Exchange, Embedded Procurement, and Hunter-Gatherer Mobility: A Case Study from the North American Great Basin

by

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To J and our furry family

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Chapter 1: Introduction

An Early Word on Some Terminology

Cultural and environmental records in North America demonstrate that the Terminal Pleistocene/Early Holocene (TP/EH; 11,500-7500 ^{14}C yr BP) was a time of dramatic change, including the elevational and latitudinal migrations of plant and animals, the disappearance of lakes and river systems, the extinction of many large mammals, and the arrival (or expansion; e.g., Bettinger and Young 2004; Fitting 1977) and settling-in of human populations. Unfortunately, archaeologists interested in the study of this period have spent much of their time confounded by the problems of cultural chronology. Efforts to achieve chronological resolution frequently rely on the seriation of projectile points, especially in settings like the Great Basin where surface lithic assemblages dominate the TP/EH archaeological record. In the Great Basin, these early lithic assemblages document several projectile point technologies, including fluted lanceolate points, unfluted lanceolate points, and large stemmed points. In the last couple of decades Great Basinists have set aside traditional concerns over culture historical unit formation to investigate other topics related to human adaptation during this period, including the organization of subsistence, settlement, and lithic technology (see papers in Graf and Schmitt 2007). Nevertheless, problems of cultural chronology persist. As I will discuss in more detail in Chapter 2, the relative temporal position of the points documented in these early Great Basin assemblages remains unclear, although it seems that stemmed points, and perhaps unfluted lanceolate points, persisted much longer in the region than did fluted points.

Because of the uncertain chronological position of fluted points in the Great Basin, as well as the implication that "Clovis" points date to a very specific time in neighboring regions (e.g., Fiedel 2004a, 2006a; Fiedel and Kuzmin 2010; Haynes 1992; Waters and Stafford 2007), many Great Basinists prefer not to use the term and simply describe them as "fluted" (e.g., Beck and Jones 1997, 2010; Bryan 1988; Grayson 1993;

Willig and Aikens 1988). Further, the term “Clovis” is often used interchangeably with “Paleoindian,” implying to many archaeologists a particular kind of adaptation (i.e., specialized big-game hunting; e.g., Kelly and Todd 1988) that has not been demonstrated in the Great Basin. Here I follow Donald Grayson (1993) in referring to these points as Great Basin fluted points. Confusion also exists over terminology, as well as morphological and temporal relationships, among different types of large stemmed points, which, at the very least, are coeval with and may, in fact, predate fluted points in the Great Basin (Beck and Jones 2010). Thus, I follow Tuohy and Layton (1977) in referring to all of these stemmed types as “Great Basin Stemmed” points, excepting Windust and Hell Gap types.

Finally, I use the term “Paleoarchaic” to refer to populations who lived in the Great Basin during the TP/EH. This term (and variants such as “Pre-Archaic”) was initially coined to distinguish early Great Basin hunter-gatherers from their big-game hunting Paleoindian counterparts (Beck and Jones 1997; Elston 1982, 1986; Fowler and Madsen 1986; Jennings 1986). Gary Haynes (2007:252) recently chastised Great Basinists, however, for the use of “awkward, misleading, and unnecessary” alternatives to the term Paleoindian, given the eroding stereotype of Paleoindian big-game hunters. Indeed, recent research demonstrates that Paleoindian sites in the Southeast (e.g., Driskell 1996; Dunbar and Vojnovski 2007; Hollenbach 2007; Walker 2007), Northeast (e.g., Dent 2007), Northern Plains and Rocky Mountains (e.g., Kornfeld 2007), Southern Plains (e.g., Collins 2002, 2007), Great Lakes region (e.g., Kuehn 2007), and Eastern Beringia (e.g., Yesner 1996, 2007) evince widespread economic diversity rather than the specialized hunting of large game (also see Borrero 1999, 2005; Dillehay and Rosen 2002; Grayson and Meltzer 2002, 2003; Meltzer 1993; Pinson 2011a; Roosevelt 2002; Roosevelt et al. 2002). Yet Haynes’s (2007) admonition seems premature given persistent argumentation for the hunting of now-extinct megafauna outside the Great Basin (e.g., Cione et al. 2009; Fiedel 2009; Fiedel and Haynes 2004; Fisher 2009; Haynes 2009; Surovell et al. 2005; Surovell and Waguespack 2009; Waguespack and Surovell 2003). Perhaps these research efforts will redraw the line in the sand; only further investigation will tell. Of more immediate concern, use of the terms “Paleoindian” and “Archaic” are often taken to imply a distinct adaptational boundary between these two periods (e.g., specialized big-game hunting vs. broad-spectrum foraging), but such a boundary does not exist in the Great Basin (Beck 1999; Simms 1988; Willig and Aikens 1988; though see Pinson 2007) nor, perhaps, elsewhere in the Americas (e.g., Bamforth 2011). Indeed, David Madsen (2007) characterizes the Paleoarchaic-Archaic transition in the Great Basin as a shift from broad-spectrum foraging to very broad-spectrum foraging. With these considerations in mind, I will use the term "Paleoarchaic" throughout this study for its geographic, rather than behavioral significance. Thus, I use "Paleoarchaic" to refer to TP/EH populations within the Great Basin, while I use "Paleoindian" more generally to refer to TP/EH populations outside the Great Basin.

The Case Study: Toolstone Procurement and Early Hunter-Gatherer Mobility in the Great Basin

Most archaeologists agree that TP/EH human populations throughout North America were highly mobile, traversing large areas to meet their resource needs (though see Cochran et al. 1990; Collins 2002; Daniel and Wisenbaker 1989; Eerkens, Rosenthal, et al. 2007; Holland 2004-2006; Speth et al. 2012). Research into this topic often concentrates on the size of a foraging range habitually occupied by a group or set of related groups, commonly employing the sources of toolstone in archaeological assemblages to infer both direction and scale of movement (e.g., Bamforth 1991a; Beck and Jones 1990a; Burke 2006; Ellis 2011; papers in Ellis and Lothrop 1989; Jones et al. 2003; Koldehoff and Walthall 2004; Madsen 2007; Reher 1991; Seeman 1994; Tankersley 1990, 1991). While this approach documents the distribution of toolstone across the prehistoric landscape, it does not, by itself, identify the way people acquired toolstone: toolstone may have been acquired directly (i.e., through residential or logistical mobility) or indirectly (i.e., through exchange). Thus, provenance analysis is complemented by technological analyses of lithic assemblages, which emphasize geographic patterns defined by variation in manufacture, transport, use, and discard tactics to infer mode of acquisition. Current models of Paleoarchaic subsistence-settlement patterns have relied heavily on identifying the sources of obsidian artifacts to define the range over which people traveled to procure resources, though these same data are used to support widely divergent views of Paleoarchaic lifeways.

Recently, George T. Jones and colleagues (2003) amassed obsidian provenance data from across the Great Basin to reconstruct the distribution of obsidian during the TP/EH, defining a series of "obsidian conveyance zones" (OCZs). They suggest that these zones "delimit geographically the foraging territories of Paleoarchaic populations," which practiced high residential mobility geared to the distribution of significant wetlands (also see Arkush and Pitblado 2000). Note that Jones et al.'s (2003) use of "territory" follows Robert Kelly (1992), who defined territorial or long-term mobility as the cyclical movement of a group utilizing a set of annual ranges over a period of perhaps a decade. Thus, Jones and colleagues (2003) view OCZs as proxies for annual or territorial (i.e., decadal) ranges, the long axes of which parallel the orientation of Great Basin mountain ranges. Significantly, they find a lack of obsidian movement between conveyance zones, which they suggest represents a lack of contact between Paleoarchaic groups in the western and eastern Great Basin, perhaps as a consequence of low population density and/or geographic barriers. In sum, Jones et al. (2003) propose that Paleoarchaic hunter-gatherers, operating in small groups under conditions of low population density and high mobility, frequently moved between resource-rich patches (e.g., wetlands and contiguous steppe), focusing on few, rapidly depleted resources, before moving on to a new patch (i.e., they were "travelers," after Bettinger 1991, 1994, 1999; Bettinger and Baumhoff 1982).

David Madsen (2007), however, has recently questioned this interpretation, recognizing that it remains unclear whether long-distance obsidian transport reflects the movement of Paleoarchaic groups as a whole or task groups composed of a subset of the population. Thus, Madsen (2007) proposes a very different model of Paleoarchaic subsistence-settlement organization to explain these same data. He suggests that male hunting parties may have procured resources that they brought back to relatively permanent wetland base camps occupied by the rest of the foraging group. Significantly, this model implies that the size and productivity of marsh habitats would have determined the relative degree of mobility practiced by Paleoarchaic populations. Where marsh habitats were small and widely scattered, Paleoarchaic groups would have been highly mobile, traversing long distances between residential camps; where marsh habitats were large and productive, Paleoarchaic groups would have been more sedentary, traversing shorter distances between residential camps (compare Madsen 1982a on the eastern Great Basin with Elston 1982 on the western Great Basin). Madsen (2007) suggests that the Paleoarchaic record of the central Great Basin, including the Eastern Nevada Study Area that has been the research locus of George T. Jones, Charlotte Beck, and colleagues, reflects the latter scenario. According to Madsen's (2007) model, therefore, OCZs delineate the spatial extent of male logistical forays to provision the rest of the social group.

Despite the differences between these models, both seem to view obsidian procurement as embedded in subsistence pursuits. The idea of embedded procurement can be traced to Lewis Binford (1979:259, emphasis added), who wrote: "Raw materials used in the manufacture of implements are normally obtained incidental to the execution of basic subsistence tasks. Put another way, procurement of raw materials is *embedded in basic subsistence schedules*." With Binford's insights in mind, Paleoindianists overwhelmingly assume that the acquisition and distribution of toolstone reflects direct procurement embedded in subsistence pursuits. Indeed, the OCZs are interpretable in relation to Paleoarchaic subsistence-settlement strategies precisely because of the expectation that toolstone procurement was embedded in subsistence-pursuits. Yet if we consider the models of Jones and colleagues (2003) and Madsen (2007) against the backdrop of ethnohistorically- and ethnographically-known hunter-gatherers, several questions arise regarding the scale of hunter-gatherer mobility and the movement of toolstone.

While both Jones et al.'s (2003) model and Madsen's (2007) model represent significant efforts to understand fundamental aspects of Paleoarchaic adaptation, both models are discordant with modern hunter-gatherer data: Jones et al. (2003) proposed residential mobility over an area far in excess of anything documented ethnographically, regardless of habitat, while Madsen (2007) proposed long-distance hunting forays in an environmental context (i.e., rich wetland and adjacent steppe) that does not seem to necessitate comparably long-distance logistical forays among ethnographically-known hunter-gatherers occupying similarly rich habitats (so long as we ignore forays to acquire flint, obsidian, or other materials that are motivated by social or ideological considerations). Recognizing this problem, Great Basinists have begun to refine and even break apart the OCZs initially defined by Jones et al. (2003; Jones and Beck 2010; Jones et al. 2012; Smith 2010). Nevertheless, these new, smaller OCZs are still far larger than the foraging ranges one sees amongst modern hunter-gatherers. In other words, OCZs may simply be too big to represent annual or territorial ranges in the pursuit of subsistence, whether employing residential or logistical mobility (see Lothrop 1989 for a similar position in the Northeast). By comparison with the Nunamiut Eskimo, Steven Simms (2008:Figure 3.8) recently reached a similar conclusion and suggests that OCZs may reflect the lifetime range (after Binford 1983a) of Paleoarchaic groups; yet, even the lifetime range of the Nunamiut tends to be much smaller than the Paleoarchaic OCZs (Binford 1983b). More significantly, though not a point pursued by Simms (2008), the lifetime range as defined by Binford (1983b) includes not only trips for subsistence, *but also trips for information, marriage, and other social purposes*. Thus, we are left with the distinct possibility that OCZs reflect regional networks maintained through what Robert Whallon (2006) calls "non-utilitarian mobility" and/or exchange, both of which seem to be under-appreciated by all but a few Paleoindianists (e.g., Anderson 1995; Hayden 1982; Tankersley 1989; see discussion in Speth et al. 2012).

Ultimately, in the research I describe here I attempt to determine what Paleoarchaic behavioral processes might account for the widespread distribution of obsidian that was initially documented by Jones and colleagues (2003). I will suggest throughout this study that disentangling these alternative interpretations of Paleoarchaic mobility and toolstone procurement requires considering the areas circumscribed by obsidian distribution in light of: (1) the paleoenvironmental and geological settings within which Paleoarchaic populations lived; (2) the technological organization of fine-grained volcanic (FGVs, e.g., andesite and dacite) and chert artifacts, as a complement to obsidian; (3) ethnohistorically- and ethnographically-documented hunter-gatherer data on mobility and resource transport; and (4) patterns of toolstone procurement and transport documented at Paleoindian sites from outside the Great Basin. At a more immediate level, my goal is to contextualize present knowledge of the procurement, transport, and utilization of obsidian within an understanding of the lithic landscape that includes the other types of toolstone utilized by Paleoarchaic populations. To do this, I conduct a technological and provenance analysis of chert artifacts from many of the same

Paleoarchaic assemblages in east-central Nevada that Jones and colleagues (2003) used in their study. George T. Jones and Charlotte Beck, with a bevy of field school students from Hamilton College in central New York in tow, have conducted archaeological fieldwork in this area since the late-1980s, collecting and analyzing over 18,000 lithic artifacts. Jones and colleagues, including several Hamilton College students working on senior theses (myself included), have conducted provenance analysis on more than 800 obsidian and 200 FGV artifacts from these assemblages, providing a rich dataset against which to compare the chert data that I present here.

Material selection patterns are pronounced within many Paleoarchaic lithic assemblages: stemmed projectile points are most often made of obsidian and other FGVs; in contrast, lanceolate points, gravers, scrapers, and crescents are typically made of chert (e.g., Amick 1995, 1999; Basgall 2000; Beck and Jones 1990a; Elston 1994; Tadlock 1966). Thus, we might expect different types of toolstone to reflect distinct aspects of Paleoarchaic behavior, realized in the different tool types and activities for which they were used (see Thacker 2006 for a similar perspective on Portuguese Estremadura during the Epipaleolithic and Mesolithic). We might imagine a scenario in which chert gravers and scrapers reflect the localized processing activities of women and other more-sedentary occupants of a camp, FGV bifaces and projectile points reflect the logistical hunting forays of men (and, perhaps, weapons used in conflict with other groups), and obsidian and high-quality chert projectile points reflect long-distance non-utilitarian mobility and/or exchange to maintain mating and informational networks. The parallels of such a scenario with current research on hunter-gatherers, which repeatedly demonstrates the divergent goals of male and female foragers, as well as the multiple scales that constitute hunter-gatherer mobility, are particularly intriguing (e.g., Bird 1999; Cashdan 1996; Elston and Zeanah 2002; Hill and Kaplan 1988a, 1988b; Panter-Brick 2002; papers in Sellet et al. 2006; Surovell 2000; Whallon et al. 2011). I do not wish to promote a new dichotomy between utilitarian and non-utilitarian pursuits, however. As I discuss at length in Chapter 3, the acquisition of obsidian through exchange or non-utilitarian mobility does not negate the utility of obsidian for more mundane tasks. Conversely, long-distance non-utilitarian forays necessarily include subsistence pursuits. Of more immediate concern, the potential to develop a comprehensive, multi-tiered model of Paleoarchaic mobility and intergroup interaction remains only partially realized, in part because chert provenance has been so poorly documented in the Great Basin.

Elsewhere in North America, Paleoindians regularly used chert to manufacture projectile points and extensive research has established that some of those cherts were derived from sources located hundreds of kilometers from the sites where the artifacts were recovered. Yet Great Basinists typically argue that obsidian, because of its "higher quality" (especially its sharpness and the ease with which it can be flaked), was preferred for projectile points and was transported long distances while chert was not (Aikens 1970; Beck and Jones 1990b, 1997). Obsidian may not be as great a material for projectile points as many Great Basinists maintain, however. In a paper frequently cited by Paleoindianists to connect the procurement of high quality toolstone and mobility, Albert Goodyear (1979, 1989) disparages obsidian because it is brittle, dulls quickly, and is prone to breakage—in short, it may not have been a reliable toolstone for Paleoindians (also see Ellis 1997; S. Hughes 1998). Before Great Basinists posit that Paleoarchaic people travelled hundreds of kilometers to procure "high quality" obsidian, we should first ask a very basic question: did the utilitarian benefits of the obsidian outweigh the costs and risks of the trip? Was the chert available in many geological formations throughout the Great Basin simply of such poor quality that it could not be reliably flaked into stemmed points? Our current knowledge of chert provenance within the Great Basin is insufficient to answer this question. Thus, at the most basic level I seek to document the geological-geographic distribution of tool-quality chert in the specific region I have selected for this study (i.e., east-central Nevada). I set the stage for these geological and technological analyses by first considering the questions posed above regarding current models of Paleoarchaic subsistence-settlement in light of previous environmental and archaeological research in the Great Basin, as well as hunter-gatherer data.

The models developed by Jones et al. (2003) and Madsen (2007) recast a decades-old debate regarding the role of wetlands in Great Basin subsistence-settlement strategies. For example, more than half a century ago, Jesse Jennings (1957) suggested that Great Basin foragers were cyclic wanderers, while Robert Heizer (Heizer and Napton 1970) suggested that the abundant marsh, river, spring, and lake resources encouraged sedentism. While most researchers now agree that wetlands are "biotic magnets" (Oetting

1999:209), the short- and long-term variability of wetland productivity (Raven 1992; Rhode 1990) encourages continued debate over the role wetlands may have played in subsistence-settlement strategies. Thus, in Chapter 2 I consider the environmental settings inhabited by Paleoarchaic people. These data demonstrate that the TP/EH, which encompasses the Younger Dryas, was a period of dramatic environmental change, the timing and extent of which varied across the Great Basin. The environmental record, therefore, suggests that we should expect significant behavioral variability. Other Great Basinists have previously made this point (e.g., Aikens 1978; Bettinger 1978, 1993; Jennings and Norbeck 1955; Madsen 1982b, 1999, 2007; O'Connell and Madsen 1982; Simms 1999), though there remains a tendency to view Great Basin prehistory through the prism of a particular valley or rockshelter (the "View From" syndrome, D. Fowler 1977). Here I draw on archaeological research throughout the Great Basin in an effort to develop the close coordination between subsistence, settlement, and seasonality studies that Lawrence Straus (1991) once argued is critical to achieving the explanatory potential of lithic studies, which so dominate Paleoarchaic research. Finally, this discussion of previous environmental and archaeological research will establish the trajectory that has led to our current understanding of Paleoarchaic behavior.

In Chapter 3 I consider the Paleoarchaic record against the backdrop of ethnohistorically- and ethnographically-known hunter-gatherers. I begin this chapter by demonstrating the discord between Jones et al.'s (2003) and Madsen's (2007) models and the ethnographic record by lining them up against previous models of hunter-gatherer mobility (e.g., Binford 1983b; MacDonald and Hewlett 1999; Sampson 1988), focusing especially on data pertaining to residential and logistical mobility in the pursuit of subsistence (from Kelly 2007). I use H. Martin Wobst's (1974, 1976) insights on Paleolithic societies to consider the spatial organization of Paleoarchaic groups, thereby "populating" the OCZs. I then discuss the role of non-utilitarian mobility and exchange in developing and maintaining a regional network across these Paleoarchaic groups. I draw on a variety of ethnographic cases, integrated through a behavioral ecological perspective on information, to argue that intergroup social interactions are likely to have been important and recurrent and, contrary to the prevailing Paleoindian wisdom, cannot simply be dismissed as "risky." My consideration of these different types of mobility is connected by an exploration of a series of questions concerning the scale of hunter-gatherer behavior: (1) What is the spatial extent of residential mobility (i.e., annual and territorial ranges) among hunter-gatherers? (2) What is the spatial extent of logistical forays among hunter-gatherers? Who participates? What do they procure? What do they transport? (3) What is the spatial extent of non-utilitarian mobility among hunter-gatherers? Who participates? What do they transport? (4) Is exchange between residentially mobile hunter-gatherers at low population density "risky" (e.g., Hofman 1992; Jones et al. 2003; Meltzer 1989)? What is the spatial extent of exchange among hunter-gatherers? Under what circumstances does exchange occur (e.g., at aggregation events such as fandangos or corroborees; Flood 1976; Steward 1938)? What is exchanged?

