
MNO-4581	x	–	–	1	–	9	–	–	.900	–	–	–
MNO-4971	x	–	–	1	–	–	–	–	–	–	–	–
Middle Period												
MNO-276	–	x	–	1	1	14	2	11	.483	.067	–	–
MNO-303	–	–	x	1	1	–	–	4	–	–	–	–
MNO-1118	–	–	x	2	1	17	1	3	.708	.042	Y	–
MNO-1161	–	–	x	1	3	15	–	–	.790	–	–	–
MNO-1166	x	–	–	1	1	–	–	–	–	–	–	–
MNO-1284	–	–	x	1	3	16	–	1	.762	–	Y	–
MNO-1333	–	x	–	1	–	–	–	–	–	–	–	–
MNO-1348	–	–	x	1	1	10	–	2	.714	–	Y	2
MNO-1374	x	–	–	1	2	–	–	–	–	–	–	–
MNO-1382	–	–	x	1	1	10	–	–	.833	–	Y	–
MNO-1395	–	x	–	1	1	2	–	1	.400	–	–	–
MNO-1427	–	–	x	1	–	1	–	–	–	–	Y	1
MNO-1451	x	–	–	1	–	1	–	–	–	–	–	–
MNO-1457	–	–	x	1	–	5	–	–	.833	–	Y	–
MNO-1537	x	–	–	3	1	2	1	1	.250	.200	–	–
MNO-1543	x	–	–	1	–	–	–	–	–	–	–	–
MNO-1573	–	–	–	1	–	–	–	–	–	–	–	–
MNO-1576	–	x	–	1	1	1	1	–	.250	.250	–	–

Site Number	Debitage Amount			Tools								
	[a]L	[b]M	[c]H	[d]PPT	[e]UD	[f]BIF	[g]FT	[h]O	[i]BI	[j]FTI	Milling	Features
MNO-1640	–	–	–	1	–	–	–	–	–	–	–	–
MNO-1947	–	–	x	1	–	2	1	2	.333	.167	Y	–
MNO-2476	x	–	–	1	–	–	–	–	–	–	–	–
MNO-3103	x	–	–	1	1	2	–	–	.500	–	–	–
MNO-3131	x	–	–	1	–	1	–	1	–	–	–	–
MNO-3858	x	–	–	2	2	4	10	–	.222	.555	Y	–
MNO-4001	–	x	–	1	–	1	–	1	–	–	Y	–
MNO-4375	x	–	–	1	–	3	–	–	.750	–	Y	–
MNO-4549	–	x	–	1	–	8	2	7	.444	.111	Y	–
MNO-4556	–	–	x	2	–	16	–	–	.889	–	–	–
MNO-4558	x	–	–	2	–	6	–	–	.750	–	–	–
MNO-4559	x	–	–	1	–	9	–	–	.900	–	–	–
MNO-4560	x	–	–	1	1	4	–	–	.667	–	Y	–
MNO-4583	x	–	–	1	–	1	–	–	–	–	–	–
MNO-4585	x	–	–	1	–	–	–	–	–	–	–	–
MNO-4796	x	–	–	1	–	–	–	–	–	–	–	–
MNO-4832	–	–	x	1	–	3	–	2	.500	–	–	–
MNO-4915	x	–	–	1	–	3	–	–	.750	–	–	–
Late Period												
MNO-265	x	–	–	1	–	4	–	–	.800	–	–	–
MNO-1165	x	–	–	1	–	–	–	–	–	–	–	–
MNO-1191	x	–	–	1	–	1	–	–	–	–	–	–
MNO-1349	–	–	x	1	1	3	–	1	.500	–	–	1
MNO-1400	–	x	–	1	–	1	–	2	.250	–	–	–
MNO-1479	–	x	–	1	–	3	–	–	.750	–	–	–
MNO-1546	x	–	–	1	–	–	–	–	–	–	–	–
MNO-1549	–	–	–	4	3	9	–	1	.529	–	–	–
MNO-1554	x	–	–	1	–	–	–	1	–	–	–	–
MNO-1555	x	–	–	1	–	3	–	–	.750	–	–	–
MNO-1605	x	–	–	1	–	1	–	–	–	–	–	–
MNO-1606	x	–	–	1	2	–	–	–	–	–	–	–
MNO-2471	x	–	–	2	–	–	–	–	–	–	–	–

Site	Debitage Amount			Tools								
Number	**[a]L**	**[b]M**	**[c]H**	**[d]PPT**	**[e]UD**	**[f]BIF**	**[g]FT**	**[h]O**	**[i]BI**	**[j]FTI**	**Milling**	**Features**
MNO-2749	x	–	–	6	2	4	n/a	3	n/a	n/a	–	–
MNO-2750	x	–	–	1	–	2	n/a	–	n/a	n/a	–	–
MNO-3114/H	x	–	–	1	–	–	2	1	.000	.500	Y	3
MNO-3116/H	–	x	–	4	3	9	6	1	.391	.261	Y	–
MNO-3122	x	–	–	1	–	1	2	–	.250	.500	Y	–
MNO-3861	–	–	x	5	4	13	3	1	.500	.115	Y	–
MNO-3863	x	–	–	2	–	3	–	1	.500	–	–	–
MNO-3864	–	x	–	1	–	4	1	–	.667	.167	–	–
MNO-3866	–	x	–	1	2	1	3	1	.125	.375	–	–
MNO-3867	–	x	–	6	–	7	1	2	.539	.063	Y	–
MNO-3868	–	x	–	6	1	9	3	–	.474	.158	Y	–
MNO-3870	–	x	–	1	–	1	4	–	.167	.667	–	–
MNO-3997	x	–	–	2	–	1	1	–	.250	.250	–	–
MNO-4003	–	x	–	1	–	5	6	5	.294	.353	Y	4
MNO-4523/H	–	–	x	4	–	100+	–	–	n/a	–	Y	4
MNO-4572	x	–	–	2	1	2	–	1	.333	–	Y	–
MNO-4790	x	–	–	1	–	5	–	–	.833	–	–	–
MNO-4795	x	–	–	1	–	2	–	–	–	–	Y	3
MNO-4826	x	–	–	1	–	6	–	–	.857	–	–	–
MNO-4835	–	–	x	2	1	30	–	–	.909	–	Y	1
MNO-4914	–	–	x	5	2	19	3	–	.655	.103	–	–

[a] L – Light
[b] M – Medium
[c] H – Heavy
[d] PPT – Projectile point
[e] UD – Undiagnostic projectile point
[f] BIF – Biface
[g] FT – Flake tool
[h] O – Other
[i] BI – Biface index
[j] FTI – Flake tool index

Table 4.2. Number of Sites with Given Debitage Densities by Cultural Period.

Debitage Densities	Cultural Period		
	Early	**Middle**	**Late**
Light	8	17	19
Medium	2	6	9
Heavy	1	11	5

Fisher's exact test: $p = .380$

Bifaces and Biface Index Values

Researchers (e.g., Kelly 1988; Parry and Kelly 1987) have described bifaces as useful tools for mobile groups due to their ability to be used as both tools and cores. In my study, bifaces are especially important because the peak in utilization and conveyance (~3,000 – 1,300 cal BP) of eastern Sierra Nevada obsidian is typified by biface manufacture (Gilreath and Hildebrandt 1997; Martinez 2009; Ramos 2009; Singer and Ericson 1977). There are 30 total bifaces from seven sites for the Early Period (Table 4.3). The average BI value for the Early Period is .667, indicating that bifaces generally represent >60 percent of the stone tools recovered at sites predating 5,000 cal BP. Bifaces for the Middle Period total 157 from 26 sites. The average BI value is .672, indicating that bifaces from Middle Period sites generally represent >60 percent of all flaked stone tools – similar to the Early Period. Bifaces during the Late Period total 149 from 29 sites. Site MNO-4523/H contained 100+ bifaces but was not included in the total for the Late Period because no exact count was given. BI values drop during this time to an average of .492, indicating that bifaces generally represent <50 percent of all flaked stone tools at Late Period sites. The results show that BI values are highest during the Early and Middle periods – prior to 1,300 cal BP – and decrease during the Late Period after 1,300 cal BP.

I used a one-way analysis of variance (ANOVA) to determine if BI values vary significantly between cultural periods. The results show that there is a significant difference in BI values (F = 3.710, df = 2, p = .033) and Tukey's post-hoc tests indicate that the significant difference occurs between the Middle and Late periods (p = .040); there is no significant differences between either the Early and Middle periods (p = .999) or Early and Late periods (p = .210).

Table 4.3. Biface and Flake Tool Totals and BI and FTI Averages by Cultural Period.

Site Number	[a]BIF (n)	[b]FT (n)	[c]BI	[d]FTI
Early Period				
MNO-1146	3	–	.750	–
MNO-2474	2	–	.500	–
MNO-3121	1	–	–	–
MNO-4530	3	–	.600	–
MNO-4552	5	–	.714	–
MNO-4553	7	2	.539	.154
MNO-4581	9	–	.900	–
Total	30	2	n/a	n/a
µ	2.73 [g]	.18 [g]	.667	.154
Middle Period				
MNO-276	14	2	.483	.067
MNO-1118	17	1	.708	.042
MNO-1161	15	–	.790	–
MNO-1284	16	–	.762	–
MNO-1348	10	–	.714	–
MNO-1382	10	–	.833	–
MNO-1395	2	–	.400	–
MNO-1427	1	–	–	–
MNO-1451	1	–	–	–

Site Number	[a]BIF (n)	[b]FT (n)	[c]BI	[d]FTI
MNO-1457	5	–	.833	–
MNO-1537	2	1	.250	.200
MNO-1576	1	1	.250	.250
MNO-1947	2	1	.333	.167
MNO-3103	2	–	.500	–
MNO-3131	1	–	–	–
MNO-3858	4	10	.222	.555
MNO-4001	1	–	–	–
MNO-4375	3	–	.750	–
MNO-4549	8	2	.444	.111
MNO-4556	16	–	.889	–
MNO-4558	6	–	.750	–
MNO-4559	9	–	.900	–
MNO-4560	4	–	.667	–
MNO-4583	1	–	–	–
MNO-4832	3	–	.500	–
WS-S-04	3	–	.750	–
Total	157	18	n/a	n/a
μ	4.36 [g]	.50 [g]	.672	.199
Late Period				
MNO-265	4	–	.800	–
MNO-1191	1	–	–	–
MNO-1349	3	–	.500	–
MNO-1400	1	–	.250	–
MNO-1479	3	–	.750	–
MNO-1549	9	–	.529	–
MNO-1555	3	–	.750	–
MNO-1605	1	–	–	–
MNO-2749	4	n/a[d]	n/a[d]	n/a[d]
MNO-2750	2	n/a[d]	n/a[d]	n/a[d]
MNO-3114/H	–	2	.000	.500
MNO-3116/H	9	6	.391	.261
MNO-3122	1	2	.250	.500
MNO-3861	13	3	.500	.115
MNO-3863	3	–	.500	–
MNO-3864	4	1	.667	.167
MNO-3866	1	3	.125	.375

Site Number	[a]BIF (n)	[b]FT (n)	[c]BI	[d]FTI
MNO-3867	7	1	.539	.063
MNO-3868	9	3	.474	.158
MNO-3870	1	4	.167	.667
MNO-3997	1	1	.250	.250
MNO-4003	5	6	.294	.353
MNO-4523/H	100+	–	n/a[f]	–
MNO-4572	2	–	.333	–
MNO-4790	5	–	.833	–
MNO-4795	2	–	–	–
MNO-4826	6	–	.857	–
MNO-4835	30	–	.909	–
WS-S-03	19	3	.655	.103
Total	149	35	n/a	n/a
μ	4.38[g]	1.03[g]	.492	.293

[a] BIF – Biface
[b] FT – Flake tool
[c] BI – Biface index
[d] FTI – Flake tool index
[e] Sites MNO-2749 and MNO-2750 did not report exact numbers of flake tools, making calculation of BI values and FTI values impossible.
[f] Site MNO-4523/H did not list an exact count of bifaces and was therefore excluded from biface totals.
[g] Biface and flake tool averages include sites without these attributes that are not included in this table.