With these theoretical considerations in mind, I turn in Chapter 4 to a technological analysis of chert artifacts from a series of Paleoarchaic localities (i.e., surface lithic assemblages) in east-central Nevada. As discussed briefly above, many Paleoarchaic lithic assemblages demonstrate pronounced toolstone preferences—"hunting gear" tends to be made of obsidian and FGVs, while "processing gear" tends to be made of chert. These toolstone preferences lead very nicely to the expectation that obsidian tools are more likely to be curated and carried over longer distances by the people who made and/or used them, while chert tools are more likely to be utilized expediently and carried over shorter distances. Explicit tests of this expectation, through simple comparisons of these subsets of Paleoarchaic lithic assemblages, are not frequently undertaken, however. Though many Paleoarchaic lithic assemblages exhibit the toolstone preferences identified above, the differential treatment (i.e., procurement, transport, utilization, and discard) of these toolstone types remains insufficiently explored. In the technological comparisons undertaken here, I find that chert, FGVs, and obsidian artifacts are not always treated as differently as Great Basinists might expect. To facilitate further comparisons between these toolstone types, I also partition the chert sub-assemblage into macroscopically-similar subgroups (i.e., different types of chert). I find that the tendency to treat chert en masse masks significant variability within these assemblages, including the potential to document distinct chert procurement ranges that operate within the OCZs. These technological analyses suggest that the annual or territorial ranges utilized by Paleoarchaic populations may be better reflected by chert or FGV provenance than by obsidian provenance.

The variability manifest amongst the chert subgroups within these Paleoarchaic lithic assemblages also begs the question: is it possible to source chert in the Great Basin? Chapter 5 provides an affirmative answer to this question, at least in some cases. In this chapter I reconstruct the lithic landscape occupied by Paleoarchaic groups, considering the distribution of tool-quality chert outcrops around the east-central Nevada assemblages analyzed in Chapter 4. Contrary to the cursory treatment of chert in much of the Paleoarchaic literature, I find that tool-quality chert—that is, cherts that are not filled with impurities, riddled with microfractures, or otherwise difficult to flake—is not ubiquitous, despite the widespread availability of chert geologically. This observation is tempered, however, by the documentation of ample tool-quality chert outcrops at much closer proximity than many FGV and obsidian sources. This fuller understanding of the Paleoarchaic lithic landscape, combined with the paleoenvironmental and archaeological data presented in Chapter 2, suggests that the subsistence and toolstone requirements of Paleoarchaic populations could have been met in ranges much smaller than even the revised OCZs. Yet I also find that the distribution of some cherts crosses the recently revised OCZs for eastern Nevada. In combination, these geological, paleoenvironmental, ethnographic, and archaeological data lead me to the conclusion that obsidian, and perhaps some high-quality cherts, may have been procured and transported over long distances through non-utilitarian mobility and/or exchange.

In Chapter 6, I reconsider the pioneering work of Jones et al. (2003) and Madsen (2007) on Paleoarchaic subsistence-settlement strategies in light of the data amassed in the preceding chapters. I suggest that Great Basinists must not hamstring themselves by privileging one set of data (e.g., obsidian provenance) over another. Previous Great Basinists have argued over the relative merits of subsistence, locational, and assemblage data (e.g., Bettinger 1981; Madsen and Berry 1975; Thomas 1981a). Certainly each dataset has strengths and weaknesses, but this realization suggests the value of a more comprehensive treatment of these data, especially if we are grappling with behaviors that are as fundamental to hunter-gatherer society as mobility. The variability manifest in these archaeological data, as well my consideration of hunter-gatherer ethnography, support important aspects of both Jones et al.'s (2003) and Madsen's (2007) models of Paleoarchaic behavior—providing we identify the time and place in the dynamic TP/EH Great Basin. None of these data, however, necessitate Paleoarchaic foraging ranges encompassing the vast areas circumscribed by OCZs (also see Duke and Young 2007; Eerkens, Rosenthal, et al. 2007) nor do they preclude the role of non-utilitarian mobility and/or exchange as processes that may have contributed significantly to the archaeological record, even if they are hard to "see." Rather, these data suggest a multi-tiered, multi-dimensional of Paleoarchaic mobility and exchange. With this in mind, I conclude by exploring the implications of this study for our understanding of later Great Basin prehistory and Paleoindian mobility, exchange, and technological organization more generally.

Chapter 2: Framing the Questions: The Terminal Pleistocene/Early Holocene Environmental and Archaeological Records

This chapter provides a detailed overview of previous research into the Great Basin Terminal Pleistocene/Early Holocene (TP/EH) environmental and archaeological records. This overview includes information from across the Great Basin because the long-distance transport of obsidian, presumably as a reflection of residential and/or logistical mobility, is a pan-Basin phenomenon. In this chapter I describe the environment inhabited by Paleoarchaic populations, as well as the research trajectory that has led to our current understanding of Paleoarchaic behavior. Significantly, the topography and geology of the Great Basin contributes to marked latitudinal and elevational variability in biotic communities. The current vegetational zones provide a baseline against which Great Basinists consider the significant latitudinal and elevational shifts in plant species and communities that accompanied TP/EH climatic variability and, in turn, impacted the Great Basin's prehistoric residents. During the TP/EH, the Paleoarchaic inhabitants of the Great Basin would have encountered pluvial lakes, extensive marshes, flowing streams, and sagebrush mingled with montane woodlands, followed by substantial biotic reorganization as the Early Holocene waned. Disagreement persists over how Paleoarchaic groups would have incorporated these highly productive, though regionally and temporally variable, localities into their subsistence-settlement strategies. In my consideration of these data, I will depict a temporally, spatially, and culturally variable setting that may, in fact, support elements of both Jones et al.'s (2003) and Madsen's (2007) models of Paleoarchaic behavior, provided we pay particularly close attention to time and place. Yet as will become clear, none of these data necessitate Paleoarchaic foraging ranges encompassing the vast areas circumscribed by OCZs nor do they preclude non-utilitarian mobility and/or exchange as significant aspects of Paleoarchaic behavior.

Physical Setting

John C. Frémont (1845) first used the term Great Basin to describe a region characterized today by great aridity, high topographic relief, and internal drainage. The Great Basin forms the central section of the intermountain region of western North America, including most of Nevada, eastern California, western Utah, southern Idaho, and southern Oregon. The hydrographic Great Basin (Figure 2.1), marked by internal drainage, is perhaps the most widely known definition of this region, though the history of changing drainage patterns within the Great Basin has periodically rendered this definition inaccurate (King 1986; Mifflin and Wheat 1979; Smith and Street-Perrott 1983). The hydrographic Great Basin actually consists of 187 separate internal drainage systems, more than 80% of which contain modern lakes or playas (King 1986:Table 1; Madsen et al. 2002:Figure 5).

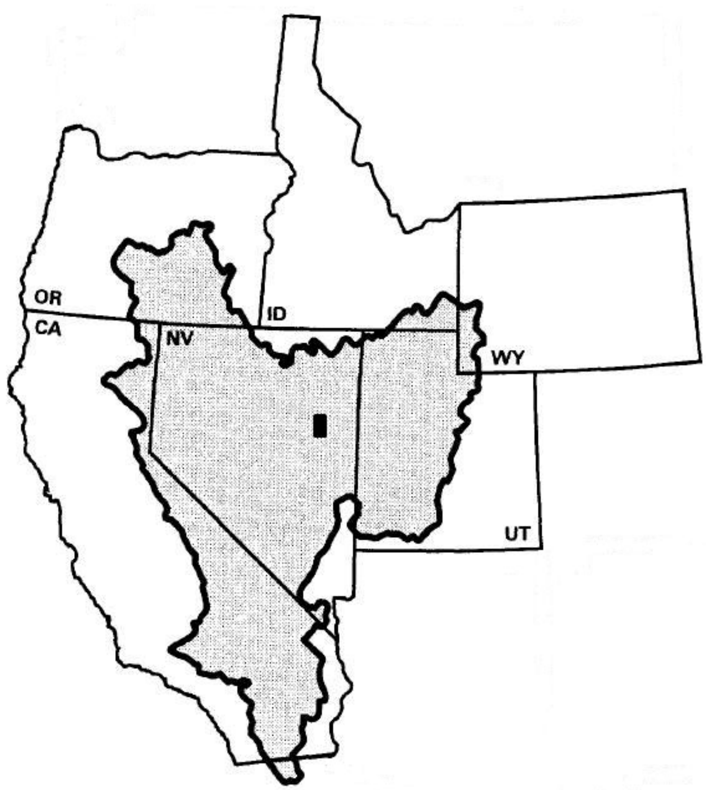

Figure 2.1: The limits of the hydrographic Great Basin (adapted from King 1986). The black box depicts the Eastern Nevada Study Area.

Since Frémont's time, the Great Basin has known several alternative characterizations (e.g., d'Azevedo 1986:Figures 2, 3; Grayson 1993; Jennings 1986; King 1986; Madsen et al. 2002). Definitions based on structural geology, biota, and cultural traditions extend the boundaries of the Great Basin beyond the limits of hydrographic drainage (Gleason and Cronquist 1964; Jennings 1986:Figure 1; Madsen et al. 2002:Figure 2). It is also common practice to divide the province into a number of subdivisions (e.g., Beck and Jones 1997:Figure 1; Houghton 1976; Hunt 1967; Jennings 1986:Figure 1; King 1986:Figure 2). The Great Basin I refer to here (Figure 2.2) follows Beck and Jones (1997:Figure 1). So defined, the Great Basin excludes King's (1986:Figure 2) Salton subdivision and that part of the hydrographic province that includes the Sonoran Desert (Madsen et al. 2002:Figure 4). The Eastern Nevada Study Area falls within the Central Great Basin.

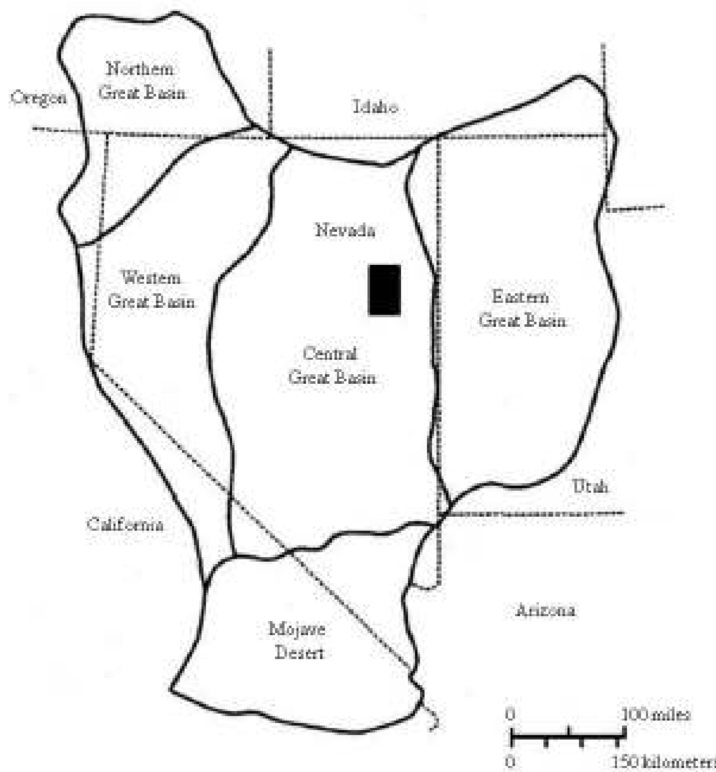

Figure 2.2: Geographic subdivisions of the Great Basin (adapted from Beck and Jones 1997:Figure 1).

The physiographic Great Basin is defined by a very distinctive topography, attributable to extensional forces which began at least as early as the Oligocene and continue to the present (e.g., Coney and Harms 1984; Effimoff and Pinezich 1981; Morrison 1965; Stewart 1980a; Zoback et al. 1981). More than 160 discontinuous, north-south trending fault-bounded mountain ranges rise 300 to 1500 m above equally numerous intervening broad valleys (Morrison 1965). Due to the combination of epeirogenic uplift and block faulting, the Great Basin in cross-section resembles a partly collapsed arch, peaking in eastern Nevada, and sloping generally southward (Morrison 1965). The gently sloping uplands of the northern Great Basin ranges give way to increasingly dissected mountains farther south (Spaulding 1990).

Volcanism associated with Quaternary block faulting extruded basaltic and andesitic flows over wide areas in the northwestern Great Basin, though Quaternary volcanism was lacking in northeastern and southeastern Nevada and in most of western Utah (Morrison 1965). Significantly, volcanic deposits containing obsidian are generally younger than 15 million years old and tend to occur along the perimeter of the Great Basin, especially to the north and west (Stewart 1980b). In the central Great Basin, volcanism tends to be greater than 30 million years old and obsidian, if present at all, occurs only as small nodules or pebbles (i.e., Apache tears; Stewart 1980b). In fact, after almost 25 years of research in eastern Nevada, George T. Jones and Charlotte Beck have not identified any sources of large obsidian nodules in the region (Jones et al. 2003). The geological distribution of volcanic deposits, especially obsidian, is of particular anthropological significance, as considered in more detail later in the chapter.

In the aftermath of intensive deformation, erosion and sedimentation became so active that most topographic features present today were formed during the Pleistocene (Morrison 1965). Erosion stripped the uplands of huge volumes of sediments and dissolved salts, depositing them in the intervening valleys to depths ranging from a few to several thousand feet (Harper 1986; Morrison 1965). Valley floors are often characterized by concentric stratification of progressively finer deposits, a testament to the deceleration imposed upon sediment-laden torrents emanating from mountain canyons by the resident pluvial lakes (Harper 1986). Thus mountain flanks are often buried by boulder-strewn bajadas, while valley bottom playas consist of only clays and salts. Dune fields, built by alternating periods of silt deposition during playa flooding and wind scouring during drying, often lie nearby (e.g., Jenkins, Droz and Connolly 2004:34-35).

Modern Environments

The Great Basin currently experiences a continental climate with large differences between summer and winter temperatures, and a large diurnal range in temperature. Located in the rainshadow of the Sierra Nevada, the Great Basin sees little of the moisture carried eastward from air masses originating in the Pacific Ocean (Aschmann 1958; Morrison 1965). The season of dominant precipitation shifts from the cold months in the north to the warm months in the south (Kay 1982:Figure 1; Mitchell 1976:Figure 3; Mock 1996:Figure 8; Spaulding and Graumlich 1986; though see Tang and Reiter 1984:Figure 17), reflecting the increasing influence of the North American monsoon (Adams and Comrie 1997). Additionally, precipitation increases and pan evaporation decreases toward the eastern edge of the Great Basin (Harper 1986:Figure 1). The precipitation that does fall in the Great Basin is strongly influenced by orography (i.e., the storms tend to precipitate increasing amounts of moisture with increasing altitude; e.g., Hirschboeck 1991). As a result, mean annual precipitation commonly differs by more than 20 inches (51 cm) over only a few miles, and varies from less than 4 inches (10 cm) in the lower basins to more than 30 inches (76 cm) on the highest mountain summits (Morrison 1965). The geologic sorting of alluvium into the concentric arrangement of soil texture and salinity described above, combined with these trends in precipitation, profoundly influences the distribution and productivity of plant species and associated fauna (Billings 1951; Gleason and Cronquist 1964; Harper 1986).

The biotic Great Basin is defined more by the distribution of plant communities than by the animals dependent upon them (Gleason and Cronquist 1964). The floristic Great Basin is characterized by areas whose lower elevations include plant communities in which shadscale (*Atriplex confertifolia*) and sagebrush (*Artemisia* sp.) predominate and whose mountain flanks are marked by some combination of piñon-juniper woodland (*Pinus edulis* or *P. monophylla-Juniperus* sp.) (Billings 1951; Brown 1994a, 1994b; Cronquist et al. 1972; Turner 1994), though the complexity of these vegetational zones varies (e.g., Harper 1986:Figure 3; Grayson 2011). The Shadscale Zone occupies the valley bottom and is characterized by a shrub community consisting of shadscale, saltbush (*Atriplex* sp.), rabbitbrush (*Chrysothamnus* sp.), and winterfat (*Ceratoides lanata*) (Cronquist et al. 1972; Turner 1994). Rodents are the primary mammalian residents of this zone, though they are so sparse as to make this region unattractive to native peoples (Harper 1986). Numerous marshes, consisting of rushes (*Scirpus* spp.), various grasses (e.g., *Distichlis spicata*, *Phragmites australis*, *Puccinellia nuttalliana*), and halophytes (e.g., *Allenrolfea occidentalis*, *Salicornia virginica*), also occur in the basins of Pleistocene lakes and were much more attractive to native peoples (Harper 1986). The Sagebrush Zone occupies the better-drained alluvial fans, usually occurring between 1200-2100 m in elevation. The primary species of this zone is big sagebrush (*Artemisia tridentata*), often mixed with bunch grasses (e.g., wheat grass, rice grass, fescus) and rabbitbrush (Billings 1951; Cronquist et al. 1972; Turner 1994). Associated animals include hares (*Lepus* sp.), rabbits (*Sylvilagus* sp.), pronghorn antelope (*Antilocapra americana*), and even bison (*Bison bison*), at least during historic times in the northern Great Basin (Grayson 2006a; Harper 1986).

The lowest extensive arboreal community, occurring between ~1500-2400 m, is the Piñon-Juniper Zone (Cronquist et al. 1972). The piñon species present in the eastern Great Basin (Colorado or double-leaf piñon, *Pinus edulis*) differs from that present in the central and western Great Basin (single-leaf piñon, *Pinus monophylla*); piñon does not grow in the northern Great Basin (Brown 1994a; Fowler 1986:Figure 1). Though few animals are closely tied to the piñon-juniper woodlands, they are frequented by elk (*Cervus canadensis*) and mule deer (*Odocoileus hemionus*) during the winter (Brown 1994a). Along the western and eastern margins of the Great Basin, the piñon-juniper woodland gives way to montane forests that include ponderosa pine (*Pinus ponderosa*), blue spruce (*Picea pungens*), white fir (*Abies concolor*), and Douglas fir (*Pseudotsuga menziesii*) (Billings 1951). In much of the central and northwestern Great Basin, montane forest is replaced by sagebrush grassland (Brown 1994b; Harper 1986). Snow-free hillsides provide winter feeding areas for mule deer, as well as numerous birds (Brown 1994b). Finally, on many of the higher mountains grows a subalpine coniferous forest that includes bristlecone pine (*Pinus longaeva*), limber pine (*Pinus flexilis*), Engelman spruce (*Pinus englemannii*), and quaking aspen (*Populus tremuloides*) (Cronquist et al. 1972).

Important floristic differences between the Great Basin deserts and the Mojave Desert are due to latitudinal influences on photoperiod, as well as climatic and edaphic factors. Mountain ranges in the Mojave Desert bound valleys that range from 1000 to 500 m in basal elevation from north to south (Spaulding 1990). Warm desertscrub, including creosote bush (*Larrea divaricata*), white bursage (*Ambrosia dumosa*), and desert spruce (*Peucephyllum schottii*), occur throughout much of the southern Mojave but is less widespread in the northern Mojave (Spaulding 1990). Blackbrush (*Coleogyne ramosissma*), Joshua tree (*Yucca brevifolia*), ground-thorn (*Mendora spinescens*), and boxthorn (*Lycium* sp.) are among the plants typical of the cold-temperate desertscrub of the northern Mojave (e.g., Brown et al. 1979:Table 6). Great Basin desertscrub is an important vegetation type on the valley flanks of the northern Mojave Desert (Spaulding 1990). On the few mountain ranges large enough to support forest vegetation, piñon-juniper woodland occurs between 1800 m and 2200 m (Spaulding 1995). In larger mountain ranges east of the Amargosa Desert, the piñon-juniper woodland gives way to a fir-pine forest (*Abies concolor-Pinus ponderosa*), while in larger mountain ranges west of Death Valley fir-pine forest is replaced by black sagebrush (*Artemisia nova*) scrub or mountain mahogany (*Cercocarpus intricatus*) (Spaulding 1990).

The interrelated variation in topography, soil texture and salinity, precipitation, flora, and fauna combined to profoundly influence the ecology of the native peoples of this region (Harper 1986; also see Fowler 1986 and references therein). The current vegetational zones provide a baseline against which Great Basinists consider the significant elevational shifts in plant species and communities that accompanied TP/EH climatic variability and, in turn, impacted the Great Basin's prehistoric residents.

Terminal Pleistocene/Early Holocene Environments

CLIMATE AND HYDROLOGY

Efforts to understand Great Basin paleoenvironments may be traced to late-19th and early-20th century descriptions of geomorphic and stratigraphic evidence for the numerous pluvial lakes scattered across the Pleistocene Great Basin (Gale 1915; Gilbert 1890; Meinzer 1922; Russell 1885). Building especially on Grove Karl Gilbert's research in the Bonneville basin (Oviatt 2002), Ernst Antevs (1935, 1937, 1940, 1945, 1952, 1953, 1955) developed careful arguments correlating lake fluctuations in the Bonneville and

Lahontan basins with the growth and decay of Northern Hemisphere ice sheets and mountain glaciers, as well as the glacial chronology of northern Europe. Antevs (1948) argued that during the late Pleistocene the North American ice sheets, especially the Cordilleran, attained sufficient size to deflect the polar front southward; consequently, storms originating in the Pacific Ocean carried moisture into the Great Basin to create the pluvial lakes. Although the details of Antevs's correlations between Lake Bonneville, Lake Lahontan, and glacial events have not withstood scientific scrutiny (e.g., Aschmann 1958; Bryan and Gruhn 1964; Durrant 1970; Jennings 1957, 1964; Madsen 1999, 2007; Martin 1963; Mehringer 1985; Zielinski and McCoy 1987), recent research has demonstrated the general validity of his conviction that the pluvial lakes responded to major climatic changes operating on a global scale (e.g., Benson et al. 1997; COHMAP Members 1988; Jimenez-Moreno et al. 2007; Minckley et al. 2004; Mix et al. 1999; Zic et al. 2002).

Additionally, computer simulations and field data support Antevs's suspicion that the North American ice sheets diverted storm tracks into the Great Basin to feed the pluvial lakes. These simulations indicate that during the Last Glacial Maximum (LGM, ~18,000 ^{14}C yr BP), the Laurentide ice sheet split the flow of the jet stream into two and pushed the polar jet stream as much as 20° south of its current position (Barry 1983; Bartlein et al. 1998; Broccoli and Manabe 1987a, 1987b; COHMAP Members 1988; Gunn 1992; Hostetler and Benson 1990; Hostetler et al. 1994; Kutzbach 1987; Kutzbach et al. 1993; Kutzbach and Wright 1985:Figure 11; Kutzbach and Guetter 1986; Manabe and Broccoli 1985; Thompson et al. 1993; though see Zic et al. 2002). This southerly displacement of the jet stream, in combination with stronger-than-present Aleutian Low and weaker-than-present eastern Pacific Subtropical High pressure systems, increased the effective moisture reaching the Great Basin from the Pacific Ocean (Minckley et al. 2004). Climatic simulations and environmental data also suggest that the Great Basin saw a decrease in mean annual temperature and evaporation at this time. These factors tipped the balance between inflow and evaporation in favor of inflow, filling more than 120 valley bottoms with ~27,800,000 acres of pluvial lakes between ~ 18,000 and 12,000 ^{14}C yr BP (Figure 2.3; Hostetler and Benson 1990:Figure 1; Grayson 1993; Thompson et al.

1993). These “lake cycles” also supported glaciers in many Great Basin ranges (Osborn 2004; Zielinski and McCoy 1987).

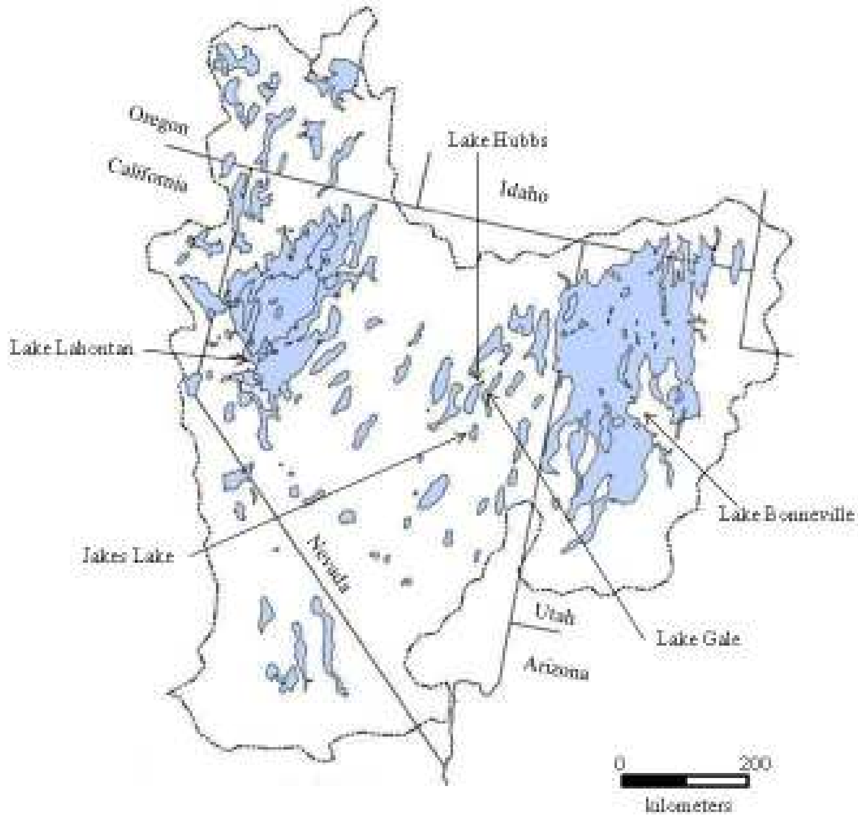

Figure 2.3: Great Basin pluvial lakes at their Pleistocene maximums, ca. 14,000 ^{14}C yr BP (adapted from Grayson 1993, 2011:Figure 5-5; Madsen et al. 2002:Figure 6; Mifflin and Wheat 1979; Williams and Bedinger 1984). Lake Hubbs (in Long Valley), Lake Gale (in Butte Valley), and Jakes Lake (in Jakes Valley) are located within the Eastern Nevada Study Area.

Following the LGM, Great Basin climatic history is complicated by a series of brief but significant climatic oscillations that interrupt a gross trend toward comparatively warmer and drier conditions (Mensing 2001; Peteet 1995). As the northern ice sheets regressed following the LGM, the polar jet stream retreated northward, resulting in less effective moisture reaching the Great Basin (COHMAP Members 1988), though evidence from glacial-cirque elevations suggest a greater-than-present latitudinal gradient of effective moisture with the northern Great Basin receiving relatively more moisture than regions farther south (Minckley et al. 2004). This moisture fed the last high stand of the pluvial lakes, which occurred closest to the LGM farther south (between 32-35° N) and slightly later farther north (between 38-40° N; Garcia and Stokes 2006). The largest and best known pluvial lakes—Lake Bonneville in the eastern Great Basin and Lake Lahontan in the western Great Basin—both reached their maximum volume and surface areas between 18,000 and 14,000 ^{14}C yr BP (Figure 2.3; Benson and Thompson 1987a, 1987b; Benson et al. 1990, 2011; Currey 1990; Oviatt 1997; Oviatt et al. 1992; Thompson et al. 1986).

Climatically-induced regression in Lake Bonneville began about 14,000 ^{14}C yr BP (Currey and Oviatt 1985; Oviatt et al. 1992; though see Godsey et al. 2005) and after 13,250 ^{14}C yr BP in Lake Lahontan (Benson et al. 1990; Dansie et al. 1988; Dansie and Jerrems 2004; Davis and Elston 1972); the Central (Thompson 1992) and Mojave Desert (Benson et al. 1990; Smith and Street-Perrott 1983; Wells 1979) subdivisions exhibit complementary pluvial chronologies. More specifically, pluvial lakes Gale, Hubbs, and Jakes in the Eastern Nevada Study Area exhibit pluvial chronologies broadly synchronous with Lahontan and Bonneville events (Benson and Thompson 1987a; Garcia and Stokes 2005, 2006; Holmes and Huckleberry 2009; Mifflin and Wheat 1979; Young and McCoy 1984). Although the regional effects of Younger Dryas cooling are not well understood (Benson et al. 1997; Oviatt et al. 2005), the Bonneville basin, at least, records an increase in lake levels during this interval (~11,000 ^{14}C yr BP). Paleoarchaic populations would have witnessed Lake Bonneville rise to the Gilbert Shoreline (~10,300 ^{14}C yr BP), more than 10 m higher and four times the surface area of the modern Great Salt Lake (Benson and Thompson 1987a). Lake Lahontan and other pluvial lakes may have enjoyed a similar transgression (Benson et al. 1990; Benson et al. 1997; Briggs et al. 2005; Grayson 2011; Licciardi 2001). Evidence from the Upper Las Vegas Valley and other basins of southern Nevada indicate the activity of alluvial systems, spring-fed channels, and marshy conditions during the TP/EH, rather than extensive pluvial lakes (Haynes 1967; Quade 1986; Quade et al. 1998). Similarly, the Sunshine Locality in the Eastern Nevada Study Area documents an active alluvial system between 10,700 and 10,000 ^{14}C yr BP, followed by marshy conditions (Holmes and Huckleberry 2009:Figure 4.1). In fact, Goebel et al. (2011) suggest that the Younger Dryas was among the best of times for Great Basin inhabitants.

Computer simulations suggest that the beginning of the Holocene (10,000 ^{14}C yr BP) roughly coincides with the summer insolation maximum and a decrease in winter insolation (COHMAP members 1988; Kutzbach et al. 1998). As a result, the Great Basin experienced colder winters and warmer summers than at present. The northern ice sheets sufficiently regressed to allow the polar jet stream to shift northward into its present-day position, and winter atmospheric circulation approximated modern conditions by about 9000 ^{14}C yr BP (Kutzbach and Guetter 1986). Effective moisture appears to decrease across the Eastern Great Basin after ~10,000 ^{14}C yr BP, at which time stream discharge decreases and Lake Bonneville recedes from the Gilbert Shoreline (Benson and Thompson 1987a; Currey 1990; Oviatt 1988; Oviatt et al. 1992; Thompson 1992). The Western and Southern Great Basin and Mojave Desert, however, seem to have enjoyed wetter conditions than at present until as late as 8000 ^{14}C yr BP (Grayson 2011; Wells et al. 2003).

The effect of these climatic and hydrologic changes on TP/EH biota was pronounced, though regionally and temporally variable.

FLORA

Increased moisture and decreased average annual temperatures during the Terminal Pleistocene prompted subalpine and montane woodlands to descend and expand throughout much of the Great Basin (Bryan 1979; Mehringer 1977; Minckley et al. 2004; Weide 1982); taxa such as piñon pine and Douglas fir were displaced southward (Spaulding 1990; Thompson 1990). Significantly, microclimatic variations caused by the topographic diversity of the region contributed to unique biotic mosaics consisting of elements of present-day woodland and basin-floor vegetation (Nowak et al. 1994a, 1994b; Thompson 1990). The inability of trees to germinate in the fine substrate of the basin floors, however, may have halted the woodland descent in at least some areas (Thompson 1990; Thompson and Mead 1982; Van Devender et al. 1987).

In the Mojave Desert, juniper is documented 900 m below its modern limits in association with steppe shrubs (Koehler et al. 2005; Spaulding 1990:Figure 2; Spaulding and Graumlich 1986); today juniper occurs above 1800 m elevation in the Sheep Range of southern Nevada. In the Western Great Basin, midden and pollen records from 12,000-11,000 ^{14}C yr BP indicate lower-elevation mosaics of desert and montane species as juniper-sagebrush expanded and montane trees and shrubs descended to more than 800 m below their modern limits (Mensing 2001; Nowak et al. 1994a, 1994b). In the Eastern Great Basin paleoenvironmental proxies record the descent of several subalpine trees (e.g., bristlecone pine, limber pine, Engelmann spruce, and several montane shrubs) more than 600 m below their modern limits, where they persisted with juniper, sagebrush, snowberry, and other shrubs until at least 12,000 ^{14}C yr BP and until ~10,200 ^{14}C yr BP in favorable mesic settings (Louderback and Rhode 2009; Rhode and Madsen 1995; Thompson 1988, 1990; Wells 1983). Interestingly, the palynological record from the Ruby Marshes in the Central Great Basin records the persistence of sagebrush-dominated steppe throughout most of the TP/EH, rather than the significant downward march of montane conifers documented elsewhere in the Great Basin (Thompson 1992). In the Northern Great Basin, various modern woodland species (e.g., piñon pine, Utah juniper, Douglas fir) were absent during the Terminal Pleistocene (Thompson 1990).

The climatic changes prompted by the regression of the northern ice sheets significantly reorganized the biotic communities the earliest Paleoarchaic populations would have encountered. Packrat middens and pollen profiles reflect decreasing effective moisture throughout the Great Basin (Wigand et al. 1995), though many of the biotic changes first occurred in the south (Spaulding 1990). Packrat middens in the Mojave Desert uplands indicate that piñon-juniper woodland replaced limber pine, which quickly climbed at least 600 m upslope after 12,000 ^{14}C yr BP (Spaulding 1990). Spaulding and Graumlich (1986) attribute this ascent to a shift to summer-dominant monsoons rather than an increase in aridity, consistent with the hydrological record (Wells et al. 2003). Between 12,000 and 10,000 ^{14}C yr BP, lower-elevation sites in the Mojave Desert document the ascent of juniper woodland to its modern elevation (~1600 m; Spaulding 1990). Cool steppe plants initially gave way to succulents (e.g., cactus and Joshua tree), which declined in favor of desert thermophiles (e.g., white bursage, creosote) between 9000 and 8000 ^{14}C yr BP (Spaulding 1990:Figure 9.22). In the Western Great Basin, the upslope retreat of juniper and transition to a more xeric lowland flora occurred between 9000 and 8000 ^{14}C yr BP (Mensing 2001; Nowak et al. 1994a, 1994b; Wigand and Mehringer 1985). In the Eastern Great Basin, Thompson (1990:Figure 10.12) suggests that, the lower limit of juniper ascended 600 m between ~9000-7500 ^{14}C yr BP. Farther east, the Wasatch Mountains document an increase in pine pollen relative to conifers at

~8000 ^{14}C yr BP, which may reflect a shift to warmer climatic conditions (Madsen and Currey 1979). At the same time, Bright (1966) documents significant reductions in arboreal pollen, reflecting increasing dryness in southeastern Idaho. In the Northern Great Basin, pollen profiles from two high elevation lakes on Steens Mountain record a significant increase in sagebrush pollen relative to grass pollen at ~7800 ^{14}C yr BP (Mehringer 1985, 1986). Likewise, lowland pollen profiles indicate a dramatic increase in desertscrub at ~7000 ^{14}C yr BP (Hansen 1947), though Pinson (2004, 2008) has recently suggested that significant drying may, in fact, have occurred ~5000 years earlier. Perhaps most significantly, piñon pine, a dietary staple of late prehistoric and historic Great Basin peoples and a significant impetus for the movement of residential camps (Steward 1938), was not present in the Eastern Great Basin until ~8000 ^{14}C yr BP, and was absent for another 1500-2000 years in the Central and Northern Great Basin (Madsen 1986:Figure 2; Madsen and Rhode 1990; Rhode and Madsen 1998; Thompson 1990:Figure 10:11). As Madsen (1986:33) puts it, "evidence of pinyon use for the period 12,000-6000 years ago can be summed up in a single word: none."

FAUNA

This period of dramatic climate change and floral reorganization also significantly influenced Great Basin fauna. Chief among these faunal changes was the extinction of several species of herbivores and carnivores. Among the 35 genera of mammals that became extinct in North America during the Late Pleistocene, 19 are known from the Great Basin (Grayson 2006b; Jefferson et al. 2004). Though chronological imprecision makes it difficult to state with certainty which of these genera coexisted with the earliest Paleoarchaic inhabitants of the region, seven can be shown to have survived beyond 12,000 ^{14}C yr BP (Grayson 1982, 2006b). The sites Beck and Jones (1997) suggest are most likely to indicate an overlap between humans and extinct fauna (i.e., those sites with the youngest dates) are Tule Springs, Gypsum Cave, the Sunshine Locality, and Huntington Reservoir, though Grayson (1994:Table 4.4) expresses concern regarding dates associated with the latter fauna. Horse (*Equus* spp.), Yesterday's camel (*Camelops hesternus*), and Columbian mammoth (*Mammuthus columbi*) are documented at Tule Springs (Haynes 1967; Mawby 1967); in fact, these three mammals, plus helmeted muskoxen (*Bootherium bombifrons*), are particularly common in the Late Pleistocene record of the Great Basin (Grayson 1982, 1993, 1994, 2006b). The Shasta ground sloth (*Nothrotheriops shastensis*), recovered from Gypsum Cave (Harrington 1933; Long and Martin 1974), is known only from the Mojave Desert subdivision where it may have persisted until 11,000 ^{14}C yr BP (Grayson 2007). At the Sunshine Locality, bones of camel were recovered from alluvial deposits dated between 10,700 and 10,000 ^{14}C yr BP, although AMS dating of bone collage yielded a date of 11,390 ± 60 ^{14}C yr BP (Beta-105662, Cannon et al. 2009; Holmes and Huckleberry 2009:Table 4.4; Jones et al. 1996). Finally, the Huntington Reservoir in the Wasatch Mountains records Columbian mammoth and short-faced bear (*Arctodus simus*) dated between 11,500 and 10,800 ^{14}C yr BP (Gillette and Madsen 1992, 1993; Madsen et al. 1976; Schubert 2010). Saber-tooth cat (*Smilodon fatalis*) and mastodon (*Mammut americanum*) also likely persisted into the Terminal Pleistocene in the Great Basin (Grayson 1989, 1991). Significantly, detailed analyses from the Eastern Great Basin suggest that the few large artiodactyls left after the Late Pleistocene extinctions (e.g., pronghorn antelope, bighorn sheep [*Ovis canadensis*], mule deer) occurred in low densities until the late Holocene, due in large part to the seasonally extreme temperature and precipitation regime of the Terminal Pleistocene through middle Holocene (Broughton et al. 2008).

Additionally, the Great Basin faunal record documents significant elevational and geographic range shifts concomitant with the vegetational reorganization detailed above. Of 16 montane mammals in the modern fauna, including pika (*Ochotona princeps*), yellow-bellied marmot (*Marmota flaviventris*), and Nuttail's cottontail (*Sylvilagus nuttallii*), many are known from Late Pleistocene sites at lower elevations and more southerly latitudes than today (Grayson 1993, 2000, 2005; Schmitt et al. 2002). As Late Pleistocene climate changes induced the descent and expansion of montane woodlands, it is reasonable to imagine that all 16 modern montane mammals became common at lower elevations (Grayson 1982). As montane and subalpine woodland ascended to higher elevations after 12,000-10,000 ^{14}C yr BP, montane mammals probably began to assume their modern distributions; this process likely began earliest in the Mojave Desert (Grayson 1993; Grayson and Livingston 1993). Pika illustrate the response of small mammals during the TP/EH quite well, demonstrating the loss of populations from lower elevations and southern latitudes as effective moisture decreased and temperatures rose (Grayson 2005:Figures 2, 3; Wilkening et al. 2011). Several other species (e.g., pygmy rabbits, yellow-bellied marmots, bushy-tailed woodrats) declined in abundance or were extirpated at the end of the Pleistocene (Grayson 2006b), although interpretation of these patterns is complicated by evidence for recent cross-valley dispersal by some montane mammals (e.g., Grayson and Madsen 2000; Lawlor 1998; contra Brown 1971, 1978).

SUMMARY AND ANTHROPOLOGICAL SIGNIFICANCE

The Great Basin records dramatic, though regionally and temporally complex, climatic and biotic changes during the TP/EH. It seems that Paleoarchaic populations entered the Great Basin during the Terminal Pleistocene, at a time when the pluvial lakes would have been on the decline, only to rebound during the Younger Dryas, and finally decline again after 10,300-9800 ^{14}C yr BP. Yet effective moisture remained high in many parts of the Great Basin, supporting "expanses of shallow lakes and marshes, and flowing streams and springs [that] must have provided attractive habitats for exploitation until perhaps as late as about 8000 B.P." (Beck and Jones 1997:172). Sagebrush steppe mingled with montane woodlands—prime wintering habitat for pronghorn and mule deer (Harper 1986)—would have descended to abut these rich river, lake, and marsh habitats. With the eventual decline of effective moisture and increase in temperature, major vegetational changes occurred, beginning first in the southern Great Basin and moving northward. As marshes dried and montane and subalpine woodlands retreated upslope, less productive desertscrub expanded, becoming widespread in the northern Great Basin after ~8000 ^{14}C yr BP. Significantly, piñon pine would have been unavailable and/or little utilized until at least the Middle Holocene.

Exactly how Paleoarchaic populations would have incorporated these highly productive, though regionally and temporally variable, localities into their subsistence regimes remains debated (see discussion by Zeanah and Simms 1999). Based on his consideration of Eastern Great Basin environmental and archaeological data, David Madsen (1982a:Figure 2; redrawn here as Figure 2.4) proposed three options, each dictated by the productivity of the resource areas. The left option in Figure 2.4 depicts "fully nomadic foragers," who move frequently across a landscape of relatively homogeneous productivity. The relative abundance of resources within any one area is insufficient to permit a high degree of permanency. This option approximates Elston's (1982) reading of the archaeological record in the Western Great Basin and Jones and colleagues' (2003) interpretation of the Eastern Nevada Study Area in the Central Great Basin. The middle option in Figure 2.4 depicts what Madsen (1982a) dubs "Steward's Shoshonian model" (Steward 1938), in which productive resource areas are seasonally variable. Thus, families aggregate at a winter village, but then disperse into smaller, independent economic units (i.e., individual families) during portions of the year when resources are less concentrated and/or abundant. The right option in Figure 2.4 depicts "sedentary collectors," who utilize a restricted area of diverse, concentrated, and abundant resources. While forays outside this procurement area occurred, they need not have been long. This option approximates Madsen's (2007) recent interpretation of the archaeological record of the Eastern Nevada Study Area.