Flake Tools and Flake Tool Index Values

Researchers (e.g., Ericson 1982; Parry and Kelly 1987) suggest that flake tools were most often employed by sedentary groups. Some researchers (e.g., Bouey and Basgall 1989; Ericson 1982; Gilreath and Hildebrandt 1997) working in the eastern Sierra Nevada propose that sedentism increased after 1,300 cal BP and contributed to the drop-off in obsidian utilization due to a decreased emphasis on bifacial technology. Flake tools were only present at one site from the Early Period: MNO-4553 contained two flake tools out of 13 total tools, resulting in a FTI value of .154. Flake tools during the Middle Period total 18 from seven sites. The average FTI value increases during that period to .199, signifying that flake tools represent ~20 percent of tools at Middle Period sites. Thirty-five flake tools were recorded at 12 Late Period sites. The average FTI value increases to .293 during that period, indicating that flake tools represent ~30 percent of flaked stone tools at Late Period sites. Though FTI values are generally low across cultural periods, they increase steadily from the Early to the Late Period.

I excluded the Early Period from statistical comparisons due to the small sample of sites with FTI values (n=1) and employed a Mann-Whitney *U* test to compare FTI values between Middle and Late period sites. Results show that there is no significant difference between the Middle and Late periods ($U = 29.0$, $Z = -1.10$, $p = .271$).

Bifaces and Flake Tools

To further explore the relationship between bifaces and flake tools between cultural periods, I compared counts of bifaces and flake tools from each period using a chi-square test (Table 4.4). Results show that there is a significant difference in the relationship between bifaces and flake tools across periods ($\chi^2 = 8.1$, $df = 2$, $p = .017$). Standardized residuals indicate that bifaces are overrepresented during the Early and Middle periods. In contrast, flake tools are overrepresented at Late Period sites.

Table 4.4. Bifaces and Flake Tools Across Cultural Periods.

	Cultural Period		
Attributes	**Early**	**Middle**	**Late**
Bifaces	30 (+0.46)	157 (+0.58)	149 (-0.76)
Flake Tools	2 (-1.15)	17 (-1.44)	35 (+1.89)

$\chi^2 = 8.1$, $df = 2$, $p = .017$
Note: Stardardized residuals shown in parentheses.

Milling Implements

As discussed in previous chapters, the Late Period (post-1,300 cal BP) in the eastern Sierra and western Great Basin is often characterized by intensified processing of nut and seed resources, specifically pinyon, and greater sedentism (Bettinger and Baumhoff 1982; Gilreath and Hildebrandt 1997; Ramos 2000). Additionally, if the Middle Period peak in biface manufacture was due to production for export, then I expect milling implements indicative of increased occupation span to be common among the study sample. Overall, milling implements are uncommon at sites in and around the Bodie Hills and were recorded at only 24 of 81 (30%) sites (Table 4.5). The Early Period sample has the fewest number of sites containing milling implements (n=1), the Middle Period contains 12 sites with milling implements, and 11 Late Period sites contain milling implements. In all cultural periods, sites where milling implements are absent outnumber sites where they are present by a ratio of three to one.

Table 4.5. Sites with Milling Implements Present and Absent by Cultural Period.

Milling Implements	Cultural Period			Total
	Early	**Middle**	**Late**	
Present	1	12	11	24
Absent	10	24	23	57
% Present	**9%**	**33%**	**32%**	**30%**

Features

The presence of features (e.g., residential structures, middens, storage pits) at sites indicates an investment in place and generally suggests prolonged occupation spans (Kelly 1992). The number of features also relates to the intensity and duration of occupation; specifically, more features should reflect longer and/or more intense occupation (Chatters 1987). Like milling implements, features are uncommon within the study sample and are present at only eight sites (Table 4.6). No Early Period sites contain features, two Middle Period sites have features present, and six Late Period sites contain features. A total of three features are present at two sites from the Middle Period, while the Late Period has a total of 16 features from six sites (Table 4.7). Although overall feature frequencies are low in the study sample, the Late Period contains the most sites with features and the largest number of features per site.

Table 4.6. Sites with Features Present and Absent by Cultural Period.

Features	Cultural Period			Total
	Early	**Middle**	**Late**	
Present	0	2	6	8
Absent	11	34	28	73
% Present	**0%**	**6%**	**21%**	**11%**

Table 4.7. Feature Quantities by Cultural Period.

	Cultural Period	
Measurement	**Middle**	**Late**
# of Sites with Features	2	6
Total # of Features	3	16
Average # of Features/Site	1.5	2.67

Projectile Point Frequencies

Temporally Diagnostic Projectile Point Frequencies

Projectile points have long been used as proxies for population density (*sensu* Bettinger 1999). Additionally, since projectile points are generally associated with hunting related activities, I expect that they will often occur in isolated contexts away from sites. Therefore, including isolates and multicomponent sites, I tallied projectile points by temporally diagnostic type and then totaled them within their respective cultural periods (Table 4.9). The Early Period point total (n=26) is substantially less than the Middle (n=104) and Late (n=106) periods, which are essentially the same.

Table 4.8. Projectile Point Frequencies by Type and Cultural Period.

	Cultural Period								
	Early				**Middle**		**Late**		
	GBF	GBCB	GBSS	Pinto	Elko	Humboldt	Rosegate	DSN	CT
Type Total	1	2	5	18	69	35	65	24	17
Period Total	**26**				**104**		**106**		

Time-Adjusted Projectile Point Frequencies

Due to the variable number of years represented by each cultural period in this study, projectile point frequencies were adjusted for the amount of time present in each period. I excluded the Early Period from time-adjustment for projectile point totals due to the long span of time (>7,000 years) represented in the Early Period and the small sample of projectile points. That the Early Period represents the longest span of time for any period yet contains the fewest projectile points of the three periods strongly suggests infrequent use of the Bodie Hills region prior to ~5,000 cal BP. The Middle Period spans from 5,000 to 1,300 cal BP – a range of 3,700 years. Dividing 3,700 by the total number of projectile points of the Elko and Humboldt series (n=104) provides a time-adjusted projectile point frequency of one point per every 35.58 years. Finally, the Late Period ranges from 1,300 cal BP to contact (A.D. 1850) – a span of 1,150 years. Dividing 1,150 by the total number of Rosegate and Desert series projectile points recorded (n=106) provides a time-adjusted projectile point frequency of one point per every 10.85 years. Although the number of projectile points recorded for the Middle and Late periods are nearly equal, time-adjusting of projectile point totals indicates that Late Period points were deposited far more frequently than either Early or Middle periods.

Comparison of Bodie Hills Projectile Point Frequencies to Projectile Point Frequencies from Other Areas

To place the Bodie Hills in a regional context, I compared projectile point frequencies from there to other areas. First, I compared the frequencies from the Bodie

Hills to Truman/Queen and Coso Volcanic Field to identify potential differences in use of Sierran obsidian sources across time. Next, I compared the Bodie Hills projectile point frequencies to those from Owens Valley, CA and Carson-Stillwater, NV to consider how diachronic use of the Bodie Hills obsidian source compared to use of more general areas unrelated to raw material sources.

Eastern Sierra Nevada Obsidian Sources. I obtained projectile points frequencies for Truman/Queen from Ramos (2000), who recorded 34 projectile points: nine from the Early Period, 14 from the Middle Period, and 11 from the Late Period (Table 4.10). Results of a chi-square test show that there is a significant difference in the frequencies of points at the two obsidian sources ($\chi^2 = 6.61$, $df = 2$, $p = .0367$) and standardized residuals indicate that Early Period projectile points are significantly overrepresented at Truman/Queen, while Middle and Late period points do not differ significantly between Truman/Queen and the Bodie Hills (Table 4.11).

Gilreath and Hildebrandt (1997) reported 149 diagnostic projectile points from their work at the Coso Volcanic Field: 62 Early Period points, 48 Middle Period points, and 39 Late Period points. Results of a chi-square test show that there is also a significant difference between projectile point frequencies in the Bodie Hills and Coso Volcanic Field ($\chi^2 = 49.17$, $df = 2$, $p < .0001$). Standardized residuals indicate that Early Period projectile points are significantly overrepresented at the Coso Volcanic Field and significantly underrepresented in the Bodie Hills. Additionally, Late Period projectile points are significantly underrepresented at the Coso Volcanic Field while Late Period points are overrepresented in the Bodie Hills sample, although not significantly.

Similarly, although not significant, Middle Period projectile points are overrepresented in the Bodie Hills and underrepresented at the Coso Volcanic Field (Table 4.12).

Table 4.9. Projectile Point Totals by Region.

Region	Cultural Period			Total	References
	Early	**Middle**	**Late**		
Bodie Hills, CA	26	104	106	236	Record Search for this Study
Truman/Queen, NV	9	14	11	34	Ramos (2000)
Coso Volcanic Field, CA	62	48	39	149	Gilreath and Hildebrandt (1997)
Owens Valley, CA	7	36	92	135	Bettinger (1999)
Carson-Stillwater, NV	0	81	139	220	Bettinger (1999)

Table 4.10. Comparison of Projectile Point Frequencies for the Bodie Hills and Truman/Queen.

Region	Cultural Period		
	Early	**Middle**	**Late**
Bodie Hills, CA	26 (-0.83)	104 (+0.08)	106 (+0.37)
Truman/Queen, NV	9 **(+2.19)**	14 (-0.22)	11 (-0.97)

$\chi^2 = 6.61$, $df = 2$, $p = .0367$
Note: Stardardized residuals shown in parentheses with significant values bolded.