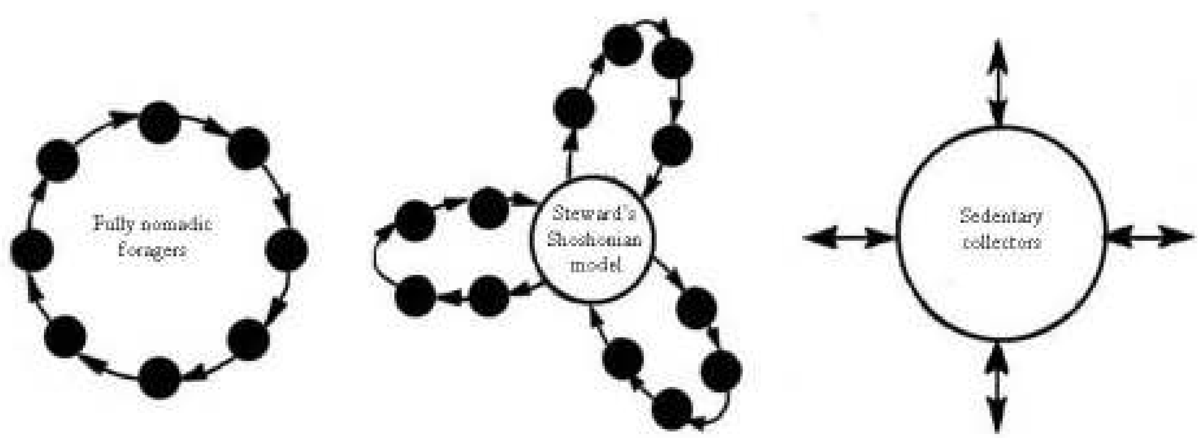

Figure 2.4: Schematic of three types of hunter-gatherer subsistence-settlement strategies (adapted from Madsen 1982a:Figure 2).

Considering only the paleoenvironmental data presented thus far, I suggest that the earliest Paleoarchaic populations may have aligned themselves closer to the right end of Madsen's (1982a:Figure 2) spectrum, especially in the Eastern, Northern, and Western Great Basin where river, marsh, and lake habitats surrounded by vertically compressed vegetational zones were seemingly more abundant. Though the Mojave Desert also may have supported less mobile populations prior to 12,000 ^{14}C yr BP, Paleoarchaic occupation may postdate significant biotic reorganization of this region (though see

Eerkens, Rosenthal, et al. 2007). In the Central Great Basin, where montane woodlands did not descend significantly and pluvial lakes were replaced in many valleys by springs and streams, Paleoarchaic populations may have been more mobile than their counterparts elsewhere in the Great Basin. During the Early Holocene, as effective moisture decreased, marshes and lakes regressed, and biotic communities reorganized, Paleoarchaic groups in many parts of the Great Basin may have become more mobile (Figure 2.4a); this is exactly opposite of what Great Basinists typically expect, though population increase, rather than a decline in environmental productivity, is usually cited as the cause (Eerkens, Rosenthal, et al. 2007). In short, the paleoenvironmental data may suggest a shift from the right end to the left end of Figure 2.4 over the course of the TP/EH, tempered by regional particulars.

With this schematic in mind, we may turn to a consideration of the archaeological record. As I will detail below, a critical problem in understanding the role of marshes and similarly rich settings in Paleoarchaic subsistence-settlement strategies is the lack of data clearly demonstrating the occupational permanency we might expect in at least some areas (though see Simms 1989), despite years of looking. In the absence of these data, Great Basinists are left with a familiar archaeological problem: "local resource abundance [may] be a necessary, but perhaps not sufficient, condition for sedentism" (Kelly 2001:7). Out of this theoretical quagmire, interpretations of locational, subsistence, and technological data often diverge. As I will show in the following section, locational and subsistence data frequently suggest the utilization of water-side habitats and small game, which may indicate smaller foraging ranges; however, Great Basinists typically interpret lithic technology as a reflection of high mobility.

Cultural Record

Though dry caves and rockshelters have figured prominently in prehistoric research in the Great Basin (Aikens 2007; Jones and Beck 1999; e.g., Aikens 1970; Bedwell 1973; Bryan 1979; Cressman 1942; Graf 2007; Hanes 1988a, 1988b; Harrington 1933; Heizer and Napton 1970; Jenkins 2007; Jennings 1957; Orr 1956, 1974; Thomas 1983a, 1985), the Paleoarchaic record consists primarily of surface lithic assemblages scattered across often-deflated TP/EH landforms (e.g., beach terraces). The stratigraphic and associational problems endemic to caves and rockshelters notwithstanding, these settings have provided rich assemblages of fauna, textiles, and other perishable specimens, as well as the chronological control necessary for cross-dating the projectile point types recovered from the significantly more numerous Paleoarchaic surface lithic scatters. In fact, given the predominance of surface lithic assemblages, locational and lithic technological studies have been central to understanding Great Basin prehistory, serving to integrate the data provided by the varied depositional contexts present in the region. The two long-standing questions with which I begin this discussion, however, are necessarily linked closely to excavations in caves and rockshelter: the antiquity of Great Basin occupation and the association of extinct fauna and artifacts.

PALEOARCHAIC ANTIQUITY AND ANTIQUE FAUNA

There are several pre-12,000 ^{14}C yr BP radiocarbon dates reported in association with cultural material in the Great Basin (Figure 2.5) and frequently these dates are also associated with extinct fauna (Beck and Jones 1997, 2001); however, none are problem-free. In Smith Creek Cave, camel hair purportedly associated with lithic artifacts and bone tools dates to 12,060 ± 450 ^{14}C yr BP (Bryan 1979; Harrington 1934; though see Thompson 1985). An apparent association of an obsidian artifact with camel (*Camelops hesternus*) and giant horse (*Equus pacificus*) at Tule Springs returned a date in excess of 28,000 ^{14}C yr BP (Harrington 1934; Harrington and Simpson 1961; Simpson 1933:Figure 4, 5; Wormington and Ellis 1967; though see Cook 1964; Haynes 1967; Shutler 1967; Tuohy 1967). The Manix Lake site in the Mojave Desert (Simpson 1958, 1960) has been controversially dated as early as 16,000 yr BP based on desert varnish (Bamforth and Dorn 1988; Whitley and Dorn 1993; though see Bierman and Gillespie 1991, 1994; Harry 1995). At Fort Rock Cave in the Northern Great Basin, Bedwell (1973:Table 19) reports a date of 13,200 ± 720 ^{14}C yr BP (Gak-1738) in association with several lithic artifacts (Bedwell 1973:Figure 42).

Several sites just younger than 12,000 ^{14}C yr BP also document supposed associations between extinct fauna and artifacts. Harrington (1933), for example, documented the occurrence of wooden artifacts intermingled with sloth dung at Gypsum Cave, though the artifacts were later found to postdate the dung by ~9000 years

(Baumhoff and Heizer 1965; Heizer and Berger 1970). At Fishbone Cave in the Winnemucca basin, Orr (1956, 1974:Table 1) documents a shredded cedar bark mat dated to 11,200 ± 250 ^{14}C yr BP (L-245) in association with basketry fragments, a partial human skeleton, chert knives, and horse, camel, and marmot bones, though taphonomic concerns regarding the bone fragments have been raised by McGuire (1980). Minor and Spencer (1977) record an association between camel bones and fragments of a lanceolate point at Fossil Lake; however, the location of at least one point fragment 15 m from the camel bones suggests redistribution (Beck and Jones 1997). In the Eastern Nevada Study Area, artifacts and camel bones co-occur in alluvial deposits at the Sunshine Locality (Cannon et al. 2009; Jones et al. 1996). Although significant because this is the youngest well-dated *Camelops* currently known from the Great Basin (11,390 ± 60 ^{14}C yr BP, Beta-105662; Holmes and Huckleberry 2009:Table 4.4; Huckleberry et al. 2001), the possibility that the camel bones and/or projectile points were redeposited renders this association insecure as well. Finally, Graf (2007) reports that the earliest unequivocal human occupation of Bonneville Estates Rockshelter, documented by a hearth rather than diagnostic projectile points associated with extinct fauna, dates to 11,010 ± 40 ^{14}C yr BP (Beta-207009).

Presently, the best evidence for both a pre-12,000 ^{14}C yr BP Great Basin occupation, as well as an association of extinct fauna and artifacts, comes from Dennis Jenkins's (2007) recent fieldwork at Paisley 5 Mile Point Cave No. 5. Cressman (1940, 1942, 1966) had previously reported horse, camel, bison, and other fauna associated with fire lenses, obsidian tools and flakes, and long bones broken for marrow extraction from Paisley 5 Mile Point Cave No. 3, though this association was dismissed as spurious because of the lack of quantification and precise provenience (Jennings 1986). In Cave 5, Jenkins (2007:Table 4.2) documents a camel bone dated to 12,300 ± 40 ^{14}C yr BP (Beta-172663) and a horse bone dated to 11,130 ± 40 ^{14}C yr BP (Beta-185942). Three human coprolites have also been recovered and dated by two separate laboratories (Beta Analytic, Inc. and Oxford AMS Radiocarbon Dating Laboratory); two provide dates in excess of 12,000 ^{14}C yr BP (Gilbert et al. 2008; Jenkins 2007:Table 4.2). Goldberg et al. (2009) and Poinar et al. (2009), however, have recently suggested that the coprolites may

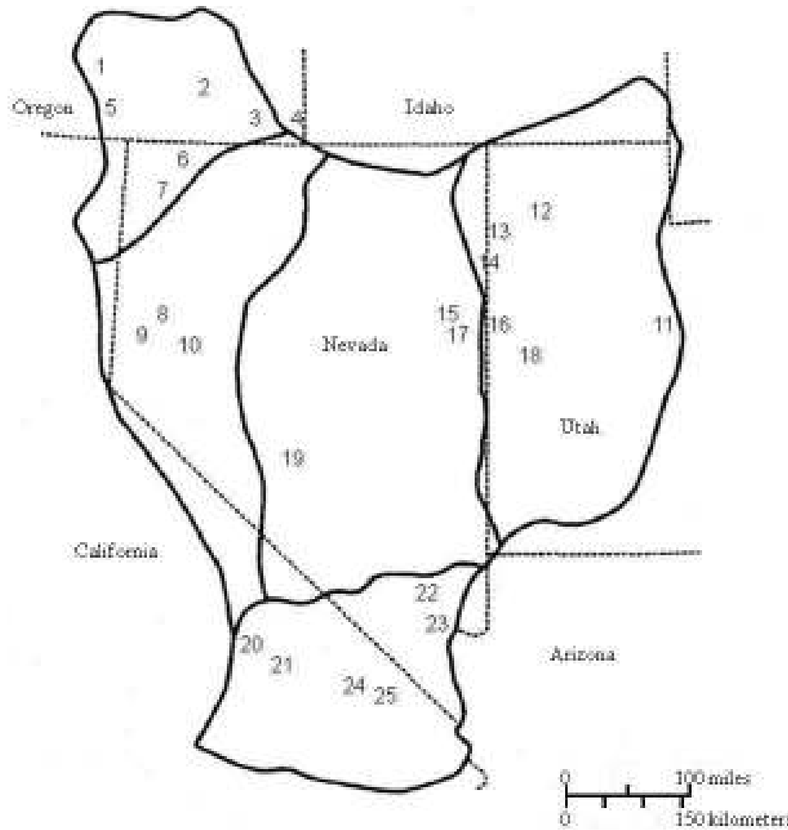

Figure 2.5: Location of significant Paleoarchaic sites: (1) Fort Rock Valley, including Fort Rock Cave, Connley Caves, Paulina Lake, Locality III, Tucker site; (2) Alkalai Basin, including the Dietz site; (3) Steens Mountain; (4) Dirty Shame Rockshelter; (5) Paisley Caves; (6) Last Supper Cave and Hanging Rock Shelter; (7) Black Rock Desert; (8) Winnemucca Lake sites, including Crypt Cave, Fishbone Cave, Shinners site A, Nicholarsen site; (9) Pyramid Lake (Wizard's Beach); (10) Hidden Cave; (11) Huntington Reservoir; (12) Hogup Cave; (13) Danger Cave; (14) Bonneville Estates Rockshelter; (15) Ruby Valley; (16) Smith Creek Cave; (17) Sunshine Locality; (18) Sevier Desert; (19) Lake Tonopah; (20) Stahl; (21) China Lake and Coso Basin; (22) Tule Springs; (23) Gypsum Cave; (24) Fort Irwin (Awl, Henwood, Rodgers Ridge); (25) Lake Mojave (adapted from Beck and Jones 1997:Figure 2).

not be human (though see the response by Gilbert et al. 2009; also see the discussion by Pinson 2011b). As such, conservative conclusions remain the same as they were 20 years ago: (1) the best evidence for the antiquity of Great Basin occupation continues to be ~11,500 ^{14}C yr BP (Grayson 1993; 2011; Waters and Stafford 2007), at least until the disagreement regarding Paisley Cave is resolved; and (2) while we know that extinct megafauna roamed the Great Basin during the Terminal Pleistocene (e.g., Gillette and Madsen 1992, 1993; Grayson 1993, 2011; Henrikson and Long 2007; Hester 1960;

Hibbard et al. 1965; Schubert 2010), it remains unclear whether they were utilized by Paleoarchaic populations.

Paleoarchaic Subsistence

What, then, was on the menu? Locational data provide some answers to this question. Since at least the time of Campbell et al.'s (1937; Antevs 1937) work in southern California, Great Basinists have recognized that Paleoarchaic sites demonstrate an affinity for shallow water settings (e.g., Schmitt et al. 2007). While not numerous, fluted points occur throughout the Great Basin, often as isolates in surface contexts, frequently near or on the terraces of extinct Pleistocene lakes, and only rarely in upland contexts (Copeland and Fike 1988; Davis and Shutler 1969; Rhode 1987; Schroedl 1991; Tuohy 1985, 1986; Warren and Phagan 1988; Willig and Aikens 1988). Stemmed points, on the other hand, have a wider distribution, which includes riverine and upland contexts as well as valley bottoms (Basgall 1993a, 1993b; Basgall and Hall 1993; Beck and Jones 1990b; Bryan 1979; Hall 1993; Layton 1972; Pettigrew 1984; Price and Johnston 1988; Warren 1990). The distribution of stemmed points suggests that, though they may have overlapped fluted points in time, they persisted longer (Beck and Jones 1997), a point I will return to later. The distribution of fluted points, at least, suggests that "whatever [Paleoarchaic people] were doing, they were doing a lot of it near shallow water" (Grayson 1993:238). Indeed, the focus on riverine, lake, and marsh settings prompted Bedwell (1973:170) to dub this economic orientation the "western pluvial lakes tradition." Recently, however, Eerkens, Rosenthal, and colleagues (2007:Table 3) documented abundant Paleoarchaic sites on relict fan deposits of the Coso Basin in the northwestern Mojave Desert, which they argue challenges the lakeshore or marsh-side focus (also see Pinson 2008). Yet the location of these sites along the Coso Wash, which certainly speaks to subsistence and technological activities away from the basin bottom, are not at odds with the expectation that Paleoarchaic populations focused on *riverine*, lake, and marsh settings, as Bedwell (1973) initially suggested. As these mesic settings would have provided the most productive environments, especially during the Terminal Pleistocene, the preference for these settings makes good ecological sense (Grayson 1993). In fact, Eerkens, Rosenthal, and colleagues (2007) interpret the low toolstone variability present at the Coso Basin sites as suggesting lower mobility than typically expected for Paleoarchaic populations, entirely consistent with this ecological setting, as I have argued above (see Figure 2.4). Furthermore, the faunal, floral, and coprolite remains, as sparse as they are, also indicate a focus on marsh, river, and lake-side settings.

In the northern Great Basin Bedwell (1973:Table 1-Table 16; Grayson 1979) recovered abundant faunal remains, especially from Connley Caves. Small mammals such as jackrabbit (*Lepus californicus*), cottontails (*Sylvilagus* sp.), and various rodents dominate the faunal assemblage, though elk, bison, deer, and antelope are also present, as well as a range of waterfowl and sage grouse (*Centrocercus urophasianus*) (Grayson 1977a; contra Bedwell 1973). Connley Caves 4B, 5A, and 6, as well as a hearth at the Locality III site dated to 9400 ± 270 ^{14}C yr BP, document the use of fish, especially tui chub (*Gila bicolor*; Greenspan 1994; Mehringer and Cannon 1994; also see Butler's [1996] discussion of tui chub taphonomy). At Dirty Shame Rockshelter, Zone VI yielded a similar faunal assemblage, though the dominant species were yellow-bellied marmot and cottontail (Grayson 1977b). Faunal remains from the TP/EH deposits at the Paulina Lake site in the Newberry Caldera are rare (Connolly and Jenkins 1999; Singer and Tasa 1999), though blood residue analysis of projectile points and bifaces suggest the hunting of bear, deer, rabbit, and sheep (Williams and Fagan 1999). Flotation samples from Feature 7, a domestic hearth at the Paulina Lake site, include cherry pits (*Prunus* cf. *emarginata*) and bulrush (*Scirpus* spp.), both of which suggest a mid- to late summer occupation (Stenholm 1999). Open air sites in the northern Mojave Desert document pronghorn antelope, deer, and mountain sheep, though small mammals (e.g., jackrabbit, cottontail, kangaroo rat [*Dipodomys* sp.], woodrat, and deer mice) constitute the majority of these assemblages (Basgall 1993a; Basgall and Hall 1993; Douglas 1990; Douglas et al. 1988; Hall 1993). In the Central Great Basin, small mammals predominate at the Sunshine Locality (Cannon et al. 2009:Table 7.1), as they do at Hanging Rock Shelter (Grayson 1988:Table 56) in the Eastern Great Basin. Faunal remains from the lower strata of Danger and Hogup caves document a greater abundance of large ungulates than elsewhere in the Great Basin, including mountain sheep, antelope, mule deer, and bison, though smaller mammals are also present (Aikens 1970; Jennings 1957). Last Supper

Cave also may indicate greater utilization of large ungulates, especially mountain sheep, though chronological and taphonomic concerns caution against making too much of this fauna (Grayson 1988). Coprolites from Danger and Hogup caves attest to the consumption of pickleweed (*Allenrolfea occidentalis*), prickly pear (*Opuntia* sp.), bulrush seeds, some *Pinus* seeds, and insects (Fry 1970, 1976). Coprolites associated with the Spirit Cave mummy in the Western Great Basin also include bulrush seed fragments, as well as at least two kinds of fish bone (Eiselt 1997; Napton 1997). Finally, a sagebrush bark fishing line was recovered from Pyramid Lake (Tuohy 1988a).

In summary, faunal remains and coprolites, though rare, indicate that Paleoarchaic populations relied on a variety of resources, including large and small game, as well as waterfowl. Interestingly, sites in the Eastern Great Basin, especially Danger and Hogup caves, exhibit greater evidence for the hunting of large ungulates than elsewhere in the Great Basin, though Danger Cave also provides the best evidence for small seed use during the Early Holocene. In fact, plant remains present a unique problem for Great Basinists, as they do not readily preserve in the many open-air sites nor were early excavation techniques necessarily suited for their recovery. Groundstone, a hallmark of Jesse Jennings' (1957:7; Jennings and Norbeck 1955:3) "Desert Culture," may serve as an indirect indicator of small seed exploitation; however, groundstone occurs only in a few sites (e.g., Danger Cave, Hogup Cave, Fort Rock Cave) prior to ~10,000 ^{14}C yr BP, after which it becomes much more common (Aikens 1970; Bedwell 1973; Bryan 1980; Grayson 1993; Jennings 1957; Madsen and Rhode 1990; Yoder et al. 2010). Robert Elston (1994) suggests that the paucity of groundstone is due to a Paleoarchaic preference for plants that required little processing, such as roots and tubers, especially given the higher-ranked alternatives presumably available at this time (for a similar conclusion in an Australian context, see O'Connell and Allen 2007; O'Connell and Hawkes 1981). Similarly, David Rhode and colleagues (2006; Rhode and Louderback 2007) argue that pickleweed seeds only became part of the staple diet at Danger Cave after animal and plant resources began to diminish as wetlands shrank after ~8500 years ago (also see Yoder et al. 2010). In all, faunal, floral, and coprolite data indicate a subsistence orientation toward rich riverine, marsh, and lakeside habitats and associated steppe. I suggest that such a diet may indicate that Paleoarchaic populations throughout much of the Great Basin utilized small ranges tethered to these rich localities; however, Great Basinists typically interpret Paleoarchaic lithic technology as a reflection of high mobility.

LITHIC TECHNOLOGY

Great Basinists typically interpret the design, manufacture, and transport of Paleoarchaic lithic technology as a reflection of high residential mobility (Goebel et al. 2011); however, not all tool types contain an equal level of information about mobility (e.g., Sellet 2006; Yerkes 1989). For example, if fluted points served an off-site hunting function and stemmed points served a more general set of on-site functions, as Basgall and Hall (1991) suggest, then the provenance analysis of fluted points may more accurately depict the long-distance forays of a hunting party and/or circumscribe the range utilized by a highly mobile residential group than a similar analysis of stemmed points. This conjecture is difficult to evaluate, however, as the temporal relationship between fluted, unfluted, and stemmed projectile points, and, in turn, whether they co-occur in the same Paleoarchaic "toolkit," remains unclear (compare Carlson 1988; Fagan 1988; Hanes 1988a, 1988b; Musil 1988). Fluted points have been reported and substantiated from buried contexts in only a handful of cases, including Danger Cave (Holmer 1986; Jennings 1957), the Old Humboldt Site (Davis and Rusco 1987; Tuohy 1984), the Henwood site (Douglas et al. 1988; Warren 1990; Warren and Phagan 1988), and the Sunshine Locality (Beck and Jones 2009a). While it is generally believed that Great Basin fluted points are coeval with Clovis points elsewhere in North America, the most reliable date for fluted points in the Great Basin—an age of roughly 10,300 ^{14}C yr BP derived from several dates on detrital charcoal from Unit E of the Sunshine Locality (Holmes and Huckleberry 2009)—may suggest that Great Basin fluted points are significantly younger than Clovis points elsewhere (Beck and Jones 2009a:149; Jones et al. 1996; also see Douglas et al. 1988 on the Henwood site).

Given the paucity of dated fluted points from the Great Basin and assumptions regarding their relationship with fluted points beyond the province, Great Basinists have referred to fluted points variously as "Clovis," "Folsom," or simply "fluted" (e.g., Beck and Jones 2007, 2010; Copeland and Fike 1988; Davis and Shutler 1969; Fagan 1988;

Simms and Lindsay 1989; Tuohy 1985, 1986; Willig and Aikens 1988; for a comparable discussion of California fluted points, see Rondeau 2009). Variability present in fluted points from the Great Basin (compare the fluted point found at Tosawihi [Ataman and Drews 1992] with the fluted points found at the Sunshine Locality [Beck and Jones 2009a]) may be due to resharpening (Fagan 1988) or it may be temporal. Beck, Jones, and Taylor (2004), for example, suggest that the morphological differences between fluted points from the Sunshine Locality and classic "Clovis" points may indicate that the Sunshine points represent a later fluted form, consistent with the younger date (also see Beck and Jones 2007, 2009a).

Unfluted lanceolate points, typically referred to as "Black Rock Concave Base" points after Clewlow (1968), also occur in the Great Basin. These points exhibit varying degrees of basal thinning (Warren and Phagan 1988) that is often mistaken for fluting (e.g., compare Hutchinson 1988 with Beck and Jones 2009a; also see Beck et al. 2004; Fagan 1975). The co-occurrence of fluted and unfluted lanceolate points in the Great Basin led Pendleton (1979) to combine them into the "Great Basin Concave Base Series," but as is the case elsewhere in North America, the lack of knowledge concerning the technological and temporal relationship of fluted and unfluted lanceolate points renders this designation problematic.

Though they are typically found as isolates, large numbers of fluted points occur in the Alkali Lake basin of north-central Oregon (Fagan 1988; Pinson 1996; Willig 1988, 1989, 1991), China Lake in southeastern California (Davis 1978a, 1978b), in the vicinity of Pleistocene Lake Tonopah in southern Nevada (Campbell and Campbell 1940; Pendleton 1979; Tuohy 1988b), and at the Sunshine Locality in east-central Nevada (Beck and Jones 2009a; Hutchinson 1988). Many of these sites also contain large numbers of stemmed points. Some, therefore, have argued that fluted and stemmed points are contemporary technologies (e.g., Bedwell 1973; Bryan 1980, 1988; Davis et al. 1969). Basgall and Hall (1991), for example, suggest that fluted points may have served an off-site hunting function and stemmed points may have served a more general set of on-site functions. Others maintain that they represent distinct technologies, based especially on the spatial separation between fluted and stemmed forms documented at sites such as Pleistocene Lake Owens and Lake Tonopah (Campbell 1949; Campbell and

Campbell 1940), the Dietz site in central Oregon (Fagan 1988; Willig 1988), the Alvord Desert of southeastern Oregon (Pettigrew 1984), and recently in Jakes Valley in eastern Nevada (Estes 2009).

Fortunately, the dating of stemmed points has been somewhat more successful than fluted points, although radiocarbon dates are still not numerous (Beck and Jones 1997:Table I). The earliest and greatest number of radiocarbon dates associated with stemmed points comes from the Fort Rock Basin in the Northern Great Basin and Smith Creek Cave in the Eastern Great Basin (Beck and Jones 1997:Table II). Dates associated with stemmed points in the Northern Great Basin range from ~13,000 ^{14}C yr BP at Fort Rock Cave (Bedwell 1973; Bedwell and Cressman 1971) to ~7000 ^{14}C yr BP at the Paulina Lake site (Connolly and Jenkins 1999), though the earliest of these dates has been questioned (Haynes 1971). Bryan (1979, 1988) reports 17 radiocarbon dates, ranging from ~14,000-9000 ^{14}C yr BP, on the Mt. Moriah zone at Smith Creek Cave, leading him to suggest that stemmed points may predate fluted points in the Great Basin. Danger and Hogup caves provide dates associated with stemmed points that range between 10,000-8000 ^{14}C yr BP for the Eastern Great Basin (Aikens 1970; Jennings 1957), consistent with the dates Simms and Lindsay (1989) obtained from the Sevier Desert. In the Central Great Basin, the Sunshine Locality provides several dates of ~10,000 ^{14}C yr BP in association with stemmed points (Jones et al. 1996). Stemmed points are numerous in surface assemblages of the Mojave Desert (e.g., Basgall 1993a, 1993b; Hall 1993; Warren 1990); however, only seven radiocarbon dates, ranging between ~9000-7000 ^{14}C yr BP, are associated exclusively with stemmed point horizons (Douglas et al. 1988; Jenkins 1987, 1991; Warren 1967, 1990; Warren and Phagan 1988). In summary, 70% of radiocarbon dates associated with stemmed points occur between 10,000 and 7500 ^{14}C yr BP (Beck and Jones 1997:Table II), overlapping the waning of fluted points.

Since their earliest discovery along the shores of Pleistocene Lake Mojave (Campbell et al. 1937), several stemmed point types have been defined within what has come to be known as the Great Basin Stemmed Series (Figure 2.6; Bryan 1980; Carlson 1983; Tuohy and Layton 1977). These types, defined on the basis of morphology, also have a spatial component. Haskett and Windust points tend to occur in the Northern

Great Basin and on the Columbia Plateau (e.g., Butler 1965; Fenner 2011; Leonhardy and Rice 1970; Rice 1972; though see Clewlow 1968; Beck and Jones 1990a, 2009a; Hester and Jameson 1977; Wallman and Amick 1991). Cougar Mountain and Parman types tend to occur in the Northern, Western, and Central Great Basin (Beck and Jones 1990b, 2009a; Clewlow 1968; Hutchinson 1988; Layton 1972; Tuohy 1969, 1970, 1974, 1984, 1988b). Lake Mohave and Silver Lake points occur most often in the Mojave Desert, though they are also found in the Western and Central Great Basin (Beck and Jones 1990b; Davis and Rusco 1987; Fenner 2011; Tuohy 1969, 1970). In short, there is some evidence for regionalization amongst stemmed points, though they do not appear to be temporally distinct, as they persist over a period of ~4000 years. In fact, the temporal overlap and co-occurrence of many stemmed types has led to the suggestion that they may grade into each other after a series of use and resharpening episodes (Beck and Jones 1993).

It also seems likely that stemmed points did not function exclusively as projectile points, as they often exhibit different production sequences and raw material preferences than fluted points (e.g., Amick 1993; Basgall 1993b; Basgall and Hall 1991; Beck and Jones 1993; Bryan 1979; Fagan 1988; Pendleton 1979; Simms and Isgreen 1984; Stevens and Codding 2009). In the Campbell collection from the vicinity of Pleistocene Lake Tonopah, Pendleton (1979) found that 88% of concave-based points (n = 104) and 24.4% of stemmed points (n = 90) are manufactured from cherts; 60% of stemmed points are manufactured from obsidian. In fact, the preferential utilization of chert for fluted points repeats itself over much of the Great Basin (e.g., Amick 1995; Basgall 1993b; Basgall and Hall 1991; Beck and Jones 2009b:Table 5.12; Butler 1970; Clewlow 1968; Copeland and Fike 1988; Davis 1978a, 1978b; Davis and Shutler 1969; Fagan 1988; Taylor 2003; Tuohy 1969; Wallace and Riddell 1988; Warren and Phagan 1988; Willig and Aikens 1988). Chert and obsidian also were preferred for unfluted lanceolate points (Amick 1995; Basgall 1988, 1993b; Basgall and Hall 1991; Beck and Jones 2009b:Table 5.12; Butler 1970; Clewlow 1968). Use of fine-grained volcanics (FGVs, e.g., basalt, andesite, dacite, rhyolite, felsites) is more common among Great Basin Stemmed Series forms (Basgall 1993a, 1993b; Basgall and Hall 1991; Beck and Jones 1988, 1990a, 1990b,

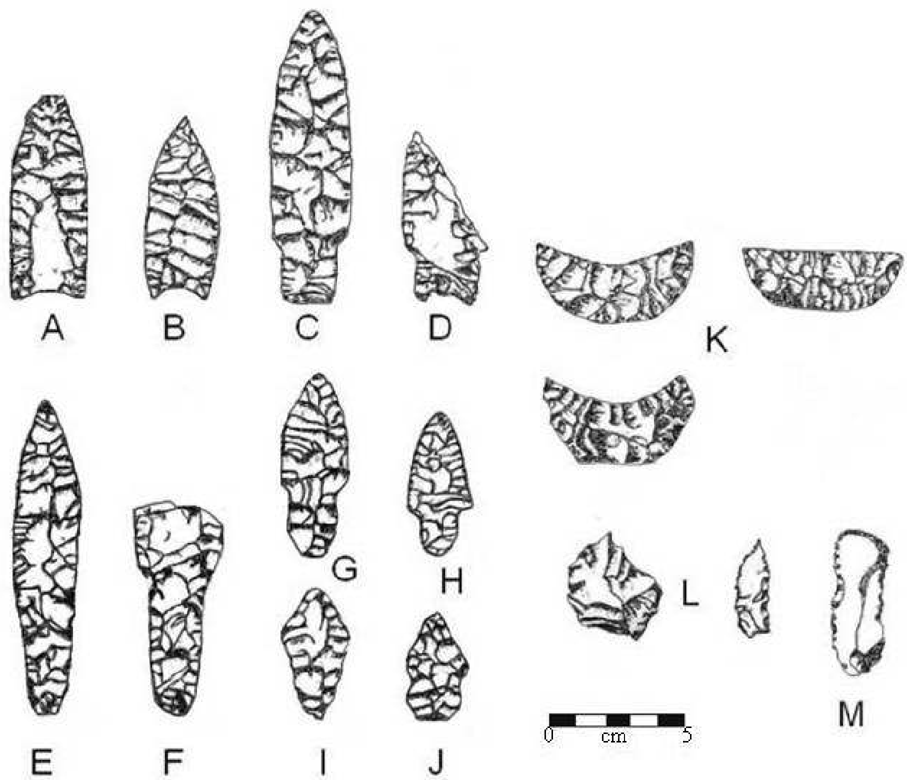

Figure 2.6: Paleoarchaic projectile points and associated artifacts: (A) fluted, (B) Black Rock Concave Base, (C) Windust Square-Stem/Cody, (D) Windust Concave-Base, (E) Haskett, (F) Cougar Mountain, (G) Parman, (H) Lind Coulee, (I) Lake Mohave, (J) Silver Lake, (K) crescents, (L) gravers, (M) end scraper (adapted from Beck and Jones 1997:Figures 3 and 4).

2009b:Table 5.12; Elston 1994; Tuohy 1970; Warren and Phagan 1988), though variable by region. In the Eastern Nevada Study Area, for example, andesite and dacite are the primary materials used for the manufacture of stemmed forms, while chert was rarely used for stemmed points despite its local availability (Beck and Jones 1990a, 1990b, 1992, 2009a). Mojave Desert assemblages exhibit a similar pattern (Basgall 1993b; Basgall and Hall 1991; Warren and Phagan 1988), as do assemblages from the Mule Canyon area in the Western Great Basin (Elston 1994). Interestingly, Amick (1995, 1996) finds that 99% of stemmed points (80 of 81) in the Black Rock Desert are manufactured from obsidian; none are made of FGVs.

Stemmed points, despite their shape, frequently exhibit characteristics suggesting they were multipurpose tools. Musil (1988:374), for example, suggests that Cougar Mountain, Parman, Lake Mohave, and Silver Lake types do not always meet the criteria of effective and efficient projectile points. These point types are often asymmetrical with battered and rounded edges and tips (e.g., Amick 1993; Basgall 1993b; Basgall and Hall 1991; Beck and Jones 1993; Tuohy 1969). In fact, only Haskett points consistently have sharp tips and edges as might be expected of projectile points (Beck and Jones 1997). In short, contracting-stemmed points seem to have been used for cutting and scraping, in addition to thrusting (e.g., Beck and Jones 1993). At Smith Creek Cave, for example, Bryan (1979) documents several stemmed point bases that seem also to have served as scrapers.

The other tools associated with both fluted and stemmed points include bifacial knives, gravers, and end- and side-scrapers; crescents, manos, and metates are more likely to occur with stemmed points than fluted points, at least judging by the Dietz site (Fagan 1988; Willig 1988, 1989). The problems with distinguishing fluted versus stemmed "toolkits," as discussed above, may warn against making too much of this distinction in other parts of the Great Basin, however. Many of these non-projectile points are typically made of chert.

Crescents are a case in point. Crescents are bifacially flaked, crescentic-shaped stone tools found throughout much of the Great Basin, though at variable abundances even at sites in close proximity (e.g., the Sunshine Locality [Beck and Jones 2009b; Hutchinson 1988] compared to stemmed-point sites in Butte and Jakes valleys [Beck and Jones 1990a]). Crescents range widely in size and shape (Amsden 1937; Mitchell et al. 1977; Tadlock 1966), though they are almost always made from chert (Amick 1995, 1999; Beck and Jones 1990b, 2009b; Butler 1970; Clewlow 1968; Hester 1977; Tadlock 1966). The function of crescents, however, remains less certain. Use-wear, resharpening, and breakage patterns suggest that the points of the crescents were the tool, probably used for cutting and scraping (e.g., Beck and Jones 2009b; Butler 1970; Mitchell et al. 1977). Clewlow (1968; after Tadlock 1966) suggested crescents were used as transversally hafted projectile points to stun waterfowl (Beck and Jones 2009b:Figure 5.16B; Wallace and Riddell 1988); however, this hafting configuration is inconsistent with the damage patterns noted above. Regardless, the overwhelming use of chert for crescents suggests that they were used for activities requiring good quality, durable stone.

In sum, obsidian and FGVs appear to be preferred for the manufacture of Great Basin Stemmed Series points even when chert is locally available. Chert, on the other hand, is preferred for fluted and unfluted lanceolate points, as well as gravers, scrapers, crescents, and other "resource processing gear." The stark differences in material preferences exhibited by stemmed and lanceolate points suggest that they served different functions, consistent with the damage patterns noted above. Thus, Beck and Jones (1997) suggest that large contracting-stemmed points were likely used as thrusting spears in conjunction with cutting and scraping or other animal-processing activities. Lanceolate and square-based points (e.g., Windust Square-Stem) points, on the other hand, likely tipped javelins or atlatl darts. It seems that "resource processing gear" was often made of chert because it is "much tougher and less brittle than obsidian or welded tuff, though [it] perhaps cannot be worked to quite as keen an edge" (Aikens 1970:67).

Ethnographic data consistently suggest that large-game hunting involves the coverage of larger ranges than gathering (Kelly 2007); therefore, we may expect projectile points to be manufactured from nonlocal lithic sources more frequently than gravers, scrapers, and crescents. Incorporating the raw material preferences noted previously, we would expect chert projectile points to be curated and carried over long distances, much as we see at other Paleoindian sites. Chert utilized to manufacture gravers, scrapers, and crescents would likely derive from local sources and be utilized in an expedient fashion. Obsidian and FGVs may have been procured from nonlocal sources, as stemmed points served, at least some of the time, as projectile points. Yet the additional use of stemmed points for tasks that would shorten their use lives may work against a high rate of curation and, in turn, long-distance transport. Furthermore, the brittleness of obsidian would seemingly render it inadequate as a raw material for stemmed points. Susan Hughes (1998), for example, notes that if penetration was more important than durability to a hunter, obsidian would be the preferred material, but chert is the best all-around material because it carries a sharp edge and embodies both compressional and tensile strength. In short, we might expect Paleoarchaic people to carry at least some cherts longer and farther than obsidian or FGVs during the course of their subsistence pursuits; however, current interpretations of Paleoarchaic obsidian provenance data stand in direct opposition to this expectation.

Obsidian Conveyance Zones and Paleoarchaic Ranges

Studies of toolstone procurement and distribution (i.e., residential or task-group mobility and/or exchange) in the Great Basin have relied largely on obsidian source provenance analyses conducted over the last 40 years (e.g., Arkush and Pitblado 2000; Basgall 1989, 1993a, 1993b; Basgall and Hall 1993; Bouey and Basgall 1984; Bowman et al. 1973; Connolly 1999; Dugas et al. 1994; Eerkens et al. 2008; Ericson 1977, 1981, 1982; Estes 2009; Gilreath and Hildebrandt 1997; Graf 2001; Hughes 1982, 1983, 1985, 1986, 1988, 1989, 1994a, 1994b, 2001a, 2001b; Hughes and Milliken 2007; Jack 1976; Jackson 1984, 1986, 1988; Jackson and Ericson 1994; Johnson and Wagner 2005; Jones et al. 2003; Nelson 1984; Oetting 1993, 2004; Smith 2004, 2005, 2010; Stoner et al. 2000; Tuohy 1984). The geographic patterning of sourced artifacts "may provide information about seasonal procurement ranges, acquisition strategies, territorial or ethnic boundaries, the locations of prehistoric trails and travel routes, the curation value of particular sources or formal artifact types, cultural preferences regarding glass quality and color, the presence of trade and exchange systems, the existence of intergroup interaction, and the exchange of prestige items between elites of different groups" (Skinner et al. 2004:227). Despite these many alternatives, obsidian provenance data is almost always interpreted in relation to subsistence. This interpretive slant stems from two pervasive ideas: (1) "Although we recognize that people may make locational decisions based on ritual and ideation, we believe…that most variation in the archaeological record…is congruent with simple models of economic behavior" (Elston 1994:351); and (2) "procurement of raw materials is embedded in basic subsistence schedules" (Binford 1979:259). In chapter 3, I will utilize hunter-gatherer data to look more closely at these ideas. For present purposes, note that Paleoarchaic research utilizes obsidian provenance data to circumscribe the areas exploited in the course of subsistence pursuits.

Recently, Jones and colleagues (2003:19) pulled together several obsidian provenance analyses from across the Great Basin to define a series of obsidian conveyance zones (OCZs; Figure 2.7), which they suggest "delimit geographically the foraging territories of Paleoarchaic populations in the central Great Basin." These data delineate OCZs measuring some 450 km north-south and 150 km east-west in the Eastern, Central, and Western Great Basin, stretched in accordance with the north-south trending mountain ranges. In the Northern and Southern Great Basin, where the mountains are less formidable, the OCZs are less elongated. Interestingly, there is little evidence for the movement of obsidian east-west between OCZs. The Eastern Nevada Study Area, for example, lacks artifacts made from western and northwestern Great Basin obsidian sources, even though some of these obsidian sources are no more distant (measured in a straight line) than the sources that dominate the assemblages. Jones et al. (2003:32) suggest that this pattern indicates a lack of interaction between peoples living within these OCZs, perhaps as a consequence of low population density and the tethering of Paleoarchaic groups to significant wetlands, which are less common in central Nevada. Based on these data, Jones et al. (2003) conclude that Paleoarchaic populations were "travelers" (after Bettinger 1991, 1994, 1999). Operating in small groups under conditions of low population density and high mobility, Paleoarchaic populations invested effort in movement between resource-rich patches (e.g., wetlands and contiguous steppe), focusing on few, rapidly depleted resources (also see Arkush and Pitblado 2000). OCZs delineate the annual or territorial (after Kelly 1992) ranges of these highly mobile Paleoarchaic groups. This model of Paleoarchaic subsistence-settlement strategies approximates the option on the left of Figure 2.4.

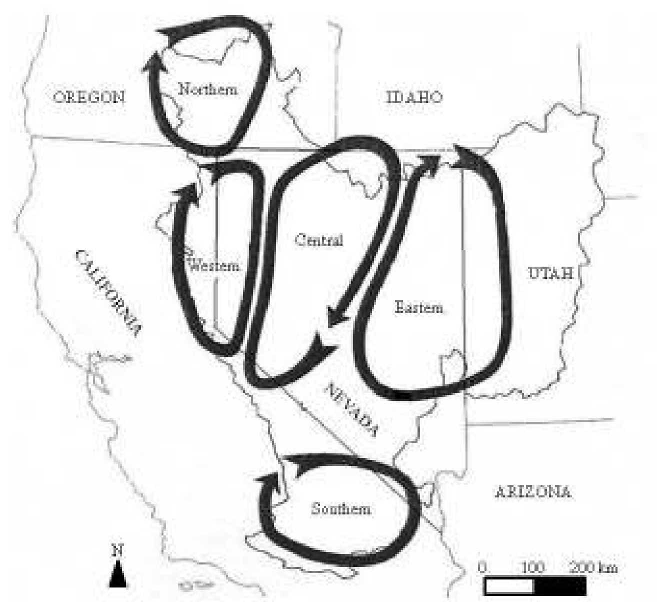

Figure 2.7: Paleoarchaic obsidian conveyance zones (adapted from Jones et al. 2003:Figure 13).