Table 4.11. Comparison of Projectile Point Frequencies for the Bodie Hills and Coso Volcanic Field.

Region	Cultural Period		
	Early	**Middle**	**Late**
Bodie Hills, CA	26 **(-3.80)**	104 (+1.12)	106 (+1.82)
Coso Volcanic Field, CA	62 **(+4.79)**	48 (-1.41)	39 **(-2.28)**

$\chi^2 = 49.17$, $df = 2$, $p < .0001$
Note: Stardardized residuals shown in parentheses with significant values bolded.

Other Regional Samples. Bettinger (1999) reported 135 diagnostic projectile points from his work in Owens Valley, CA: seven Early Period points, 36 Middle Period points, and 92 Late Period points (see Table 4.10). Results of a chi-square test show that there is a significant difference between projectile point frequencies for the Bodie Hills and Owens Valley (χ^2 = 18.86, *df* = 2, *p* < .0001). Standardized residuals indicate that Middle Period projectile points from Owens Valley are significantly underrepresented while Late Period points are significantly overrepresented. Altough no standardized residuals are significant for any period in the Bodie Hills, results show that Early and Middle period projectile points are generally overrepresented, while Late Period points are underrepresented (Table 4.13).

Table 4.12. Comparison of Projectile Point Frequencies for the Bodie Hills and Owens Valley.

	Cultural Period		
Region	**Early**	**Middle**	**Late**
Bodie Hills, CA	26 (+1.09)	104 (+1.58)	106 (-1.78)
Owens Valley, CA	7 (-1.45)	36 **(-2.09)**	92 **(+2.35)**

χ^2 = 18.86, *df* = 2, *p* < .0001
Note: Stardardized residuals shown in parentheses with significant values bolded.

Projectile point counts for the Carson Desert-Stillwater Marsh were obtained from Bettinger (1999) and total 220: 81 Middle Period points and 139 Late Period points (see Table 4.10). A chi-square test shows that there is a significant difference between the projectile point frequencies from the Bodie Hills and Carson-Stillwater (χ^2 = 32.78, *df* = 2, *p* <.0001) and standardized residuals show that Early Period projectile points are significantly overrepresented in the Bodie Hills compared to Carson-Stillwater – not surprising since no points from the Early Period were reported in the latter region. Middle Period projectile point frequencies are similar for both regions, while the Late

Period is underrepresented in the Bodie Hills and overrepresented in Carson-Stillwater (Table 4.14).

Table 4.13. Comparison of Projectile Point Frequencies for the Bodie Hills and Carson-Stillwater.

	Cultural Period		
Region	**Early**	**Middle**	**Late**
Bodie Hills, CA	26 **(+3.42)**	104 (+0.84)	106 (-1.85)
Carson-Stillwater, NV	0 **(-3.54)**	81 (-0.87)	139 (+1.91)

$\chi^2 = 32.78$, $df = 2$, $p < .0001$
Note: Stardardized residuals shown in parentheses with significant values bolded.

The results of these various comparisons show that there are significant differences between projectile point frequencies in the Bodie Hills and those in other areas. Bodie Hills and Truman/Queen point frequencies are the most similar, with no periods differing significantly. Early and Late period points are significantly overrepresented in the Coso Volcanic Field. Interestingly, Early Period points are overrepresented in the Bodie Hills compared to Owens Valley and Carson-Stilllwater, and Late Period points are overrepresented at both of the latter regions.

Distribution of Bodie Hills Obsidian in California and the Great Basin

Distribution in California

Bodie Hills obsidian is present in significant quantities to the north and west of the source (Jackson 1974; Moratto 2002), often dominating lithic assemblages (>80%) in

Placer, Amador, Calaveras, and Tuolumne counties west of the Sierra Nevada Crest in California (Jackson 1974). Late in time (post-1,500 cal BP), there was an influx of north-central California obsidian (e.g., Napa Glass Mountain); however, Bodie Hills material remained dominant in the northern Sierra Nevada foothills. A similar trend was noted by Moratto (2002) at sites evaluated for the New Melones Reservoir on the Stanislaus River in Tuolumne County. There, Moratto (2002) noted that the Sierra Phase (3,000 – 1,500 cal BP) – typified by intense, sedentary occupation – contained substantial quantities of Bodie Hills obsidian with lesser amounts of Casa Diablo obsidian. The subsequent Redbud Phase (1,500 – 700 cal BP) was characterized by ephemeral use of the region and greatly diminished quantities of eastern Sierra Nevada obsidian (e.g., Bodie Hills and Casa Diablo). Finally, the Bend Phase (700 cal BP – contact) saw increased occupation as well as an increased presence of Bodie Hills and Casa Diablo obsidian at sites, although not in quantities like those present during the Sierra Phase.

A geographic distinction between Bodie Hills and Casa Diablo obsidian has been noted on the western side of the Sierra Nevada, with Bodie Hills obsidian dominating assemblages in the north and Casa Diablo dominating in the south (Jackson 1974; Moratto 1972). Moratto's (1972) cultural resource inventory for the Buchanon Reservoir in Madera County identified 27 archaeological sites from which 19 artifacts – representing a variety of types and temporal periods – were submitted for XRF analysis. Casa Diablo was the sole source represented, save for two artifacts of unknown origin. Although the sample was small, the results nonetheless point to a dominance of Casa Diablo obsidian south of Tuolumne County on the western front of the Sierra Nevada. Jackson (1974:65) identified the same trend at sites in Monterey and San Luis Obispo counties on the South Coast Ranges, where Casa Diablo and Coso Volcanic Field obsidians were the dominant materials and Bodie Hills obsidian was absent. Surprisingly, there is no evidence for diachronic shifts in obsidian importation at sites on the South Coast Ranges; yet, moving into the Central Valley at sites in Sacramento and San Joaquin counties there is evidence of a substantial shift late in time (Jackson 1974:66).

Sites in southern Sacramento and northern San Joaquin counties – similar to Amador and Calaveras counties immediately to the east – contain small quantities of Bodie Hills obsidian (~20%) (Heizer 1974; Jackson 1974:67). While Napa Valley obsidian is the dominant source (~80%) for all periods, prior to ~1,500 cal BP there was a significant presence of eastern obsidian sources (e.g., Bodie Hills). At the beginning of the Late Horizon (~1,500 cal BP), however, "Napa is clearly the source of obsidian for the lower Sacramento and Upper San Joaquin groups" (Jackson 1974:69; emphasis in original).

In Yosemite National Park – closer to the Bodie Hills and Casa Diablo obsidian sources – a geographic distinction between the two sources is still apparent. Sites in the southern portion of the park tend to be dominated by Casa Diablo obsidian, while Bodie Hills obsidian reaches frequencies near 50 percent in the northern portion of the park (Hull 1988:172). One hundred and twenty-four typable projectile points recovered during multiple projects in Yosemite National Park were submitted for XRF analysis and 31 percent (n=38) were found to have been manufactured from Bodie Hills obsidian. Of the 38 projectile points made from Bodie Hills obsidian, two are contracting-stem points (analogous to Gatecliff Contracting Stem), two are Elko Series points, two are concave base points (likely Humboldt), 10 are Rosegate points, and 21 are Desert Series points (Hull 1988:174). Excluding the concave base projectile points due to uncertain typing, the two contracting stem and two Elko points indicate a minimal presence of Bodie Hills obsidian during my study's Middle Period (5,000 – 1,300 cal BP). The 10 Rosegate and 21 Desert Series projectile points show a substantial increase in the abundance of Bodie Hills obsidian during the Late Period (post-1,300 cal BP).

King et al. (2011) used material and source profiles for sites in the aforementioned regions to evaluate diachronic shifts in Bodie Hills obsidian abundance and conveyance to ultimately decipher the mechanisms responsible for the distribution of this material across time and space. The authors noted the same drop-off in the abundance of Bodie Hills obsidian (and other eastern Sierra Nevada sources) in the northern Sierra Foothills identified by Moratto (2002). King et al. (2011) showed that the use of different materials (e.g., cryptocrystalline silicates) increased when the abundance of Bodie Hills obsidian decreased. They elaborated on the diachronic shift in Central Valley obsidian source profiles first identified by Jackson (1974), where Bodie Hills obsidian (and other eastern sources) represents ~20 percent of lithic assemblages prior to ~1,100 cal BP and only ~4 percent thereafter. As I discussed in Chapter 3, the material and source profiles studied by King et al. (2011) led them to suggest that production for exchange with a post-Archaic collapse is likely the reason for the obsidian production profile at the Bodie Hills obsidian source.

Distribution in the Great Basin

Bodie Hills obsidian is present in the Great Basin in varying quantities (Table 4.15; Figure 4.1). Although lacking typological and, in turn, chronological control, the sample of 269 artifacts from Nevada made on Bodie Hills obsidian compiled by Craig Skinner of the Northwest Research Obsidian Studies Laboratory nevertheless provides some data regarding the distribution of Bodie Hills obsidian in the Great Basin. The artifacts come from 42 sites situated mainly in western Nevada. Washoe County contains the largest frequency of artifacts in the sample, accounting for 37 percent of all artifacts (n=100), sites in Douglas County account for 32 percent (n=85) of artifacts in the sample, Lyon County sites account for 24 percent (n=64) of artifacts in the sample, 13 artifacts (5%) come from Area J at the Eagle Valley Village Site (26OR214) in Carson City, sites in Storey County account for ~2 percent of the artifacts (n=5), the Old Humboldt Site (26PE670) in Pershing County accounted for one artifact, and one artifact came from Nye County in south-central Nevada.

Other geochemical sourcing data come from multiple published and unpublished sources. Twenty-eight "Early Man" projectile points from Nevada were sourced by Richard Hughes using XRF analysis and four projectile points manufactured on Bodie Hills obsidian were identified (Tuohy 1984:193). Two of those projectile points – a "deeply fluted and scratched Clovis point" (Tuohy 1984:197) and a Humboldt Concave-base point – were found near Washoe Lake in Washoe County. Two GBSS points recovered from Brady's Hot Springs in Churchill County were also identified as being made of Bodie Hills obsidian (see Figure 4.1). Jones et al. (2003) also identified one

Early Period projectile point made on Bodie Hills obsidian from the Knudtsen Site in Lander County.

Table 4.14. Bodie Hills Artifact Counts in the Great Basin by County.

County	Artifacts (n)	%
Carson City	13	4
Churchill	45	14
Douglas	85	26
Lander	1	<1
Lyon	64	20
Nye	8	2
Pershing	1	<1
Storey	5	2
Washoe	103	32
Total	**325**	**100**

Note: Counts include all sourced artifacts.

In the Carson Desert and Stillwater Mountains, XRF analysis identified eight projectile points manufactured from Bodie Hills obsidian: one Humboldt point, one Elko Series point, four Rosegate points, and one Desert Side-notched point (Kelly 2001). At the Sadmat Site (26CH163) in Churchill County, Bodie Hills obsidian accounts for the largest percentage (24.9%) of obsidian artifacts sourced there and three GBSS projectile points were identified as being made on Bodie Hills obsidian (Graf 2001). One GBSS projectile point was also identified at the Coleman Site (26WA308) as being made from Bodie Hills obsidian (Graf 2001). At Hidden Cave (26CH16), Bodie Hills was the second most common obsidian source represented – similar to the Carson-Stillwater study – behind Mt. Hicks. A sample of 176 artifacts, including 153 typable projectile points, was sourced using XRF analysis. Twenty-nine (19%) of those projectile points are manufactured from Bodie Hills obsidian, the majority of which (n=15) are Gatecliff Series (analogous to the temporal range of the Elko Series in the current study). Eight Humboldt, one Elko Eared, and two Rosegate projectile points from Hidden Cave are also made on Bodie Hills obsidian (Thomas 1985).

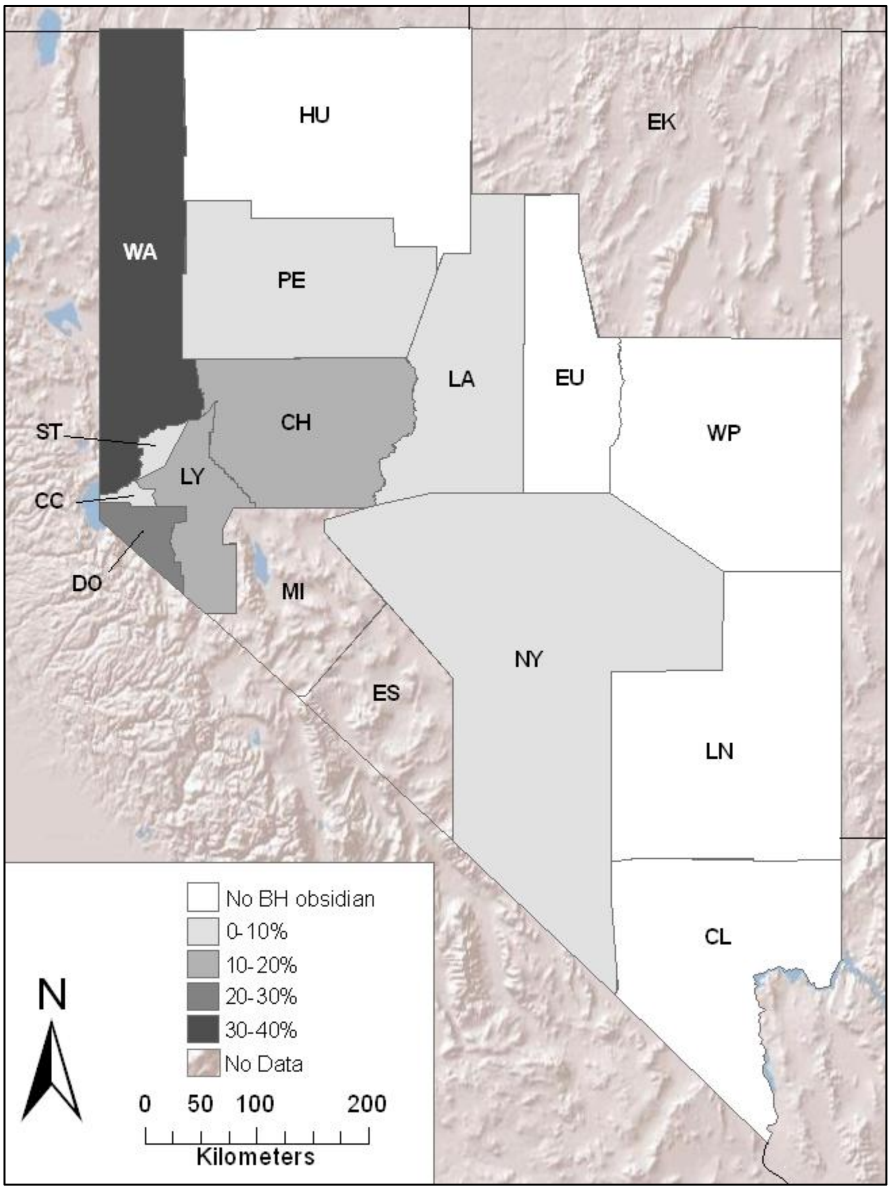

Figure 4.1. Frequency of Bodie Hills obsidian in Nevada by county. Image Source: ESRI.

Approximately 220 km east-northeast of the Bodie Hills at Gatecliff Shelter in northern Nye County, Bodie Hills obsidian is present in very small quantities. Only two artifacts, both Elko Corner-notched projectile points, were sourced to the Bodie Hills. Both came from Horizon 7, dated to ~3,300 cal BP. Twenty-three artifacts from Horizon 8 and 9 (~3,450 – 3,300 cal BP) were made from Truman/Queen obsidian, located 185 km to the southwest (Thomas 1983).

Approximately 200 km north of Gatecliff shelter near Elko, NV, several sites contained obsidian from the Mono Lake region; however, no Bodie Hills obsidian was identified there (Bieling 1992:43). In the same region, Hauer's (2005) study in Eureka and White Pine counties identified artifacts made of Truman/Queen, Mt. Hicks, and Casa Diablo, but not Bodie Hills, obsidian. No diagnostic projectile points made on those obsidians were present in Hauer's (2005) sample; however, the results from obsidian hydration analysis suggest that there is no appreciable difference in the frequency of those obsidians across time.

Finally, ~185 km east-southeast of the Bodie Hills in Nye County, a major obsidian sourcing study for the Nevada Training and Test Range revealed small amounts of Bodie Hills obsidian there. Three projectile points were identified as being manufactured on Bodie Hills obsidian: one GBSS point from the Lowengruhn Beach Ridge at Mud Lake (26NY1101) and one Elko Eared point and one Humboldt Series point from the Tippipah Spring Site (26NY3) (Johnson and Haarklau 2005). Two more GBSS points made on Bodie Hills obsidian were subsequently identified at sites around Mud Lake and Lake Tonopah (Fenner et al. 2011). Other eastern Sierra Nevada obsidian sources were identified in variable amounts in the different sub-regions of the project;

however, in the eastern sub-region, which straddles the border of Nevada and Utah, no eastern Sierra obsidian sources were identified (Johnson and Haarklau 2005).

Although Bodie Hills obsidian has been identified in the Great Basin at sites over ~220 km away (e.g., Gatecliff Shelter), it is most commonly restricted to western Nevada. Generally, when projectile points are identified in Nevada as being manufactured on Bodie Hills obsidian, they are types characteristic of the Early and Middle periods (prior to ~5,000 cal BP). Late Period points have only been identified in small quantities in the Carson Desert (n=5) and Hidden Cave (n=2). Like the situation in California, the greatest frequency of diagnostic projectile points sourced to the Bodie Hills occurs during the Middle Period (n=31).

Summary

In this chapter, I presented the results of descriptive comparisons and statistical analyses using the methods outlined in Chapter 3. Results show that there is a significant difference between BI values for the Middle and Late Periods. There is also a significant difference in the number of flake tools and bifaces for the Middle and Late Periods. Results of statistical tests comparing projectile point frequencies from the Bodie Hills to those at other obsidian sources and other regions show that in all cases there are significant differences. These differences suggest that the Early Period is overrepresented in the Bodie Hills compared to regions unrelated to toolstone sources (e.g., Owens Valley and Carson-Stillwater), while the Late Period is overrepresented in the latter regions. Additionally, the Middle Period is overrepresented in the Bodie Hills compared to Owens Valley and Carson-Stillwater. Interestingly, Early Period points are underrepresented in the Bodie Hills compared to Truman/Queen and the Coso Volcanic Field; however, the Middle and Late periods in the Bodie Hills and Truman/Queen are remarkably similar.

I also summarized the findings of my review of published and unpublished source provenance data aimed at characterizing the eastern distribution of Bodie Hills obsidian and how it compares to Bodie Hills obsidian conveyance in California. In the next chapter, I use these results to evaluate the expectations outlined in the previous chapter. The expectations are then used to test the hypotheses presented in previous chapters.

CHAPTER 5

Discussion

Researchers (e.g., Bouey and Basgall 1984; Gilreath and Hildebrandt 1997; Hall 1983; Martinez 2009; Ramos 2000; Singer and Ericson 1977) have identified peaks in obsidian utilization at various eastern Sierra Nevada obsidian sources dating to between ~3,500 and ~1,000 cal BP associated with intensive biface production. The drivers responsible for the regional peak in biface production at these sources remain a topic of discussion. Some researchers (e.g., Ericson 1982; Gilreath and Hildebrandt 1997, 2011; Singer and Ericson 1977) have suggested that large-scale biface manufacture for exchange – specifically with groups in the western Sierra Nevada foothills – was responsible for the regional peaks and subsequent collapse in exchange systems, which is reflected in the drop-off in obsidian use and conveyance seen after ~1,300 cal BP (King et al. 2011). Others (e.g., Basgall 1989; Bouey and Basgall 1984; Ramos 2000) have proposed that increased biface production at eastern Sierra Nevada obsidian sources from ~3,500 to ~1,000 cal BP was due to increased direct procurement of raw materials by mobile groups who embedded toolstone acquisition within other pursuits.

Drawing upon previous research in the Bodie Hills and other eastern Sierra Nevada obsidian sources, I developed hypotheses related to diachronic shifts in land-use in the Bodie Hills. To test these hypotheses, I characterized a sample of 81 single-component sites near the Bodie Hills obsidian source and created expectations. I employed models of technological organization to characterize my sample by asking two questions:

(1) What types of artifacts and features are present at the sites; and

(2) Do artifact and feature types/frequency vary between cultural periods?

The results of my analysis were presented in Chapter 4 and are interpreted below to test my hypotheses. The results of my study generally support previous models (e.g., King et al. 2011; Singer and Ericson 1977) that propose the peak in utilization and conveyance of Bodie Hills obsidian was due to production for exchange.

I also reviewed published and unpublished literature containing geochemical sourcing data to test my hypotheses related to the distribution of Bodie Hills obsidian in the Great Basin. I compared my findings to the distribution of Bodie Hills obsidian in California to provide a more complete view of obsidian procurement and conveyance and how it changed diachronically. Results show that there are differences in the degree and timing of the conveyance of Bodie Hills obsidian into the Great Basin and California. Diachronic shifts in conveyance of Bodie Hills obsidian generally align with changes in prehistoric land-use identified by my characterization of sites.