David Madsen (2007), however, has recently questioned this interpretation, suggesting that male hunting parties may have procured resources that they brought back to relatively permanent wetland base camps occupied by women and other less-mobile members of the group (after Elston and Zeanah 2002; Zeanah 2004). Significantly, this model implies that the size of marsh habitats would have determined the relative degree of mobility practiced by Paleoarchaic populations, as reflected in Figure 2.4 (Madsen 1982a:Figure 2). Where marsh habitats were small and widely scattered, Paleoarchaic groups would have been highly mobile, frequently traversing long distances between residential camps; where marsh ecosystems were large and productive, Paleoarchaic groups would have been less mobile, infrequently traversing shorter distances between residential camps. Madsen (2007) suggests that the Paleoarchaic record of the central Great Basin, including the Eastern Nevada Study Area, reflects the latter (Figure 2.8); these Paleoarchaic groups approximate the "sedentary collectors" of Figure 2.4.

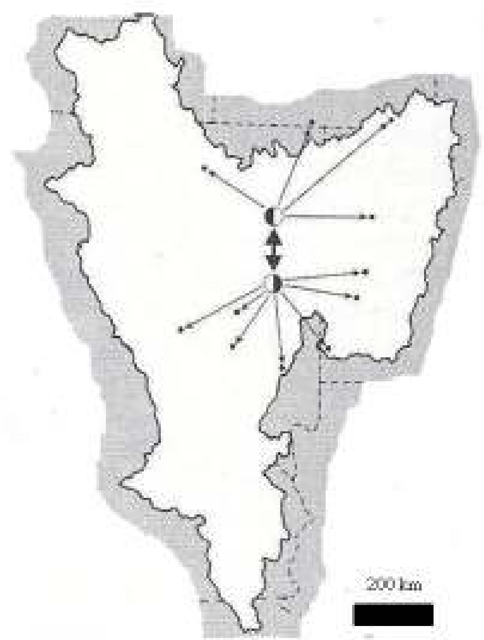

Figure 2.8: Madsen's model of Paleoarchaic mobility organization. Logistical forays (the rays) emanate out from home bases (half-shaded circles) toward obsidian sources (black dots) (adapted from Madsen 2007:Figure 1.12, with permission from the publisher).

According to this model, OCZs delineate the spatial extent of male logistical forays to provision the rest of the forager group. Note, however, that the long-distance forays envisioned for hunting and the procurement of obsidian by Madsen (2007) are inconsistent with his (Madsen 1982a:211) expectation that sedentary collectors would engage only in short forays beyond the bounds of the marsh habitat.

Additionally, the areas circumscribed by OCZs, whether interpreted to reflect residential or logistical mobility, are inconsistent with the spatial extent of ethnohistorically- and ethnographically-known hunter-gatherers. This observation has not been lost on Great Basinists, who have worked to revise the OCZs since they were proposed by Jones et al. (2003). Both in the Western Great Basin (Smith 2010:Figure 5) and in the Central Great Basin (the eastern OCZ; Jones and Beck 2010; Jones et al. 2012), the OCZs have been broken into two based on obsidian provenance data from sites not considered in their initial construction. Nevertheless, the revised OCZs still encompass areas far greater than hunter-gatherers utilize, at least in the environmental contexts most Paleoarchaic populations are thought to have occupied. Forty years ago, Condie and Blaxland (1970; also see Fry and Adovasio 1970) suggested that the utilization of different obsidian sources by the inhabitants of Danger and Hogup caves indicated that they were distinct populations. Population differentiation at this local scale is not reflected in current OCZs. Considered in this light, Great Basinists might entertain the possibility that Paleoarchaic obsidian distribution reflects non-utilitarian mobility (after Whallon 2006) and/or exchange between distinct but interconnected populations within the OCZs. I will return to this possibility in subsequent chapters.

This foreshadowing notwithstanding, it is sufficient to note at present that competing interpretations of OCZs recast a decades-old debate regarding the role of wetlands and other rich localities in Great Basin subsistence-settlement strategies, as alluded to in my earlier consideration of paleoenvironmental and subsistence data.

In his report on Danger Cave, Jesse Jennings (1957:7-8) wrote:

> The pattern of life was a cyclic wandering…small groups moved regularly from place to place, from valley to upland, in search of the seasonal animal or plant resources…material possessions were few, utilitarian and durable or easily

> manufactured at need…never any great concentrations of people except when pine-nut harvests or animal drives brought several groups temporarily together.

This projection of Julian Steward's (1938) model of Great Basin foragers onto the archaeological record became known as the Desert Culture. And though Jennings recognized variability in Great Basin lifeways (e.g., Jennings and Norbeck 1955), the Desert Culture, as quoted above, was widely used by archaeologists within the western United States to interpret the archaeological record.

Robert Heizer, who grew up in Lovelock, Nevada, was quite familiar with the Paiute's use of the Humboldt Sink's wetland resources and used this knowledge to argue against the Desert Culture as *the description* of past lifeways in the Great Basin (Heizer and Napton 1970; Weide 1968). Relying on ethnographic data from marsh-oriented groups outside the Great Basin, such as the Klamath and Modoc of northern California, and archaeological data from the Humboldt Sink in northwestern Nevada, Heizer (1967) proposed the concept of limnosedentism, suggesting that the intensive use of abundant river, marsh, spring, and lake resources would have encouraged sedentism or, at least, semi-sedentism. Heizer and his students argued that the lacustrine biome was more productive than the piñon-juniper biome and it was this productivity that made sedentism feasible.

In developing this model, however, Heizer took for granted that wetlands contained abundant resources, never demonstrating the productivity of the Humboldt Sink nor year-round occupation (Kelly 2001). As Kelly (2001:7) notes "[o]n a purely theoretical basis, local resource abundance appears to be a necessary, but perhaps not sufficient, condition for sedentism." Furthermore, domestic structures, which may suggest longer occupation, have been reported from only a few Early Holocene contexts in the Northern Great Basin (e.g., Paulina Lake, Connolly and Jenkins 1999; the Tucker site; Pinson 2004). And these structures occur at a time when the Northern Great Basin seems to be drier (i.e., less productive) than previously thought (e.g., Pinson 2008). In short, Great Basinists continue to struggle to incorporate subsistence, locational, and technological data into a model of Paleoarchaic subsistence-settlement strategies. We are still left to discern whether the rich river, marsh, and lake-side settings of the TP/EH were the locus of sedentary or semi-sedentary Paleoarchaic groups or simply one of many stops in the course of a far-ranging subsistence regime (e.g., Kelly 1985); the divergent viewpoints regarding OCZs reflect these alternatives. Paleoarchaic perishable technology, however, may shed some light on this problem.

PERISHABLE TECHNOLOGY

Although less abundant than the lithics that dominate the Paleoarchaic record, the dry caves and rockshelters of the Great Basin also preserve a rich record of perishable technology. While a consideration of this technology may seem out of place in a study focused on lithic technology, perishable technology provides insight into aspects of subsistence and social organization often overlooked amidst the emphasis on rocks, megafauna, and men in current efforts to understand Paleoindian lifeways (Adovasio et al. 2004). For example, the recovery of perishable artifacts, especially evidence for basketry and weaving, testify, based on cross-cultural research, to the labor of women (Adovasio et al. 2004). Furthermore, the possibility of net hunting, as suggested by the cordage recovered from Stratum DI at Danger Cave (Jennings 1957:Figure 209) and the net recovered from Fishbone Cave in the Winnemucca basin (Orr 1974), implicates the entire co-residential group in mass harvests. These harvests would result in the production of a surplus, and may have occurred as part of aggregations that facilitated other socioeconomic functions, as documented for the Kawich Mountain Shoshone for example (Steward 1938; Thomas 1981b). Of additional significance, perishable technology provides a seemingly unparalleled indication of population differentiation and movements (Adovasio 1986a, 1986b; Adovasio and Pedler 1994; Fry and Adovasio 1970). This may all seem like much to make from some baskets and a few pieces of cordage, but archaeologists regularly build equally elaborate stories from stone tools. Indeed, Jennings (1957:279) once observed that "flint was cheap, expendable and unimportant, whereas cordage, basketry, buckskin, bone and horn tools, handles, arrows all represented greater skill, a greater expenditure of effort, and had actually a higher practical and investment value than did the stone. If flint were thus cheap one wonders how important it was."

Excavations in dry caves and rockshelters from almost all sections of the Great Basin have provided basketry remains that span nearly 11,000 years of human occupation

(Adovasio 1986a). Based on the analysis of over 5000 specimens, James Adovasio (1970a, 1986a) has identified three major Western Archaic textile complexes variously referred to as the Oregon Complex (Northern Basin Center), Western Nevada Complex (Western Basin Center), and Eastern Basin Complex (Eastern Basin Center), each of which can be traced through a series of developmental stages. The root of all three complexes is simple two-element twining, though the Oregon Complex may date slightly earlier than the Western Nevada and Easter Basin complexes (Adovasio 1970a; Rozaire 1969). Each complex demonstrates a trend toward regional specification and technical divergence over time (e.g., Adovasio 1970b, 1986a; Adovasio et al. 1977; Aikens 1970; Bedwell 1973; Connolly 1994; Connolly and Barker 2004; Cressman 1942; Dalley 1970; Hattori 1982; Mehringer and Cannon 1994; Orr 1974; Rudy 1957; Tuohy and Dansie 1997); however, some degree of mutual influence between these complexes was always present (Adovasio 1970a).

Despite the fragmentary nature of the early perishable technology, Adovasio's (1970a) conclusion is particularly significant because obsidian provenance analysis suggests limited interaction east-west between OCZs (Jones et al. 2003), as discussed above. Julie Francis (1991) provides an informative example from the northwestern High Plains. In Wyoming Francis (1991) finds that patterns of lithic procurement seemingly define each major basin as a settlement system with the mountain ranges acting as barriers between them. Yet, she goes on to suggest that the lack of interaction between these basins seems inconceivable; rather, lithic materials may not have been used as a medium of exchange or groups were sufficiently familiar with toolstone sources that there was no need to transport large quantities of material over great distances (Francis 1991:313). If the former suggestion is valid in the Great Basin, perhaps regional interaction is reflected in the perishable technologies preserved in the dry caves and rockshelters of the region, as suggested by Adovasio (1970a). Similarly, *Olivella* shell beads derived from the Gulf of California and recovered from Early Holocene contexts in the Fort Rock Basin attest to the beginning stages of a long-distance exchange network, cross-cutting OCZs, that would blossom during the Middle Holocene (Jenkins, Largaespada, Largaespada, and McDonald 2004:Figures 2, 3). On the other hand, if Francis's (1991) latter suggestion is valid, then perhaps OCZs are simply too big to be

Paleoarchaic foraging ranges because they are not. Perhaps the procurement of obsidian is bound up more with social and ideological concerns than with functional concerns.

Summary

While gross generalizations regarding Great Basin climate change may be extracted from the paleoenvironmental data discussed above, the spatial and temporal variability evident in sub-regional climate histories warns against casual chronological and ecological correlations across such a large area (Kay 1982; Madsen 1982b, 1999, 2007; Minckley et al. 2004; Negrini 2002). Because of this, Madsen's (1982a, 2007) model of Great Basin subsistence-settlement strategies is particularly significant, as it explicitly incorporates variability and, in doing so, subsumes alternative interpretations (e.g., Elston 1982; Jones et al. 2003) of subsistence-settlement strategies.

In my consideration of the paleoenvironmental data, I have suggested that the earliest Paleoarchaic populations in much of the Great Basin may have utilized small foraging ranges centered on river, marsh, and other rich localities, perhaps aligning them toward the right end of Figure 2.4. Then, as marshes and lakes regressed and biotic communities reorganized, later Paleoarchaic populations may have become more mobile, shifting toward the left end of Figure 2.4, even if still geared toward these decreasingly productive habitats. Locational data and subsistence data seem to support a focus on rivers, marshes, lakes, and other mesic habitats in much of the Great Basin during the TP/EH, perhaps in accordance with decreased mobility. Great Basinists often interpret lithic technology and obsidian source provenance data to suggest high mobility, however. The lack of unambiguous evidence for occupational permanency may also indicate high mobility. Interestingly, perishable technology and shell ornaments may suggest a level of regional interaction typically denied Paleoarchaic populations, despite the incredible distances over which obsidian was distributed.

If nothing else, the divergent lines of evidence brought together here suggest we need to look more closely at the environmental, demographic, and social factors that structure hunter-gatherer mobility and intergroup interaction. In their interpretations of the archaeological data, Great Basinists typically argue about the necessary and sufficient conditions for sedentism, but leave unexplored, at least in a critical way, the motivations that underwrite mobility, assuming that subsistence fits the bill. As such, the presence of nonlocal toolstone in a lithic assemblage, no matter the distance, is almost always explained in reference to subsistence. I suggest that the areas encompassed by OCZs are inconsistent with the paleoenvironmental, subsistence, locational, and technological data, as reviewed here. Furthermore, they encompass areas far greater than those utilized by hunter-gatherers in the pursuit of subsistence, which leads me to entertain the possibility that long-distance obsidian transport reflects social and/or ideological considerations, as discussed in Chapter 3.

Chapter 3: The Cultural Geography of Paleoarchaic Hunter-Gatherers: Mobility, Exchange Networks, and Scale

In Chapter 2 I presented an overview of environmental and archaeological research in the Great Basin during the Terminal Pleistocene/Early Holocene (TP/EH). I suggested that locational data and subsistence data seem to support a focus on rivers, marshes, and adjacent steppe in much of the Great Basin during the TP/EH, perhaps in support of small subsistence ranges. Yet, Great Basinists typically interpret lithic technology and obsidian provenance data, together with the lack of unambiguous evidence for occupational permanency, to suggest high residential mobility, consistent with Paleoindianist thinking more generally. These divergent lines of evidence, and the long-standing debate regarding the incorporation of wetlands and other rich localities into Paleoarchaic subsistence-settlement strategies, suggest we need to look more closely at the environmental, demographic, and social factors that structure hunter-gatherer mobility, subsistence, and intergroup interaction, a call that has been raised by previous researchers in various contexts (e.g., Chatters 1987; Jones and Madsen 1989; Metcalfe and Barlow 1992; Orians and Pearson 1979; Speth 1990; Spielmann 1986). In turn, these insights may be utilized to reconsider toolstone provenance and technological variability as documented in lithic assemblages, topics pursued in Chapters 4 and 5.

In this chapter I consider the obsidian conveyance zones (OCZs) against the backdrop of ethnohistorically- and ethnographically-known hunter-gatherers. I begin by demonstrating the discord between Jones et al.'s (2003) and Madsen's (2007) models and the ethnographic record by lining them up against previous models of hunter-gatherer mobility (e.g., Binford 1983b; MacDonald and Hewlett 1999; Sampson 1988), focusing especially on data pertaining to residential and logistical mobility in the pursuit of subsistence. While each model has merit, when viewed from the perspective of modern hunter-gatherers, each model also presents a problem of scale (i.e., *size*, after Wandsnider 1998). Specifically, hunter-gatherer data suggest that (1) if reflecting residential mobility, OCZs circumscribe areas far greater than anything documented ethnographically; and (2) if reflecting logistical mobility, OCZs document long-distance forays in an environmental context (i.e., rich wetland and adjacent steppe) that does not seem to necessitate comparably long-distance logistical forays among ethnographically-known hunter-gatherers occupying similarly rich habitats, at least not for the purpose of subsistence. The problem Great Basinists confront, then, is in trying to connect the absolute scale of Paleoarchaic landscape units (i.e., the size of OCZs as defined analytically by archaeologists) with the relative scale of Paleoarchaic behavior (i.e., the *lived* scale of human behavior; also see Allen 1996; Duke and Young 2007; Fairclough 2006; Harris 2006; Hodder 1978a, 1978b; Green and Perlman 1985; Justeson and Hampson 1985; Lock and Molyneaux 2006; Politis 2006; White and Modjeska 1978; Wiens 1989). In other words, the size of the landscape units defined analytically by patterns of obsidian provenance (i.e., OCZs) may simply be too big to be accounted for by the behavioral processes currently advanced to explain the distribution of obsidian across the Paleoarchaic landscape.

Recognizing this problem, some Great Basinists have begun working to revise the OCZs as initially proposed by Jones et al. (2003; e.g., Jones and Beck 2010; Jones et al. 2012; Smith 2010), though the expectation that obsidian procurement and transport was embedded in residential and/or logistical mobility for subsistence pursuits remains. Steven Simms (2008), however, has presented a useful alternative, suggesting that OCZs may reflect life-time ranges (after Binford 1983a) rather than annual ranges. In fact, this perspective may be more accommodating of the fact that ethnographic observations of human behavior are recorded at a finer temporal resolution than typically achieved in the archaeological record (Greaves 2006; also see Gosden and Kirsanow 2006; Holdaway and Wandsnider 2006; Lupo 2001; Sheehan 2004; Stiner 1993). Because of this problem of temporal resolution, I cannot reject the possibility that OCZs reflect expansions or contractions of Paleoarchaic foraging ranges over centuries or millennia, an alternative that is consistent with predominant Paleoindianist thinking. Nevertheless, the reduced sizes of the revised OCZs are still excessively large compared to the annual or territorial (i.e., decadal) ranges of modern hunter-gatherers. Thus, I suggest that the OCZs may reflect the areal extent of Paleoarchaic social networks maintained through non-utilitarian mobility and/or exchange. In pursuit of this alternative, I use H. Martin Wobst's (1974, 1976) insights into Paleolithic social systems to consider the spatial organization of Paleoarchaic groups, thereby populating the OCZs. I then discuss the role of non-utilitarian mobility and exchange in developing and maintaining a regional network across these Paleoarchaic groups. By drawing on a number of ethnographic and ethnohistoric examples, integrated through a behavioral ecological perspective on information, I suggest that intergroup Paleoarchaic interactions are likely and, contrary to the prevailing Paleoindian wisdom, cannot simply be dismissed as "risky." In this light, non-utilitarian mobility and exchange become viable processes to explain the distribution of obsidian. I conclude by reconstituting the models of Jones et al. (2003) and Madsen (2007), adding the elements of intergroup interaction considered here.

At the risk of an overly long introduction to this chapter, let me add that I recognize that it is one thing to suggest that processes beyond those rooted in subsistence pursuits contributed to the archaeological record and quite another to demonstrate that they in fact did so. Furthermore, I do not wish to promote a dichotomy between utilitarian and non-utilitarian pursuits; indeed, the ethnographic record belies this dichotomy (e.g., Robb 1998; Sinclair 1995; also see Whitridge 2004 on space/place). Nevertheless, I feel that a detailed exploration of the processes introduced above is warranted given the lack of attention such processes often receive in current Paleoindian literature—a tendency that is particularly striking given the widespread attention paid to intergroup interaction and exchange in even earlier, and presumably no more "complex," Old World contexts (e.g., Ambrose 2002, 2010; Ambrose and Lorenz 1990; Bordaz 1970; Cochrane 2008; Jochim 2006; McCall 2006, 2007; Mellars 2006:180; Soffer 1991; Straus 2011; Sulgostowoska 2006; Tortosa et al 2002:254; Valde-Nowak 2009; Whallon 2006; Wilkins 2010). In his discussion of agents, George Cowgill (2000:57) captures the sentiment that prompts the discussion presented here, writing: "I have no problem…with postulating entities that we know are there, even if we cannot detect them. I reject the contrary ontology that says that if we cannot detect something it is not there, or at least we must not think about it." Moreover, "once the issue is clearly framed, if we think about the matter enough perhaps we could see how to gain such evidence" (Cowgill 2000:58; e.g. Plog 1980). While the processes considered in this chapter are complex and potentially difficult to distinguish archaeologically (e.g., Fitting 1977; Meltzer 1989), it is my hope that this discussion of hunter-gatherer mobility and intergroup interaction will help us to appreciate the significance of these processes for understanding Paleoarchaic and Paleoindian behavior and, in turn, to build toward their recognition in these archaeological records.