Diachronic Shifts in Land-Use in the Bodie Hills

The Early Period (pre-5,000 cal BP)

Based on previous studies (e.g., Gilreath and Hildebrandt 1997; Halford 2001) that have shown that obsidian use in the eastern Sierra Nevada during the Early Period (pre-5,000 cal BP) was limited, I developed the hypothesis that use of the Bodie Hills was limited during the Early Period. My characterization of sites in the Bodie Hills region supports my hypothesis and other research and shows that Early Period use of the Bodie Hills was minimal compared to later periods (Table 5.1). Although the Early Period represents the longest timespan (>7,000 years) of any of my three cultural periods, the fewest sites were assigned to this period. Artifact frequencies at Early Period sites also suggest low-level utilization of obsidian in the Bodie Hills. Although there was no significant difference (p = .380) in debitage densities between periods, most (73%) Early Period sites are light density lithic scatters, whereas only half of sites assigned to the Middle and Late periods have light debitage densities. This trend was also noted by Gilreath and Hildebrandt (1997:178) at Early Period sites in the Coso Volcanic Field.

Researchers (e.g., Gilreath and Hildebrandt 1997; Halford 2001) have suggested that *ad hoc* utilization of lag deposits of obsidian cobbles was practiced by mobile groups prior to ~5,000 cal BP. As discussed in Chapter 3, high mobility is generally associated with small populations (Hughes 2011; Jones et al. 2003) and projectile point frequencies for the Early Period are in line with this assumption. The frequency and types of artifacts present at Early Period sites also conform to previously held notions of high mobility prior to ~5,000 cal BP (Jones et al. 2003, 2012; Smith 2010). Many models of technological organization (e.g., Kelly 1988; Parry and Kelly 1988) propose that mobile groups should have employed bifacial technologies, and Early Period sites have an average BI value of .667, indicating there was an emphasis on bifaces. In contrast, flake tools are rare at Early Period sites. With an emphasis on bifacial technology, this paucity of flake tools is not unexpected (Parry and Kelly 1987); however, other researchers (e.g., Andrefsky 2009; Kelly 1988; Kuhn 1995) have suggested that when raw material is high quality and locally available – as is the case in the Bodie Hills – expedient tools (i.e., flake tools) should also have been made. That flake tools are rare during the Early Period suggests that the presence of high quality obsidian in local abundance did not affect technological organization prior to 5,000 cal BP. Instead, it appears that high mobility resulted in a technological provisioning strategy focused on individuals (*sensu* Kuhn 1995) and that occupations in the Bodie Hills were not long enough to prompt adjustment in strategies to one focused on places.

Table 5.1. Summary of Results vs. Expectations by Cultural Period.

Archaeological Measure	**Early Period**		**Middle Period**				**Late Period**	
			Model 1		**Model 2**			
	[d]Exp	**[e]Res**	**[d]Exp**	**[e]Res**	**[d]Exp**	**[e]Res**	**[d]Exp**	**[e]Res**
Debitage Density	Light	Light	Heavy	Heavy	Heavy	Heavy	Light	Light
[a]BI Values	High	High	High	High	High	High	Low	Low
[b]FTI Values	Low	Low	High	Low	Low	Low	High	High
Milling	Rare	Rare	Common	Common	Rare	Common	Common	Common
Features	Rare	Rare	Common	Rare	Rare	Rare	Common	Common
[c]PPT Frequencies	Low	Low	High	High	Low	High	High	High

[a] BI – Biface Index
[b] FTI – Flake Tool Index
[c] PPT – Projectile Point
[d] Exp – Expectations
[e] Res – Results

Halford (2001) proposed that groups exploited secondary cobble flows at the Bodie Hills obsidian source while targeting subsistence resources during the Early Period. This embedded procurement of lithic resources (*sensu* Binford 1977, 1979) suggests that raw material acquisition was not the main impetus for visiting lithic source areas; rather, stops at toolstone sources such as the Bodie Hills were likely part of frequent moves primarily related to foraging and/or hunting activities (see Basgall 1989). Previous researchers (e.g., Jones et al. 2003, 2012; Smith 2010) have compiled source profiles from multiple sites in the Great Basin to construct lithic conveyance zones, which they suggest are synonymous with foraging territories. Difficulties arise when compiling source profiles from multiple sites to establish foraging territories; specifically, how to account for the presence of sources at great distances in opposing directions; however, by establishing the distribution of a single source – in this case Bodie Hills obsidian – it is possible to avoid arbitrary delineation of conveyance zones based on source profiles from multiple sites. Using the distribution of Early Period projectile points in the Great Basin made on Bodie Hills obsidian, I reconstructed the conveyance zone in place before ~5,000 cal BP and used that conveyance zone to test the hypothesis that the distribution of Bodie Hills obsidian in the Great Basin was most extensive during the Early Period (Figure 5.1).

The most notable difference between the distribution of Bodie Hills obsidian during the Early Period as compared to later cultural periods is its absence in central California early in time. Bodie Hills obsidian first appears at sites across the Sierra Nevada ~4,500 cal BP (Heizer 1974). Even though this time predates the period of peak production (~2,500 cal BP) at most eastern obsidian sources, a date of ~4,500 cal BP fits securely within the Middle Period of this study. Prior to ~5,000 cal BP, Bodie Hills obsidian was conveyed solely into the western and central Great Basin. While Bodie Hills obsidian is present in the southwestern Great Basin during the Early Period (Basgall 1989; Eerkens et al. 2007, 2008) the amount is small enough to assume that the southwestern Great Basin was not a significant destination for groups using that material.

Early Period projectile points made on Bodie Hills obsidian appear to the north at Washoe Lake in southern Washoe County (Tuohy 1984), the Coleman Site in eastern Washoe County (Graf 2001), and Brady's Hot Springs (Tuohy 1984) and the Sadmat Site (Graf 2001) in western Churchill County. Early Period points also occur along relict shorelines at Mud Lake (Fenner et al. 2011; Johnson and Haarklau 2005) in central-eastern Nye County and a single point was located at the Knudtsen Site (Jones et al. 2003) in northern Lander County.

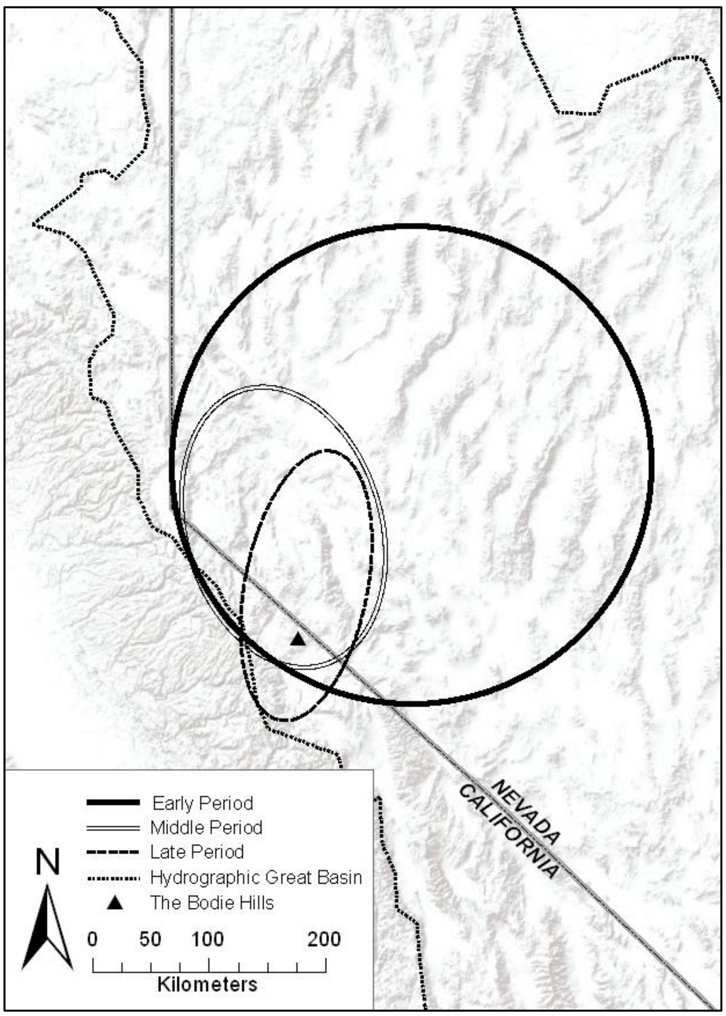

Figure 5.1. Bodie Hills conveyance zones by cultural period. Image Source: ESRI.

The Bodie Hills conveyance zone suggests that Early Period groups were extremely far-ranging, covering an area of more than 92,700 km^2 and traversing both the western and central conveyance zones defined by Jones et al. (2003). It seems unlikely that groups would have covered this area annually or even within a lifetime (see Kelly 2011). Rather, it is likely that such conveyance zones are the product of many millennia of human behavior created by the seasonal movements of multiple generations. While Kelly (2011) suggests that it is unlikely that changes in foraging territories over time could account for the presence of both southern and northern obsidians in the Carson Desert, his work used temporally diagnostic projectile points spanning only the past 5,000 years. Smith (2010) has shown that his Middle Period (~7,800-1,200 cal BP[1]) groups were less far-ranging than earlier and later groups in the western Great Basin. Additionally, the Early Period projectile points for my study are GBSS and GBF points, the former of which were used for perhaps as long as 5,000 years. Given that populations were probably low (Bettinger 1999; Louderback et al. 2011) and mobility was probably high (Jones et al. 2003; Smith 2010) during that period, it is likely that mobile Early Period groups, and not trade between *in situ* populations, were responsible for conveying of Bodie Hills obsidian into the Great Basin during that time.

Summary of Early Period Land-Use. My characterization of sites supports my hypothesis that use of the Bodie Hills was limited during the Early Period (pre-5,000 cal BP). BI values and debitage densities at Early Period sites suggest that visitors to the Bodie Hills were highly mobile and, based on previous research (e.g., Halford 2001), likely utilized secondary obsidian cobble flows while they exploited wetland resources along the East Walker River. Comparisons of Bodie Hills projectile point frequencies to those from the Owens Valley and Carson-Stillwater region suggest that the availability of both raw material and subsistence resources in the Bodie Hills prompted increased utilization of the region compared to those other areas. My review of published and unpublished geochemical sourcing data supports my hypothesis that conveyance of Bodie Hills obsidian into the Great Basin was most extensive during the Early Period. Prior to 5,000 cal BP, no Bodie Hills obsidian was conveyed into California; rather, it was transported across a fairly large area (~92,700 km^2) encompassing the western and parts of the central Great Basin, likely by mobile foragers occupying a sparsely-populated landscape.

The Middle Period (5,000 – 1,300 cal BP)

Peaks in obsidian exploitation (~3,000 – 1,100 cal BP) similar to that observed at the Bodie Hills have been identified at other eastern Sierra obsidian sources. Based on research that has shown those regional peaks, I developed the hypothesis that the Bodie Hills were most intensively used during the Middle Period (5,000 – 1,300 cal BP) and my characterization of sites and projectile point frequencies support this hypothesis. I outlined the two opposing models and associated expectations in the previous chapter to attempt to determine the reason for the intensive use of the Bodie Hills region during the Middle Period. Researchers (e.g., Bouey and Basgall 1984; Hall 1983; Gilreath and Hildebrandt 1997, 2011; King et al. 2011; Martinez 2009; Ramos 2000; Singer and Ericson 1977) have presented alternative hypotheses related to two different behaviors potentially responsible for the peaks and the associated conveyance of obsidian into central California: (1) exchange; and (2) direct/embedded procurement. The difficulty in distinguishing these two behaviors using archaeological data has fostered ongoing arguments for the past few decades. Bouey and Basgall (1984) argued that direct procurement was responsible for the peak in obsidian exploitation and conveyance of Casa Diablo obsidian. They suggested that high mobility during the Newberry Period (3,150 – 1,350 cal BP) in the western and southwestern Great Basin was not conducive to formal exchange networks with non-egalitarian groups living in the western Sierra Nevada foothills. They instead posit that the peak in Casa Diablo production was a product of direct procurement by both eastern and western groups.

Other researchers (e.g., Martinez 2009; Ramos 2000) working in the eastern Sierra Nevada have argued for embedded procurement of obsidian, specifically at the Mount Hicks and Truman/Queen sources. Mount Hicks and Truman/Queen obsidian are minimally present west of the Sierra Crest; yet, they exhibit hydration profiles similar to those developed for other eastern Sierra obsidian sources. This led Martinez (2009) and Ramos (2000) to suggest that peaks in obsidian exploitation reflect embedded procurement of material at those sources by mobile western Great Basin groups. Basgall's (1989) examination of source profiles at various eastern Sierra sites also supports the procurement and consumption of obsidian by local populations; however, his study only looked at sites in the eastern Sierra Nevada and not the western foothills. Additionally, Basgall (1989:119) admitted that developing reliable source profiles in the Long Valley Caldera region has been made difficult by the number of sites related to exchange-based activities there. He did, however, identify diachronic shifts in obsidian procurement related to shifts in mobility; therefore, while he acknowledged the occurrence of exchange, his work did show that local populations likely directly procured and consumed eastern Sierra Nevada obsidian as well.

Supporters of exchange-based models (e.g., Ericson 1982; Gilreath and Hildebrandt 1997, 2011; King et al. 2011; Singer and Ericson 1977) have generally relied on data from consumer populations (e.g., western Sierra foothill and southern California populations). Although Ericson's (1982) conclusions are not supported by current research (see King et al. 2011), his work in deciphering production trends at the St. Helena, Bodie Hills, and Casa Diablo obsidian sources showed variation in diachronic shifts in production between the Central Valley and eastern Sierra Nevada. Gilreath and Hildebrandt (1997, 2011) proposed that the magnitude of production at the Coso Volcanic Field exceeded the needs of local populations and they proposed that the peak in its production and distribution indicated that exchange was most likely responsible for the distribution of Coso obsidian. King et al. (2011) provided a recent test of the various explanations for the peak in biface production at the Bodie Hills obsidian source and concluded that the rise of interregional exchange was responsible.

While my characterization of sites generally supports the model that exchange was responsible for conveying Bodie Hills obsidian west across the Sierra Nevada, some of my results are at odds with it. Specifically, the development and maintenance of exchange networks between Bodie Hills and western foothill groups would have required at least seasonally stable populations at the former location to mass produce bifaces for export. My results show that sites with milling equipment (12 of 36; 33%) peak during the Middle Period; however, sites with features are uncommon (2 of 36; 6%) during that time. While the increase in milling equipment at Middle Period sites indicates there was more emphasis on subsistence, the paucity of features is inconsistent with expectations for exchange facilitated by *in situ* populations in the Bodie Hills. The general lack of features at Middle Period sites could suggest that direct/embedded procurement was responsible for the peak in biface production and conveyance of Bodie Hills obsidian. Additionally, flake tool frequencies are consistent with models based on mobility and direct/embedded procurement rather than exchange.

It is also possible, however, that Middle Period residential bases were simply not identified during my records search. Bieling (1992) identified residential bases during his graduate work in northwest Bridgeport Valley which were attributed to the Newberry Period (3,150 – 1,350 cal BP) through obsidian hydration analysis. He suggested that those sites "functioned as camps from which tasks involving both hunting and vegetal food processing were carried out" (Bieling 1992:85). Additionally, previous research in Owens Valley (e.g., Bettinger 1975, 1989; Delacorte 1990) has identified that a logistical strategy, in which groups ventured out from residential bases on the valley floor to adjacent upland areas to procure resources, was practiced during the late Newberry Period (2,000 – 1,350 cal BP). In the Bodie Hills, it is likely that residential bases were similarly located on the valley floor. Unfortunately, no site forms were obtained for this area because land there is private (see below for further discussion). However, analysis of other factors (e.g., projectile point frequencies) may account for the lack of residential sites. The results of projectile point frequency comparisons show that Middle Period points are overrepresented in the Bodie Hills compared to both the Coso Volcanic Field and Owens Valley. Gilreath and Hildebrandt (1997:177) have shown that the Coso Volcanic Field was never extensively exploited for resources other than obsidian.

Additionally, logistical parties from residential sites in Owens Valley brought resources back to residential bases, creating a disctinction between upland and valley resource areas. The overrepresentation of Middle Period projectile points in the Bodie Hills suggests that – similar to the Early Period – the availability of both subsistence resources and raw material was an incentive to occupy the Bodie Hills.

Additional data suggesting that the Bodie Hills were an important area for subsistence pursuits come from projectile point frequencies from the nearby Dry Lakes Plateau, located ~5 km east of the Bodie Hills obsidian source (Halford 1998). Halford (1998) studied sites there with the intent of showing that the Dry Lakes Plateau was an important upland resource area throughout the Holocene. Results of a chi-square test show a significant difference ($\chi^2 = 28.53$, $df = 2$, $p < .0001$) in projectile point frequencies between the Bodie Hills and Dry Lakes Plateau (Table 5.2); however, this difference does not occur during the Middle Period where standardized residuals show little difference. Instead, standardized residuals show that a significant difference occurs between the Early and Late periods in the two regions. The fact that the Dry Lakes Plateau has been argued to be an important upland resource area and Middle Period projectile point frequencies there and in the Bodie Hills do not differ significantly, suggests that the latter location was also an important subsistence resource area at that time.

Table 5.2. Comparison of Projectile Point Frequencies for the Bodie Hills and Dry Lakes Plateau.

	Cultural Period		
Region	**Early**	**Middle**	**Late**
Bodie Hills, CA	26 **(-2.42)**	104 (+0.14)	106 (+1.48)
Dry Lakes Plateau, CA	32 **(+3.85)**	39 (-0.22)	22 (**-2.36**)

$\chi^2 = 28.53$, $df = 2$, $p < .0001$
Note: Stardardized residuals shown in parentheses with significant values bolded.

If we accept that the Bodie Hills was an important subsistence resource area during the Middle Period, then it is easy to imagine that once groups arrived in the region they became logistically organized (*sensu* Binford 1980) to take advantage of various resources in the region. McGuire and Hildebrandt (2005) suggest that this was the case in the Great Basin during the Middle Period and that the apparent high mobility recognized by other researchers (e.g., Basgall 1989; Bettinger 1999; Eerkens et al. 2008) reflects the long-distance logistical movements of males. If this was the case, then sites located during this study, which are mainly situated in higher elevations, likely represent resource-specific camps (e.g., hunting and processing, obsidian procurement and reduction, etc.). Therefore, even though no residential bases were located during my study, the character of the sites that were included and the projectile point frequencies for the Middle Period suggest that the presence of residential sites – presumably located on the valley floor – is likely.

Although the results of my characterization of Middle Period sites are in line with expectations for the exchange model, the distribution of Bodie Hills obsidian within the Great Basin during the Middle Period indicates that consumer populations in California were not solely responsible for the peak in production ~3,500 – 1,100 cal BP. The frequency of Bodie Hills obsidian in the Great Basin is less than in California during the same time period, suggesting that a different mechanism may have conveyed obsidian eastward. Researchers (e.g., Basgall 1989; Eerkens et al. 2008) have proposed that the distribution of obsidian from eastern Sierra obsidian sources throughout the eastern Sierra Nevada was due to seasonal movements along a north-south axis, with movement into lower elevations (e.g., Owens Valley) during the colder months; however, the extremely low frequencies of Bodie Hills obsidian south of the source suggests that groups occupying the Bodie Hills during the summer did not venture south to any great degree. Rather, the distribution of Bodie Hills obsidian across the Great Basin during the Middle Period (excluding the outlying Gatecliff Shelter ~220 km east-northeast of my study area) suggests that movement was along a north-south axis, with the Bodie Hills representing the southern extent of this territory. As occupation of the higher elevation Bodie Hills was unlikely during the winter months, the seasonal movements of groups probably included occupation of the western Great Basin during the winter months and movement into the Bodie Hills from spring through fall.

Based on the distribution of Bodie Hills obsidian in the Great Basin, my hypothesis that the frequency of that obsidian in the Great Basin peaked during the Middle Period is supported. More Middle Period point types are present in the Great Basin than point types from either the Early or Late periods. Based on the distribution in California and the Great Basin as well as evidence from the characterization of sites discussed above, the peak in obsidian production at the Bodie Hills obsidian source likely resulted from extensive production for trans-Sierran exchange during summer/fall and production for provisioning individuals (*sensu* Kuhn 1995) during the winter months.

Therefore, I suggest that two separate, though interdependent, distribution spheres for Bodie Hills obsidian were in place during the Middle Period: (1) a western Great Basin sphere where direct/embedded acquisition by mobile groups was primarily responsible for conveyance; and (2) a sphere west of the Sierra Nevada where exchange was primarily responsible for conveyance.

Including Gatecliff Shelter, the Middle Period conveyance zone in the western Great Basin covers ~38,800 km^2; however, Gatecliff Shelter is an outlying site that inflates the area through which Bodie Hills obsidian moved. The next most distant location containing Bodie Hills obsidian and dating to the Middle Period is Hidden Cave, ~134 km to the north-northeast of the Bodie Hills. Hidden Cave and Gatecliff Shelter are separated by ~90 km within which sourcing data are currently not available, but even without those data, I suggest that Bodie Hills obsidian is likely either present there in very low quantities or absent. Artifacts at Gatecliff Shelter are dominated by chert; obsidian represents <5 percent of artifacts there (Thomas 1983:394). Of the 54 artifacts submitted for XRF analysis, only two (3%) were manufactured on Bodie Hills obsidian. In contrast, obsidian is the dominant material type for projectile points at Hidden Cave (153 of 201; 76%), with Bodie Hills obsidian representing 20 percent (n=30) of the raw material in the projectile point sample subjected to XRF analysis. Because, as a cache site, Hidden Cave represents a rare site type, it should not be considered representative of prehistoric land-use in the Carson Desert. Therefore, I considered all projectile points from Kelly's (2011) Carson-Stillwater study, including those from Hidden Cave and numerous open-air sites. With an additional 222 projectile points from surface surveys and excavations at 26CH1062, 53 percent (222 of 423) of all projectile points in the

Carson-Stillwater region are made of obsidian. The relative abundance of obsidian in Carson-Stillwater compared to Gatecliff Shelter suggests that obsidian was a more important raw material to groups in the former location than the latter location. Therefore, it is more likely that the Bodie Hills conveyance zone covered an area closer to ~15,200 km^2 than ~38,800 km^2 (see Figure 5.1).