Ethnographic Models of Mobility

Mobility refers most broadly to the manner in which humans move across the landscape in relation to properties of the natural and social environment, which thereby influences the location and composition of sites in a region (Binford 1980; Binford and Binford 1969; Blades 2009; Bonzani 1997; Chatters 1987; Jochim 2006; Kelly 1983a; Kent 1991, 1992; Kooyman 2006; Politis 2006; Thacker 2006). Ethnographic research has demonstrated that mobility involves several dimensions of variability, related, more generally, to subsistence strategies (Elston and Zeanah 2002; Kelly 1992; Watanabe 1968), intergroup interaction (e.g. Ford 1972; Sampson 1988; Whallon 2006), and other aspects of social organization (Helm 1968; papers in Sellet et al. 2006; Wobst 2006). The archaeological application of models of hunter-gatherer mobility informed by ethnography is further complicated by the fact that mobility includes movement by individuals (e.g. Trifkovic 2006) and groups, over varying time spans, as determined by the dimensions mentioned above. Significantly, these same factors that complicate the linkage of the acquisition and circulation of resources as recorded in the archaeological record to multidimensional models of mobility and intergroup interaction, also demonstrate the centrality of mobility for understanding hunter-gatherer behavior in general.

Though not the first scheme (e.g., Beardsley et al. 1956; Murdock 1967:159, Table B; Silberbauer 1972; Wagner 1960; see discussion in Rhode 1999), Lewis Binford's (1977, 1979, 1980) forager-collector model of hunter-gatherer mobility organization is perhaps most well-known and has greatly influenced interpretations of New World lithic assemblages (Andrefsky 2008a; Odell 1996). Basically, the model establishes a continuum between residential and logistical mobility. *Foragers* exercise residential mobility, moving as a group to resources at appropriate times, exploiting those resources, and then moving as a group to a new location. Foragers acquire food resources opportunistically using a generalized, largely expedient technology and little or no food storage; their strategies are aimed at learning about the distribution of resources within a region. *Collectors* exercise logistical mobility, tending to establish multi-purpose base camps in locations not necessarily defined by food (e.g., where water or fuel are available) from which they send out task groups to exploit particular resources. Collector base-camps can be expected to have been relatively sedentary, at least on a seasonal basis (Binford 1979; Lurie 1989). Collectors tend to focus on resources that can be gathered in sufficient quantity to be stored. Technologies utilized by task groups may include specialized tools and facilities designed to successfully procure particular food resources.

Closer to home for Great Basinists, Robert Bettinger and Martin Baumhoff (1982) developed a comparable model of hunter-gatherer mobility organization in their attempt to understand the spread of Numic peoples into the Great Basin. They define two types of mobility organization: (1) *travelers* rely on resources of high quality (i.e., high rank) and incur greater costs in travel time and lesser costs in extraction and processing; and (2) *processors* rely on resources of low quality (i.e., low rank) and incur lesser costs in travel time and greater costs in extraction and processing. Bettinger and Baumhoff's (1982:488) model differs from Binford's primarily by its explicit emphasis on the differential allocation of time to subsistence pursuits, as defined by the diet breadth model. Nevertheless, these two schemes clearly approximate each other.

Despite its influence, the forager-collector model has been criticized for being too simplistic to be able to accommodate the multi-faceted decisions that individual groups must make when faced with variable environments and social constraints (Chatters 1987; Nelson 1991; Wiessner 1982a). James Chatters (1987), for example, argues against the tendency to think of the forager-collector continuum as one-dimensional; such a view is overly simplistic and limiting and does not reflect Binford's (1980) intent. In fact, Binford (1980:12) anticipated Chatters's (1987) concern, acknowledging that "logistical and residential variability are not to be viewed as opposing principles…but as organizational alternatives which may be employed in varying mixes in different settings," including from season to season (Binford 1982). Likewise, Matt Grove (2010:1918) writes that "all 'foragers' are 'collectors' to a degree." Chatters (1987:337-

338) suggests we conceive of adaptation as multidimensional, which enables us to better understand the influence of environmental change, demography, and/or innovation on hunter-gatherer behavior. In this regard, Polly Wiessner's (1982a) call to go "beyond willow smoke and dogs' tails" is quite fitting (also see Root 1983). Wiessner (1982a:172) argues that "if archaeologists are to make full use of available data, hunter-gatherer organization must be viewed in light of a theory which accounts for various forms of organization by taking the entire productive process into account, that is, both the organization around resources and the organization around other persons in social relations of production" (also see Gurven et al. 2000:Figure 9; Ridges 2006; Stanner 1965a). Significantly, Binford's (1983b) later model of hunter-gatherer mobility, though still centered on subsistence pursuits, incorporates social pursuits and leaves room, literally, for change over time.

Binford's (1983b) generalized model of mobility, therefore, provides a firm starting point for understanding hunter-gatherer subsistence-settlement patterns. Of particular significance for the current study, the different subsistence pursuits, modes of resource acquisition, and spheres of mobility and interaction employed by different subsets of a population can all be included within this framework. Based on his ethnographic work with the Nunamiut, Binford (1983b) identifies five levels of mobility (Figure 3.1):

1. The foraging radius is the area used during daily subsistence, rarely extending beyond 10 km (also see Lee 1968, 1972; Morgan 2008; O'Connell and Hayward 1972);
2. The logistical radius is the zone exploited by parties who stay away from the residential camp at least overnight;
3. The annual range is the area used during a year for both residential and logistical purposes;
4. The extended range is the residentially unoccupied area beyond the logistical radius, which may be taken up by excess population or incorporated into a group's annual range in the event of resource stress;

5. The lifetime range is the area over which an individual might expect to travel during a lifetime, including trips for subsistence, information, marriage, and other social purposes.

To this model, Robert Kelly (1992) adds territorial or long-term mobility to account for the cyclical movement of a group utilizing a set of annual ranges over a period of perhaps a decade (in fact, Binford [1983b:36] anticipated this too).

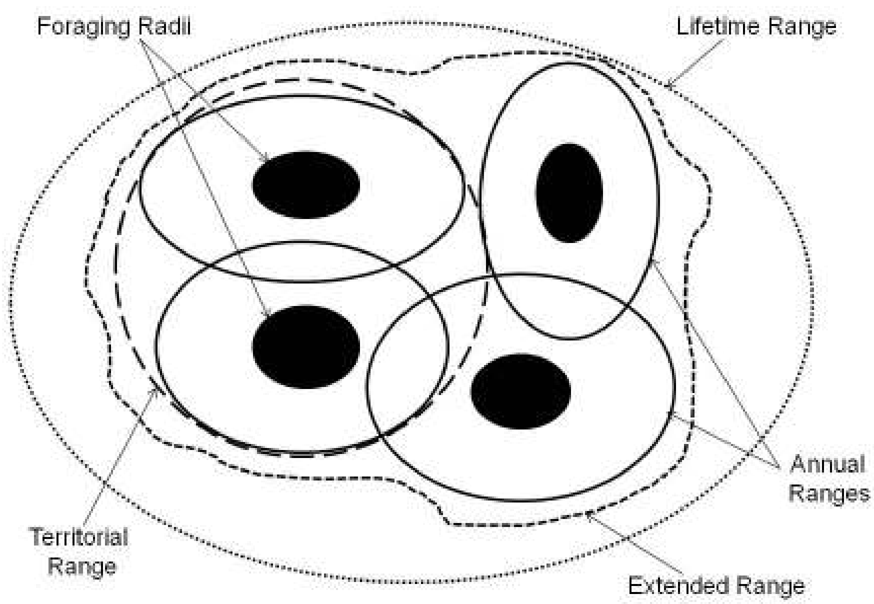

Figure 3.1: Binford's (1983b) model of hunter-gatherer mobility (adapted from MacDonald and Hewlett 1999:Figure 1).

More recently, MacDonald and Hewlett (1999; MacDonald 1999) developed a model of hunter-gatherer mobility that complements Binford's (1983b) model by considering reproductive and social interests more explicitly (Figure 3.2). MacDonald and Hewlett (1999) define three levels of movement: (1) micromovement refers to individual and group mobility for subsistence pursuits; (2) mesomovement refers to mobility at intermediate distances to visit friends and relatives, and likely includes the mean mating distance of a population (e.g., Wiessner 2009); and (3) macromovement refers to mobility to explore exotic sites for scarce or new reproductive and/or somatic resources. Significantly, they expect individual and group mobility trajectories to overlap, encouraging trade, mating, information exchange, and/or aggression. Such overlap, if sufficiently frequent, will eventually lead to interregional resource transport/acquisition as an integral part of established mobility organization.

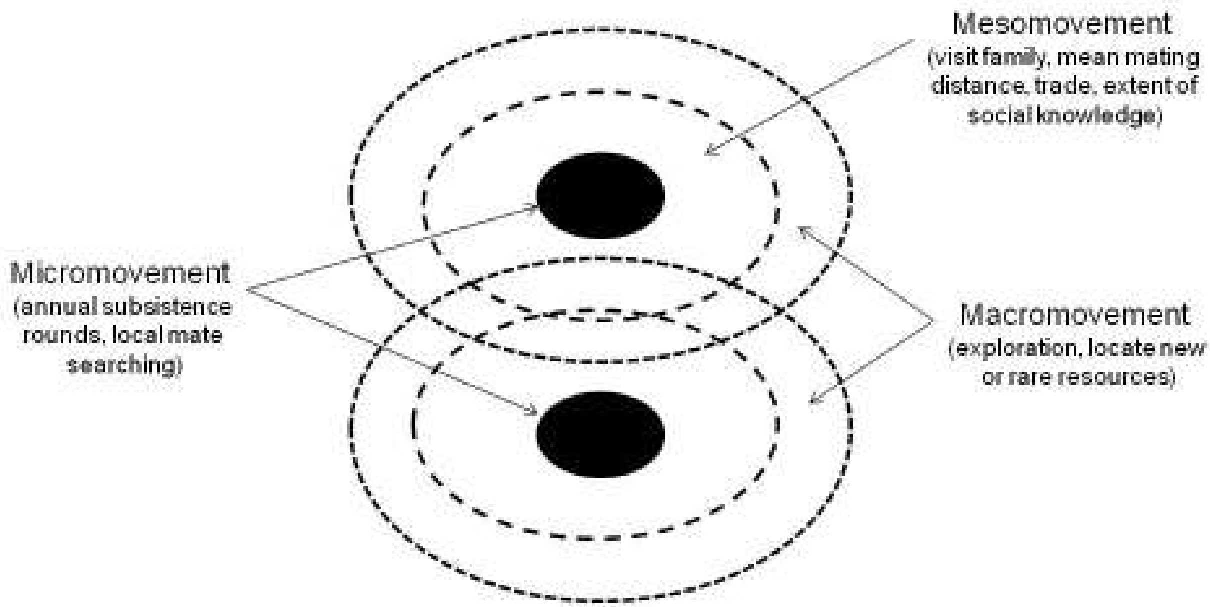

Figure 3.2: MacDonald and Hewlett's model of hunter-gatherer mobility (adapted from MacDonald and Hewlett 1999:Figure 10).

These models provide a framework for integrating the different spheres of mobility and modes of resource acquisition proposed to have been utilized by Paleoarchaic populations in relation to resource availability, occupation span, and other ecological, technological, sociological, and ideological considerations. Significantly, the models of mobility discussed here include subsistence, information, mating, and other social pursuits, while Great Basinists and Paleoindianists tend to privilege subsistence pursuits in their construction of settlement patterns, assuming that toolstone procurement and transport is embedded within such pursuits. Yet, when we consider the area encompassed by current models of Paleoarchaic subsistence-settlement, as defined by obsidian provenance, against the backdrop of modern hunter-gatherer data, problems of scale and context become evident, suggesting that we might profitably pursue alternative models for understanding toolstone acquisition.

Paleoarchaic Subsistence-Settlement Patterns in Ethnographic Perspective

In suggesting that current models of Paleoarchaic subsistence-settlement patterns are discordant with ethnographic data, I do not wish to simply project the ethnographic record onto the archaeological record; Wobst (1978, 1993) has argued cogently against such an approach (also see Kelly 1999; Spriggs 2008; Widlok 2004). Yet in the present context, it is a telling irony that persistent concerns regarding the "inherently limiting" nature of analogy for our understanding of prehistory (e.g. Gould 1980; see discussion in Wylie 2002) have, in most cases, limited our view of Paleoindians to matters pertaining almost exclusively to subsistence and technology. Enriching our view of Paleoindians requires that we look to the ethnographic record once again in order to gain insight into the processes, whether utilitarian or not, that produced the archaeological record (S. Binford 1968; Clark 1968; Isaac 1968). After all, ethnoarchaeology and middle-range theory developed around attempts to do just that (e.g. Binford 1968, 1977, 1978a, 1978b, 1979, 1981; Gould 1978, 1980; O'Connell 1987, 1993; Thomas 1983b; Yellen 1977). Thus, my goal in this section is to stack up the areas encompassed by OCZs against the areas exploited and distances traveled by hunter-gatherers through residential and logistical mobility, thereby turning a critical eye toward the behavioral processes currently proposed to account for Paleoarchaic obsidian procurement and transport.

Recall from Chapter 2 that Jones and colleagues (2003) suggest OCZs reflect the annual or territorial (i.e., decadal, after Kelly 1992) ranges of residentially mobile Paleoarchaic groups. Using the equation for the area of an oval (area = π[ab/4]), the OCZs can be translated into area measurements for comparison to the annual or territorial ranges of ethnographically-known hunter-gatherers (Table 3.1).

Table 3.1: Area of OCZs (sq. km).

OCZ	**Length of a (km north-south)**	**Length of b (km east-west)**	**Area (sq. km)**
North	200	250	39270
East	475	250	93266
Central	550	200	107992
West	150	375	44179
South	300	200	47124

Obviously, the OCZs defined by Jones et al. (2003) are not perfect ovals; thus, the area measurements provided here are best viewed as approximations. Even so, comparison with hunter-gatherer ethnographic data (Kelly 2007:Table 4-1) clearly demonstrates that the ranges defined by OCZs are far greater than any known hunter-gatherer foraging ranges (Figure 3.3).

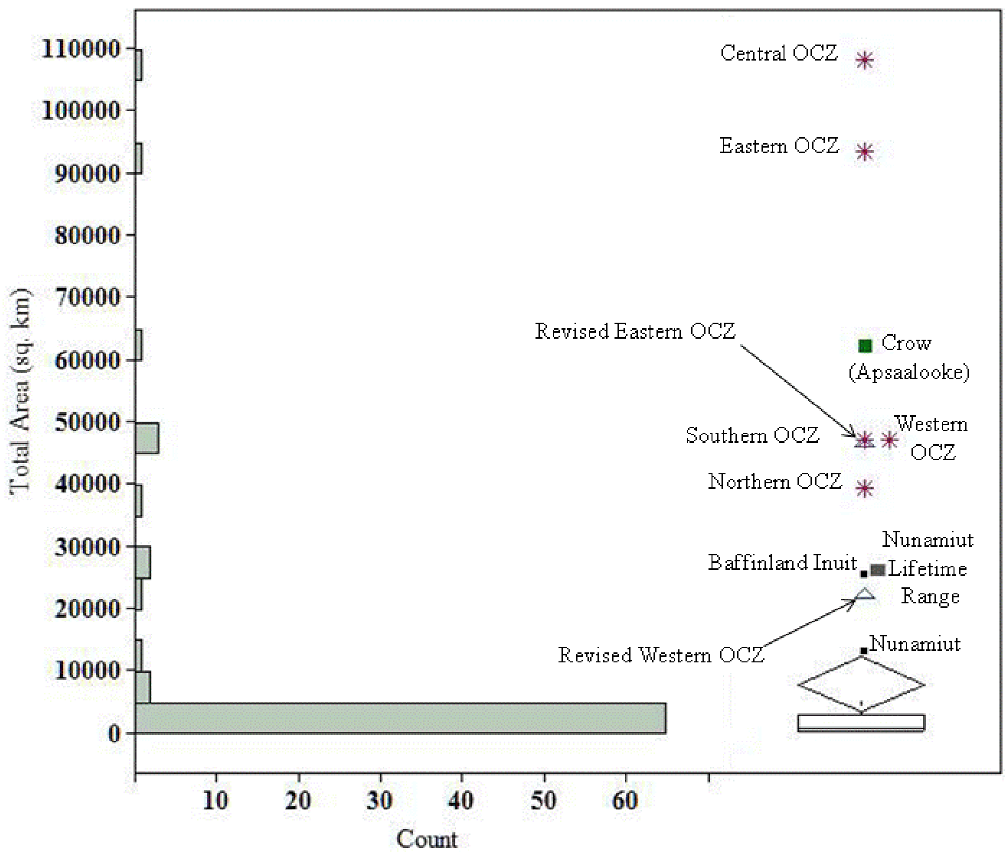

Figure 3.3: Histogram and box-plot comparing OCZs with modern hunter-gatherer data from Kelly (2007:Table 4-1). Stars represent original OCZs (Jones et al. 2003). Triangles represent revised OCZs (Jones and Beck 2010; Jones et al. 2012; Smith 2010). Also labeled are the Nunamiut lifetime range and the total area utilized by the Crow (Apsáalooke), Baffinland Inuit, and Nunamiut.

The only comparable groups are (1) the Crow (Apsáalooke), equestrian bison hunters, and, more distantly, (2) the Baffinland Inuit and Nunamiut, two Arctic groups. If these three outliers are removed from Kelly's (2007) data, the mean "home range" for hunter-gatherers drops to only 1177 sq. km – an area with a radius of 19.4 km (Alvard 2006).

The incredible size of these OCZs has prompted two significant responses by Great Basinists. First, Geoffrey M. Smith (2010), working in western Nevada, and George T. Jones and Charlotte Beck (2010; Jones et al. 2012), working in eastern Nevada, have significantly reduced the OCZs as initially proposed (Jones et al. 2003); yet, even these revised OCZs are markedly bigger than the foraging ranges used by all but the few hunter-gatherer outliers noted above (Figure 3.3). Second, Steven Simms (2008:Figure 3.8) recently suggested, through a comparison with the Nunamiut Eskimo, that OCZs may reflect the lifetime range (after Binford 1983a) of Paleoarchaic hunter-gatherers; yet even the lifetime range of the Nunamiut (~25,900 sq. km; Binford 1983b:42) is smaller than all but the revised western OCZ (Figure 3.3). Significantly, Simms's (2008) suggestion does allow for processes other than subsistence (e.g., trips to gather information, visit kin, marry, and other social pursuits) to account for the long-distance movement of obsidian. I discuss these processes later in this chapter. At present, note simply that the original and revised OCZs simply seem too big to represent the annual or even territorial (i.e., decadal) ranges utilized by residentially mobile Paleoarchaic groups.

Alternatively, OCZs may reflect the spatial extent of male logistical hunting forays, as proposed by David Madsen (2007). The ethnographic record demonstrates a strong relationship between the relative dependence on hunting and the total area exploited by a hunter-gatherer group (e.g., Kelly 1983a:Figure 5, 2007:Figure 4-8; Grove 2010:Figure 1a). Additionally, hunter-gatherers heavily dependent on hunting tend to utilize logistical mobility to cover their foraging area more so than groups heavily dependent on gathering. As such, logistical mobility is certainly worth considering in an attempt to approximate the size of the OCZs. Yet Paleoarchaic populations may not have been sufficiently dependent on hunting (especially big-game hunting) to utilize such a strategy (e.g. Grove 2010:Figure 2). Significantly, Madsen's (2007) model does not rest on the premise that Paleoarchaic populations were heavily dependent on hunting, which seems unlikely (see Chapter 2). Rather, Madsen's model derives from the premise that men and women contribute different resources to the foraging group. Thus, men and women make different subsistence decisions and, in turn, use different spheres of mobility (e.g., Bird and Bliege Bird 2005; Bliege Bird et al. 2009; Elston and Zeanah

2002; Hawkes 1990; Hilton and Greaves 2008; Hurtado and Hill 1990; Kelly 2007:250; Kuhn and Stiner 2006; Lee 1979; Woodburn 1968a; Zeanah 2004). Women, children, and other less mobile individuals exercise thorough coverage of a relatively small area (e.g., the center of an OCZ) in their subsistence pursuits. Their efforts are confined largely to a daily foraging radius, and infrequent residential moves over short distances are dictated by the depletion of the resources gathered within this range. Long-distance male hunting forays complement the more critical gathering pursuits of the rest of the group, though we may also question whether such forays would have covered the distances implied by the OCZs.

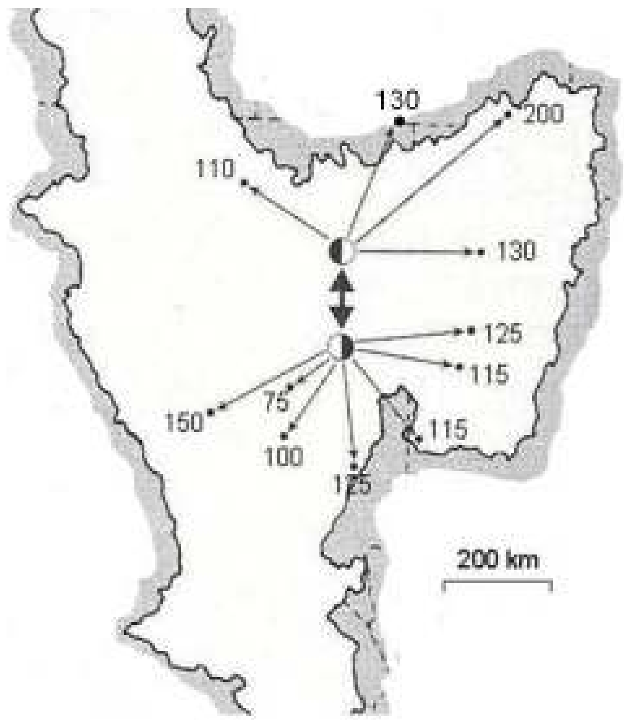

Figure 3.4 Distances of hunting forays (adapted from Madsen 2007:Figure 1.12).