Summary of Middle Period Land-Use. My hypothesis that the Bodie Hills were most intensively used during the Middle Period is supported by my expectations under the model for exchange. Expectations for the Middle Period were based on the results of previous research in the Bodie Hills that has related the peak in production to an emphasis on biface production. Support for the exchange model is found in the presence of milling implements at a number of Middle Period sites and high projectile point frequencies, while support for the direct/embedded procurement model comes from the rarity of features and low FTI values. While elements of both models are supported, I suspect that Middle Period residential sites were not located during my records search, a possibility that I explore further below. My hypothesis that the frequency of Bodie Hills obsidian in the Great Basin peaked during the Middle Period is supported by the geochemical sourcing data. Additionally, my review of the distribution of Bodie Hills obsidian in both California and the Great Basin presents two related distribution spheres: (1) a Great Basin sphere where direct/embedded procurement by mobile populations was likely the primary drivers; and (2) a California sphere where exchange was likely the primary behavior responsible for the conveyance of Bodie Hills obsidian.

The Late Period (post-1,300 cal BP)

The expectations for the hypothesis that there was a decreased emphasis on obsidian and an increased focus on subsistence activities in the Bodie Hills after ~1,300 cal BP were met. Although these activities are not mutually exclusive (Binford 1980), such a shift in focus has been identified at other eastern Sierra Nevada obsidian sources (e.g., Coso Volcanic Field [Gilreath and Hildebrandt 1997] and Truman/Queen [Ramos 2000]). Hildebrandt and Ruby (2006) noted that intensified pinyon nut exploitation marked by the switch from brown-cone to green-cone pinyon processing (i.e., from fully ripened to premature harvesting) took place in the Coso Range after 1,350 cal BP. While green-cone pinyon processing is more costly than brown-cone processing, harvesting pinyon nuts before they ripen both eliminates competition from other animals and increases yields (Bettinger and Baumhoff 1983:832). Because increased yields from the green-cone method also amplifies transport costs due to increased loads (Barlow and Metcalfe 1996; Jones and Madsen 1989; Rhode and Madsen 1998; Zeanah and Simms 1999) and in-turn decreases return rates, groups may have altered their settlement patterns to reduce the transport distance of pinyon resources. In fact, Hildebrandt and Ruby (2006) noted that there was an increase in residential sites in upland locations after ~1,350 cal BP, which they interpret as an effort to reduce the distance that green-cones were transported. Thus, the change from brown-cone to green-cone processing was not only seen in the intensity and timing of pinyon harvesting, but also in the settlement strategy that groups employed (Hildebrandt and Ruby 2006:15).

The paucity of features at Middle Period sites (2 of 36; 5%) may be explained by lower transport costs due to a diet not heavily dependent on pinyon nuts, meaning that there was more benefit in being located in the valley and not relocating residential sites to the higher elevations. During the Late Period, however, the number of sites with features (6 of 34; 18%) increases. Bieling (1992) identified a drop in the use of the northwest Bridgeport Valley after ~1,300 cal BP, and based on my characterization of sites it appears that valley residential bases were abandoned in favor of upland regions. Ramos (2000:197) also interpreted a settlement reorganization ~1,300 cal BP at the Truman/Queen obsidian source. There, the percentage of hydration readings from upland sites increases from 58 percent during the Newberry Period (3,150 – 1,350 cal BP) to 71 percent during the post-Newberry Period (post-1,350 cal BP). Ramos (2000:197) suggested that settlement patterns became more centralized and organized around fall and winter pinyon nut procurement. Although there is a bias due to a lack of valley sites in my sample, the fact that features are present at more sites and in greater quantities during the Late Period than the Middle Period suggests that a similar settlement reorganization occurred in the Bodie Hills ~1,300 cal BP. Comparisons of projectile point frequencies between the Bodie Hills and Truman/Queen region, which indicate no significant over- or underrepresentation between the Middle and Late periods, provide additional support for this hypothesis.

Additional evidence for increased residential sites in the Bodie Hills uplands is found in the overrepresentation of flake tools during the Late Period. An overrepresentation of flake tools is consistent with models of technological organization suggesting that there should be an emphasis on expedient tools in more sedentary occupations. That bifaces are also fairly common in the Late Period sample is not surprising given the abundance of high quality obsidian in the Bodie Hills – Andrefsky (1994) has demonstrated that when high quality toolstone is locally available, groups often employed both formal (e.g., bifacial) and informal (e.g., flake) tool technologies. That flake tools are underrepresented during the Early and Middle periods suggests that groups were more mobile before ~1,300 cal BP. As discussed above, the greater occurrence of milling implements at Middle Period sites suggests that occupation span increased between 5,000 and 1,300 cal BP; yet, flake tools remain underrepresented. There are at least two factors that may have contributed to this underrepresentation. First, bifaces were likely mass-produced during the Middle Period; therefore, although flake tools do occur in greater frequencies than the Early Period, they still appear to be underrepresented. Second, the underrepresentation of flake tools is likely in part a function of the lack of valley sites in my sample. If residential sites were located in the Bridgeport Valley during the Middle Period, as I have suggested, then I expect such sites to have been locations where activities involving flake tools and other informal technologies took place (see Bieling 1992).

Researchers (e.g., Bettinger 1989, 1991; Bettinger and Baumhoff 1982; Hildebrandt and Ruby 2006) have argued that the intensification of previously marginal resources was due to increased populations. In the Great Basin, there is ample evidence for increased exploitation of higher elevation zones previously used primarily for hunting ~1,300 cal BP (Bettinger 1991; Hildebrandt and Ruby 2006; Morgan et al. 2012a, 2012b). Additionally, there is evidence of increased populations in Owens Valley and surrounding regions (Allen 1986; Bettinger 1989; Bettinger and Baumhoff 1982) concurrent with the appearance of residential sites in the Coso Mountains, which provides support for population-based explanations of resource intensification. Furthermore, a comparison of projectile point frequencies from Owens Valley and Bodie Hills indicates that Late Period projectile points are significantly overrepresented in Owens Valley. That Late Period points are underrepresented in the Bodie Hills, yet similar trends in settlement patterns are evident, suggests that the overrepresentation of Middle Period points in the Bodie Hills is more real than apparent. While the discard rate of Late Period projectile points is 1/10.85 years, as compared to 1/35.58 years for Middle Period points, this may be partly a function of differences in the durability of dart and arrow points: arrow points have shorter use-lives than do dart points (Connolly and Jenkins 1997; Odell and Cowan 1986; Skinner et al. 2004). Therefore, it is more likely that Middle Period projectile points actually occur in greater than expected frequencies due to higher discard rates for Late Period projectile points. This finding counters previous research proposing that populations continually increased throughout the Late Holocene, suggesting instead that populations in the Bodie Hills actually reached their peak during the Middle Period. This may be a function of the longer timespan of the Middle Period (3,700 years) as compared to the Late Period (1,150 years); however, it may also suggest that populations were higher in the Bodie Hills during the Middle Period than they were in areas unrelated to toolstone sources. While this may be contrary to findings in other regions, it is not entirely unexpected given the extensive quarrying activity that occurred at the Bodie Hills obsidian source during that time.

The proposed increase in population during the Late Period has been suggested as having limited access by outsiders to eastern Sierra obsidian sources (Bouey and Basgall

1984); however, this restriction did not result in a fluorescence of trade but rather a diminution of exchange networks. The distribution of Bodie Hills obsidian during the Late Period suggests that this obsidian source became more readily available to populations to the south while becoming more restricted in the Great Basin. The percentage of debitage from Bodie Hills obsidian at MNO-446 – located 40 km south of Bodie Hills – more than doubles from 7 to 15 percent after ~1,350 cal BP. The percentage of Bodie Hills obsidian in the projectile point sample at MNO-446 is even larger at 31 percent – equal to the contribution of Casa Diablo obsidian in the projectile point sample. While Casa Diablo and Bodie Hills obsidian are equally represented among projectile points, Casa Diablo obsidian dominates debitage at the site throughout time. Regardless of whether obsidian from Bodie Hills arrived at MNO-446 via direct/embedded procurement or informal exchange – as the discord between projectile points and debitage suggests – its presence there indicates that access to areas south of Bodie Hills was less restricted after ~1,350 cal BP. Hull's (1988) work in Yosemite National Park also indicates that the geographic distinction between the Casa Diablo and Bodie Hills obsidian sources apparent during the Middle Period on the eastern and western slope of the Sierra Nevada was not as evident during the Late Period.

During the Late Period, the conveyance of Bodie Hills obsidian into the Great Basin was more restricted in both range and frequency compared to earlier periods, supporting my hypothesis that the frequency of Bodie Hills obsidian in the Great Basin was lowest after ~1,300 cal BP. Late Period points made of Bodie Hills obsidian are found exclusively in the Carson Desert, including at Hidden Cave. Late Period points made on Bodie Hills obsidian represent only 15 percent of diagnostic projectile points in the Great Basin identified during my literature review. This figure is even less than the Early Period projectile points, which make up 21 percent of the sample. The decreased distribution of Bodie Hills obsidian into the Great Basin clearly signals restricted conveyance of that material, either due to decreased mobility or less interaction with groups in the western Great Basin. There is some ethnographic evidence for a southern exchange route encompassing the Carson Desert and Mono Basin (Steward 1933); therefore, it is possible that constricted movements due to population pressure resulted in the formation of exchange networks in place during ethnographic times. It is, however, interesting to note that exchange apparently did not reach the level present during the Middle Period. This may be evidence for the decreased importance of eastern Sierra Nevada obsidian, in sharp contrast to Ericson's (1982) argument for post-Archaic expansion of obsidian exchange. Including areas south of the Bodie Hills in the Great Basin conveyance zone, the Late Period exhibits the smallest zone of any cultural period at 12,900 km^2 (see Figure 5.1).

Summary of Late Period Land-Use. The results of my characterization of sites in the Bodie Hills region are consistent with a drop in biface production concurrent with an increase in sedentism related to subsistence pursuits. The greater occurrence of features and flake tools at Late Period sites is likely related to a restructuring of settlement patterns – a trend that has been identified at the Truman/Queen source (Ramos 2000) and in the Coso Mountains (Gilreath and Hildebrandt 1997; Hildebrandt and Ruby 2006). Additionally, the distribution of Bodie Hills obsidian during the Late Period suggests that movements became more restricted – likely due to increased populations throughout the

Great Basin – while the geographic distinction between the Casa Diablo and Bodie Hills sources became less apparent.

CHAPTER 6

Conclusion

In this study, I explored diachronic shifts in land-use in the Bodie Hills through a characterization of sites and used the results to test hypotheses related to models of obsidian procurement and conveyance in the eastern Sierra Nevada. I developed expectations based on previous research at eastern Sierra Nevada obsidian sources and used those expectations to test the following hypotheses related to diachronic shifts in land-use in the Bodie Hills:

(A) Prior to ~5,000 cal BP there was limited use of the Bodie Hills region;

(B) The most intensive use of the Bodie Hills occurred between ~5,000 and ~1,300 cal BP; and

(C) After ~1,300 cal BP, obsidian procurement in the Bodie Hills decreased and subsistence activities intensified.

My expectations were evaluated using sites that I characterized based on models of technological organization. To characterize these sites, I asked two questions:

(1) What types of artifacts and features are present at the sites; and

(2) Do artifact and feature types/frequency vary between periods?

To further examine diachronic shifts in Bodie Hills land-use I also reviewed published and unpublished XRF sourcing data from the Great Basin to test the following hypotheses:

(A) Conveyance of Bodie Hills obsidian into the Great Basin was the most spatially extensive prior to ~5,000 cal BP;

(B) Frequencies of Bodie Hills obsidian in the Great Basin reached a peak between ~5,000 and ~1,300 cal BP; and

(C) Frequencies of Bodie Hills obsidian in the Great Basin were lowest after ~1,300 cal BP.

In Chapter 1, I summarized models of technological organization as well as the results of previous researchers at various toolstone source areas. Because one of the goals of my study was to test models of obsidian procurement and conveyance in the eastern Sierra Nevada, my literature review focused on studies of obsidian sources in that region. I also briefly discussed the potential benefits of studies of technological organization at sites in and around lithic source areas.

Chapter 2 described my study area, the process by which I obtained my dataset, and how I established chronological control. The sites in my study were identified through a records search that I performed at the EIC in Riverside, California. Because the purpose of this study was to test hypotheses related to diachronic shifts in land-use, I only used single-component sites. Chapter 2 outlined the temporal span of different diagnostic projectile point types in my study area and how I separated sites based on the presence of particular points. Sites were assigned to the Early Period (pre-5,000 cal BP) if GBF, GBSS, and/or Pinto/Little Lake projectile points were present. Middle Period (5,000 – 1,300 cal BP) sites are those that contain Elko and/or Humboldt Series projectile points. Sites were assigned to the Late Period (post-1,300 cal BP) based on the presence of Rosegate and/or Desert series projectile points.

The methods that I employed to characterize sites, evaluate projectile point frequencies, and review published and unpublished geochemical sourcing data literature were outlined in Chapter 3. Based on the presence of diagnostic projectile points, 81 single-component sites were identified and included in further analysis. Sites were characterized based on the models of technological organization presented in Chapter 1. From site forms, I extracted data that have been shown to reflect a variety of prehistoric behaviors, including mobility and occupation span. Bifaces and flake tools have been shown to reflect aspects of prehistoric mobility, with the former reflecting high mobility and the latter reflecting increased sedentism (Ericson 1982; Kelly 1988; Parry and Kelly 1987). To show the relative importance of those two tool types at sites in my study, I created an index for each by dividing the number of bifaces or flake tools by the entire flaked stone tool assemblage at each site. All other attributes were simply tallied by site and totaled within each cultural period. Additionally, to calculate projectile point frequencies, I included all isolated finds and multi-component sites and counted the number of diagnostic points by type and cultural period. Finally, I obtained geochemical sourcing data from numerous published and unpublished studies to establish the distribution of Bodie Hills obsidian in both California and the Great Basin.

Summary of Results

The results from my characterization of sites show that there were changes in land-use in the Bodie Hills region across time. Previous research (e.g., Gilreath and Hildebrandt 1997; Halford 2001) has shown that eastern Sierra Nevada obsidian sources did not experience extensive quarrying prior to ~5,000 cal BP. Researchers (e.g., Gilreath and Hildebrandt 1997; Halford 2001) have instead suggested that there was low-level utilization of secondary obsidian deposits at the Coso Volcanic Field and Bodie Hills by mobile hunter-gatherers who exploited subsistence resources. The results from my characterization of Early Period sites support my hypothesis and previous research and show that there was minimal use of the Bodie Hills region prior to ~5,000 cal BP. Projectile point frequencies also indicate that populations in the Bodie Hills were small during the Early Period. However, when compared to regions unrelated to toolstone sources (e.g., Owens Valley and Carson-Stillwater) Early Period points are overrepresented in the Bodie Hills, suggesting that the availability of subsistence and toolstone resources together was attractive to early populations. As such, Early Period groups likely embedded stops at the Bodie Hills within seasonal movements. The distribution of Bodie Hills obsidian at sites throughout the Great Basin supports my hypothesis that the distribution of that material was most extensive prior to ~5,000 cal BP, and suggests that the conveyance zone was quite large (~92,700 km^2) during the Early Period.

Middle Period sites in my study indicate that a change in population and occupation span occurred after ~5,000 cal BP. Based on previous research at numerous eastern Sierra Nevada obsidian sources (e.g., Bodie Hills [Singer and Ericson 1977], Casa Diablo [Bouey and Basgall 1984; Hall 1983], Coso Volcanic Field [Gilreath and Hildebrandt 1997, 2011], Mount Hicks [Martinez 2009], and Truman/Queen [Ramos 2000]), I hypothesized that the Bodie Hills were most intensively used during the Middle Period and my characterization of sites supports this hypothesis. Additionally, some eastern Sierra obsidians (e.g., Bodie Hills, Casa Diablo, and Coso Volcanic Field) are found in varying quantities in sites west of the Sierra Nevada, leading some researchers (e.g., Ericson 1982; Gilreath and Hildebrandt 1997, 2011; King et al. 2011; Singer and Ericson 1977) to suggest that exchange was responsible for the conveyance of those materials. Others (e.g., Bouey and Basgall 1984; Martinez 2009; Ramos 2000) argue that a majority of eastern Sierra obsidian was consumed by populations east of the Sierra Nevada and that direct/embedded procurement was responsible for the peaks in obsidian use.

Most of my expectations for the model of exchange were met except for the common occurrence of features and high FTI values. These factors, however, were likely present but not identified because no sites were obtained from the valley floor due to private land ownership. Research (e.g., Bettinger 1975, 1989; Delacorte 1990) in Owens Valley has shown that residential sites were located on the valley floor during the Middle Period and there is no reason this pattern should have differed in the Bodie Hills. While my characterization of sites suggests that exchange was responsible for the production peak and conveyance of Bodie Hills obsidian, the distribution of that material within the Great Basin suggests that consumer populations west of the Sierra were not solely responsible. The Middle Period conveyance zone in the Great Basin covered an area of ~15,200 km^2 along a north-south axis, suggesting that the seasonal movements of groups from that time included spring-fall occupation of the Bodie Hills when exchange with western Sierra foothill populations took place, and winter occupation near Carson-Stillwater in Nevada.

My characterization of Late Period sites supports my hypothesis that there was a shift in focus from toolstone to subsistence resources in the Bodie Hills. This shift has been identified by other researchers (e.g., Gilreath and Hildebrandt 1997; Hildebrandt and Ruby 2006; Ramos 2009) working elsewhere in the eastern Sierra Nevada and is typified by a decreased emphasis on obsidian procurement and conveyance with a concurrent increase in sedentism and focus on low-return resources (e.g., pinyon). Hildebrandt and Ruby (2006) and Ramos (2000) identified an increase in upland residential sites after ~1,350 cal BP in the Coso Mountains and Truman/Queen obsidian source, respectively. An increase in upland habitation is evident in my sample by an increase in the occurrence of features in Late Period sites, a majority of which are located in the uplands. Additionally, the Late Period conveyance zone is the smallest of any cultural period (~12,900 km^2) and contains the lowest frequency of artifacts identified as being made on Bodie Hills obsidian, thus providing support for my hypothesis.

Future Research

In addition to the primary goal – testing hypotheses related to diachronic shifts in land-use in the Bodie Hills – this study serves as an example of the potential of revisiting existing archaeological data. I compiled sites for this study that were recorded over multiple decades and used them to evaluate models of obsidian procurement and conveyance in the eastern Sierra Nevada. The large amount of archaeological data produced through various CRM and government agency projects is often not used to their fullest extent. Employing existing archaeological data in a study increases the utility of the fieldwork conducted by archaeologists and allows the data to make a useful contribution to the ongoing study of prehistory.

There are also continuing research topics that should be addressed in the Bodie Hills specifically. First, it is evident from my literature review that reevaluating the quarry area in the Bodie Hills studied by Singer and Ericson (1977) is necessary to support or refute the findings of Prior to this reevaluation, however, an accepted hydration rate for Bodie Hills obsidian must be developed. A problem in Singer and Ericson's (1977) study is that the hydration rate used was not paired with radiocarbon dates and the development of their hydration curve was based on a very small sample (n=98). Due to uncertainty associated with the hydration rate that they used, some researchers (e.g., Bouey and Basgall 1984:136) have chosen to exclude production trends at the Bodie Hills from discussion until further refinement of the curve has been completed.

Second, there is additional work that researchers (e.g., Bouey and Basgall 1984; Singer and Ericson 1977) have suggested should be undertaken in the Bodie Hills. As discussed above, future work should focus on developing an accepted hydration rate and evincing similar production trends at off-quarry sites. Outlying production sites at both Casa Diablo and Coso Volcanic Field have been used to show that production trends varied across time at those sources. Although my study sought to evaluate current models of obsidian procurement and conveyance through the characterization of sites in the Bodie Hills region, an evaluation of production trends at those sites was beyond the scope of this study.

Finally, my literature review of geochemical sourcing data made clear the importance of source provenance studies, especially in the Great Basin. The Great Basin is unique in that multiple obsidian sources occur along the outer rim, while the central basin is essentially devoid of obsidian (Thomas 2012). Establishing the distribution of different obsidian sources at archaeological sites, as I have done here for the Bodie Hills source, can reveal trends in procurement and conveyance that are not apparent in source profiles from single sites. Future CRM and government agency work should include the geochemical characterization of obsidian artifacts so that the dataset for the distribution of artifacts made on various obsidian sources will continue to increase, allowing more informed interpretations of the behaviors that may or may not have been responsible for the conveyance of those materials.

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