The distances male hunting parties must travel in order to account for the spatial extent of OCZs are shown in Figure 3.4. The distance from the northern base camp to the obsidian sources averages ~142.5 km; the distance from the southern base camp to the obsidian sources averages ~115 km. While Binford (1983a) points out that a Nunamiut male might hunt over 300,000 sq. km in his lifetime, few of these logistical forays (measuring 8-274 km roundtrip; Binford 1977:Table 1) exceed the distances required by

Madsen's (2007) model, and many Nunamiut hunting trips were aided by snowmobiles and/or dog teams. Furthermore, ethnographic data from the Great Basin also suggest forays of shorter distances than those proposed in Madsen's (2007) model.

Let us look at the Reese River Valley Shoshone (RRVS) as one Great Basin example (Steward 1938; Thomas 1971, 1972, 1973, 1981b). The RRVS exploited a relatively more stable and generally more resource-redundant environment than did most of their neighbors in surrounding valleys. The seasonal round included only one or two major areas of residence, supplemented by a number of task-specific locations and temporary field camps. Primary residential areas occurred along the lower margin of the piñon-juniper woodland, typically on the west-facing slopes which lie in the local rain shadow. Most of the foraging occurred within about 8 km of the traditional winter base camp. People tended to move only in the event of local piñon crop failure. Task-specific journeys, either to conduct communal antelope or rabbit drives, or to hold fandangos (i.e., periodic aggregations), rarely exceeded 60-80 km, much shorter than the forays suggested by Madsen's (2007) model. To be fair, however, note that piñon, which facilitated the semi-sedentism of the RRVS, appears to have been restricted to the southern Great Basin prior to 11,000 years ago (Madsen 1986:Figure 2; Madsen and Rhode 1990; Rhode and Madsen 1998; Thompson 1990:Figure 10:11). Yet, piñon, not game, was also the primary reason for many Great Basin groups to move camp (Steward 1938), as well as a sufficiently calorie-rich resource for long-distance transport (Jones and Madsen 1989:Table 1). In short, though the RRVS are not a perfect analogue for Paleoarchaic hunter-gatherers, they serve to illustrate the discordance between ethnographically-documented logistical mobility in the pursuit of subsistence and that proposed in Madsen's (2007) model. In fact, Kelly's (1983:Table 1) data indicate that logistical forays for many hunter-gatherers were even less than those noted above for the RRVS (e.g., Silberbauer 1972). Furthermore, if we suppose that the riverine, lake, and marsh settings of the TP/EH were biotic magnets (Oetting 1999), then the need to undertake long-distance hunting forays to meet nutritional requirements may have been negated, as large and small game would have been drawn to these "sweet spots" (Willig 1988:478). In fact, we might suppose that under these conditions the differences between male and female foraging decisions that underwrite the sexual division of labor central to

Madsen's (2007) model would be diminished (Zeanah et al. 1995), again negating the long-distance hunting forays that Madsen (2007) imagines. With these considerations in mind, we might entertain an alternative motivation for long-distance logistical forays: regular encounter of representatives from neighboring bands to maintain social and informational networks (e.g. Binford 1982; Cavalli-Sforza and Hewlett 1982; Hewlett et al. 1982; Grove 2009a, 2010; Kelly 1983a; Whallon 2006). I discuss this alternative in more detail later in this chapter.

Presently, the discussion of these models leads us to an intermediate position: Paleoarchaic groups in many parts of the Great Basin may have practiced residential mobility geared to rich wetland and adjacent steppe (consistent with Jones et al. 2003), *though this mobility strategy did not encompass areas as large as the OCZs*. The importance of wetlands within hunter-gatherer subsistence-settlement systems depends on resource type, diversity, productivity, and reliability (Nicholas 1998; Raven 1992). Although values for these characteristics vary considerably, cattail marshes (which can produce up to 5 tons of biomass/hectare/year) and sedge marshes (which can produce up to 1.5 tons of biomass/hectare/year), as just two examples, equal or exceed the productivity of many forests and, in some cases, cultivated land, while simultaneously avoiding the difficulty and hazards that accompany food procurement in places such as the canopy of rainforests (Nicholas 1998). Additionally, the role wetlands played in subsistence-settlement strategies also depends on the resource opportunities provided by the associated hinterlands (Nicholas 1998; Oetting 1999; Raven 1992). Raven (1992) suggests, for example, that the dominant subsistence orientation of the Carson Desert was tethered to Stillwater Marsh because there were few better foraging opportunities around it—water was scarce and upland resources only rarely repaid departures from the marsh (Raven 1990). In the Harney Basin, by contrast, the near ubiquity of watered places rendered the exploitation of resources more distant from Malheur Lake less costly. In short, these rich settings may have provided the necessary conditions for reduced mobility (e.g., a reliable water supply; Nicholas 1998; storable resources; Kelly 1983a), though whether they also provided sufficient conditions for sedentism remains unclear (Kelly 2001).

Nicholas (1998) suggests that the archaeological record associated with wetlands should yield evidence of reduced mobility, surplus production and storage, territoriality, social stratification, increased population density, gender-specific activities, and local cultural and economic diversity. Material correlates of reduced residential mobility may include “increasing distance to areas of trash disposal, the use of more uniform building materials and evidence of ‘over-building,’ more function-specific materials (e.g., the use of different materials for the roof and walls), larger houses, use of a variety of house types, and a greater variety of more function-specific features” (Kelly et al. 2005:415; also see Binford 1990; Oetting 1999; Porčić 2010; Trinkaus 1985). Moreover, small prey use, as evident during the TP/EH in many parts of the Great Basin (see Chapter 2), typically involves a reduction in human group mobility, connected to limited short distance, seasonal movements of prey species that do not require much hunter mobility (e.g. Cashdan 1992; Tortosa et al. 2002). Finally, Tuohy (1988a) suggests that the staggered fish runs, documented at Pyramid Lake for example, would have permitted fishing to occur year-round. Nevertheless, given the current lack of evidence for increased occupational permanency (see Chapter 2; also Simms 1989), perhaps the safest conclusion is that Paleoarchaic groups were not (semi-)sedentary, even though their mobility strategy may have been tethered to rich wetland and other mesic settings. Hardesty (1972), for example, suggests that integration into lacustrine ecosystems in the western Great Basin was not associated with reduced residential mobility (also see Hockett 2007 for the eastern Great Basin; Willig 1988 for the northern Great Basin). Citing ethnographic data for the Honey Lake Paiute (Riddell 1960) and the Modoc (Ray 1963), Hardesty (1972) proposes that lakes in the western Great Basin were exploited by “quite mobile” hunter-gatherers. Even so, these “quite mobile” hunter-gatherers utilized an area of only 1600 square miles (~4100 sq. km) during their annual cycle!

In a moment of transcendent (and self-critical) honesty, we may be forced to conclude nothing more insightful than that we simply have mobility on the brain. After all, mobility is logically consistent with Marshall Sahlins’s (1968, 1972) classic characterization of hunter-gatherers as the “original affluent society” (also see Harrison 1949; Meillassoux 1973). As Feit (1994:424) puts it, Sahlins “tells us that [hunter-gatherers] weigh the advantages of owning more than a minimal tool kit, or storing surplus subsistence, or using resources more intensively, or having numerous young offspring, or increasing local group size, against the diminishing returns of staying put when there are fresh lands to forage if one can move relatively efficiently." Furthermore, we know that hunter-gatherers move for many reasons besides simply being "pulled" to the next productive patch, including the accumulation of unpleasant debris from butchery activities (Yellen 1977:67; Potts 1984, 1988), as well as even smaller concerns (e.g., fleas; Cressman 1964; also see Cohen 2009:593; Horne and Aiston 1924; Woodburn 1968b; Yellen 1977). Yet in the decades since Sahlins's formulation we have learned that hunter-gatherers are much more complicated, if not "complex," than we once thought, both in how they relate to each other and in how they relate to their land (e.g., Altman 1974; Begler 1978; Binford 1990; Bird and Bird 2009; Bliege Bird et al. 2008; Feit 1994; Flanagan 1989; Hayden 2009:598; Jarvenpa and Brumbach 2009; Keen 2006; Leacock 1982; Lee 1982; Osborne 2007; Rowley-Conwy 2001; Testart 1982; Read 2010; Smith et al. 2010; Wiessner 2002a; papers in Williams and Hunn 1982; Woodburn 1982). Indeed, much rethinking of the diagnostics of hunter-gatherer society and the reticulation of people and land and people and people privileges the latter (e.g., Hodder 1978c; Ingold 1987). As such, hunter-gatherer ethnography denies any simplistic notion that: (a) hunter-gatherers will become sedentary because, if the setting is sufficiently rich, then why not?; and (b) hunter-gatherers will be highly mobile because, if the land is out there, then why not?

While I would not deny that ecological factors underwrite the potential for sedentism, the decision to pursue a more sedentary lifestyle seems intimately connected to concomitant changes in social relations (e.g., Bettinger et al. 2009; Birdsell 1968; Endicott 1988; Holly 2005; Kelly et al. 2005, 2006; Marshall 2006; Rowley-Conwy 1983; Suttles 1968). What emerges from these considerations is the realization that Great Basinists have really only begun the task of understanding Paleoarchaic behavior. The focus on ecology, technology, and subsistence has built a firm baseline for our understanding of Paleoarchaic lifeways, but questions regarding topics as pervasive as the nature of Paleoarchaic subsistence-settlement systems cannot be answered solely by recourse to the tenants of a Stewardian cultural ecology (i.e., a cultural ecology that, excepting shamanism and fandangos, was not concerned with social relations and ideology; C. Fowler 1977, 1999; Myers 2004; Thomas 1972; for a similar perspective see Bradley 1984), for what we are arguing about—high residential mobility tethered to rich ecological settings vs. (semi-)sedentism at these rich localities—is closely tied to changes in how hunter-gatherers relate to each other as well as to the land. Indeed, C. Melvin Aikens (1977) reminded us over thirty years ago that models founded on an "ecological systems orientation," though productive, are not sufficient to the whole task of archaeological research in the Great Basin.

It is with this in mind that I find Steven Simms's (2008:Figure 3.8) model of Paleoarchaic OZCs particularly intriguing. Recall that Simms (2008) suggests that the OCZs may reflect the lifetime range of Paleoarchaic foragers (Figure 3.5), yet even the lifetime range of the Nunamiut is smaller than all but the revised western OCZs (Figure 3.3).

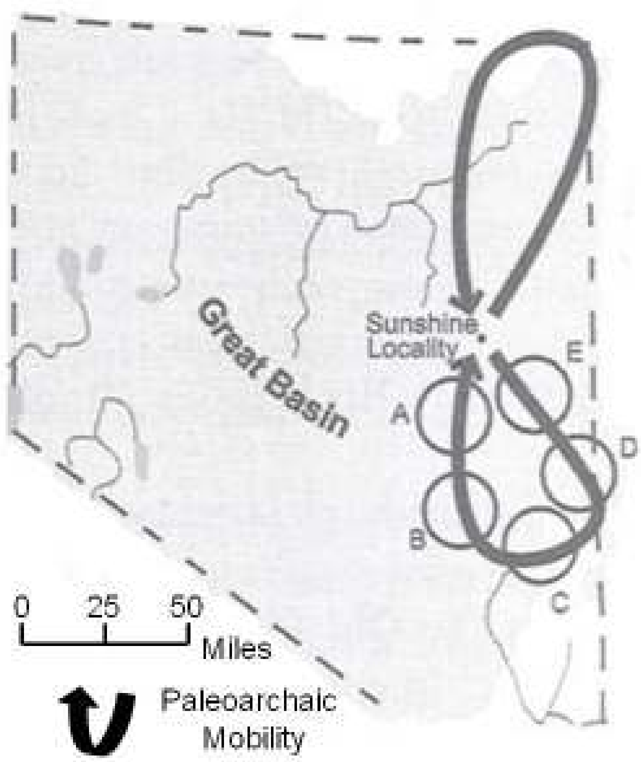

Figure 3.5: Paleoarchaic mobility centered on the Sunshine Locality, as modeled after Nunamiut lifetime land use (Binford 1983a:115). (A) Birth country, 1-9 years; (B) Courting country, 10-18 years; (C) Baby country, 19-27 years; (D) Wife's country, 28-32 years; (E) Hunter's country, 33-41 years. (adapted from Simms 2008:Figure 3.8, with permission from the publisher).

More significantly, the lifetime range as defined by Binford (1983b) includes trips for subsistence, *as well as information, marriage, and other social purposes*. In short, as we stretch obsidian transport over both time and space, we are left with the distinct possibility that OCZs delineate regional networks maintained through non-utilitarian mobility and/or exchange. I am not suggesting that we explain the long-distance transport of obsidian by simply substituting non-utilitarian mobility and/or exchange for residential or logistical mobility in the course of subsistence pursuits. That would not constitute a substantive contribution to our understanding of Paleoarchaic behavior on my part. I am suggesting, however, that we seriously consider the possibility that at least some of the toolstone circulated throughout the Great Basin may reflect social rather than subsistence pursuits, especially given the distances involved. I address these considerations next, beginning by using H. Martin Wobst's (1974, 1976) insights into Paleolithic social systems to populate the OCZs and then moving on to consider the processes that would maintain such a system (e.g., non-utilitarian mobility, exchange).

Wobst to the Rescue? Or, Putting the People Back on the Land

Twenty years ago, Kenneth Ames (1988:357) suggested that the investigation of "Late Pleistocene-Early Holocene social networks is a crucial line of research in expanding our understanding of the earliest prehistory of western North America." Ames (1988) looked to the work of H. Martin Wobst (1974, 1976) to better understand the distribution of hunter-gatherer groups across the Southern Columbia Plateau during the Pioneer Period. I propose that this line of research remains underdeveloped in Paleoindian studies in general; therefore, I follow Ames's (1988) lead in order to develop a model of mobility and resource acquisition that attempts to put the people back into the OCZs.

Wobst (1974) suggests that Paleolithic societies are comprised of three levels: (1) the nuclear family; (2) the minimum band (25-75 people); and (3) the maximum band or mating network (174-475 people). Aside from the nuclear family, the minimum band is defined by Wobst (1974; after Steward 1969; though see Woodburn 1968b) as the most permanent and strongly integrated social unit in a hunter-gatherer society. The minimum band is large enough to survive prolonged periods of isolation by articulating its members through cooperation, food-sharing, and other cultural practices; it is also small enough to not overstress the local food resources. Thus, the minimum band consists of several families who share a common settlement pattern and participate in a given range of cultural activities, at least seasonally. In order to enhance its chance of biological and cultural survival, a minimum band tends to participate in a larger social network; that is, the maximum band. Minimum bands are interconnected within the maximum band through ritual communication, marriage, and exchange. The maximum band is the social correlate of the hunter-gatherer cultural system, constituting the natural and analytical unit in the investigation of cultural process (also see Peterson 1976a). Building on the insights of Joseph Birdsell (1968; also see Johnson 1982), Wobst (1974) imagines these Paleolithic social groups arranged in an hexagonal lattice (though for objections to the hexagonal model see Moore 1981, 1985).

In developing his model of Paleolithic social systems, Wobst (1974, 1976) provides two sets of figures for hunter-gatherer population densities. Based on hunter-gatherer ethnography from northern and southern hemispheres, the tropics, and the Arctic, Wobst (1974:170) provides population densities of 0.002 to 0.8 persons/sq. km. Based on a smaller sample, the inland hunter-gathers of Alaska, Canada, and Siberia, Wobst (1976:50) provides population densities that vary from 0.005 to 0.5 persons/sq. km, although he suggests that most groups would show population densities below 0.05 persons/sq. km. Because Paleoindians likely lived at low population densities, I use population densities of 0.005 to 0.05 persons/sq. km to calculate the number of people and the number of maximum bands that might have occupied a given OCZ (Table 3.2).

Table 3.2: Number of people and number of maximum bands calculated for each OCZ.

OCZ	**Area (sq. km)**	**Number of People (pop. density = 0.005 people/sq. km)**	**Number of Max. Bands (175-475 people/band)**	**Number of People (pop. density = 0.05 people/sq. km)**	**Number of Max. Bands (175-475 people/band)**
North	39270	196	1 to 2	1964	4 to 11
East	93266	466	1 to 2	4663	10 to 27
Central	107992	540	1 to 3	5400	11 to 31
West	44179	221	1 to 2	2209	5 to 13
South	47124	236	1 to 2	2356	5 to 13

Obviously, the population density and number of people in each maximum band significantly influences the number of maximum bands that might have occupied an OCZ. Nevertheless, Wobst's (1974, 1976) ideas about the spatial distribution of social systems provide a means to populate the OCZs defined by Jones and colleagues (2003). Furthermore, Wobst's (1974:172) simulation of Paleolithic social systems demonstrates that "in the absence of natural and cultural mechanisms controlling the size of local populations, local groups of small size are strongly selected against and a strong trend operated toward the agglomeration of the minimum bands of a society into a single local group" (also see Birdsell 1968; Williams 1968; Renfrew 1974). Indeed, forager societies with low population densities incorporate similar numbers of people into their social realm by increasing their mean mating and socializing range (MacDonald 2004; also see Binford 2006; Read 2003; Wobst 1993). At the same time, however, environmental and social constraints do not permit consistent long-term aggregations. Thus, hunter-gatherer bands are distributed to avoid overstressing the resource base, yet they must periodically aggregate and interact in order to remain biologically and culturally viable.

In the models of hunter-gatherer mobility organization discussed earlier in this chapter, information is critical. Forager and collector strategies, for example, are two ways to effectively organize subsistence and social pursuits relative to information obtained about the distribution of resources and other social groups within a region. Great Basinists, therefore, have readily incorporated paleoenvironmental data into their considerations of how prehistoric Great Basin populations would have utilized their landscape (see Chapter 2). Yet, social networks, insofar as they facilitate the distribution of information pertaining to resources and other social groups, also significantly influence the subsistence-settlement strategy utilized, as typified by hxaro, fandangos, and other examples discussed below. These informational and social dimensions, while recognized by Great Basinists and Paleoindianists alike, have not been adequately considered in discussions of Paleoarchaic and Paleoindian mobility. Building on populated OCZs, I consider whether the magnitude of these OCZs might indicate that obsidian was a material correlate of non-utilitarian mobility (after Whallon 2006) and/or an item exchanged as part of social networks that incorporated multiple Paleoarchaic groups.

Risk and Information Viewed from the Perspective of Behavioral Ecology

Hunter-gatherers assess risk based on their perception of the environment (Hitchcock and Bleed 1997), with risk referring to: (a) unpredictable variation in an ecological or economic variable (i.e., greater variance is greater risk), and/or (b) the probability of a loss or hazard (Cashdan 1990; also see Bird et al. 2009; Brantingham et al. 2000; Codding et al. 2010; Read 2008). Both definitions of risk are relevant to a consideration of subsistence-settlement strategies, as both types of risk can be perceived by hunter-gatherers and, in turn, may influence their decision-making. Also, note that if we define uncertainty as an individual's lack of knowledge about the world, then greater uncertainty is also greater risk, at least according to the first definition, and we may use these terms interchangeably (Cashdan 1990). Risk can refer to variance over time in the abundance of a resource, the frequency of fluctuations in resource abundance, the size of the area affected by a resource's fluctuations, and predictability (Kelly 1983a). Polly Wiessner (1982a:172-173), augmented by Brian Hayden (2009:598) identifies several risk-reducing strategies: (1) prevention of resource loss by manipulation and/or exclusive territoriality; (2) transfer of risk or loss from one party to another, either by passing out resources or taking resources by force (e.g., Gould 1982); (3) self assumption of risk, often through storage; and, (4) pooling risk by distributing it over a broad segment of the population, often through intra-band sharing and the mobilization of regional social networks that facilitated inter-band visiting, hospitality, and exchange.

Critical to the determination of appropriate strategies to cope with environmental variability are the acquisition, circulation, and maintenance of information (e.g. Whallon 2006, 2011), which serves to lessen the risk associated with temporally and spatially disparate resources because information renders the environment more predictable and, in turn, decreases the probability of a loss (Bamforth and Bleed 1997; Keene 1981; Sobel and Bettles 2000). Furthermore, James Moore (1985) finds through simulation that settlement systems that operate with extremely limited patterns of information sharing are inefficient when measured by the total percentage of the region that can be brought into utilization, and also in terms of movement costs. Information is not free, however (Hegmon and Fisher 1991; Kaplan and Hill 1992). Just like any other resource, information must be gathered either directly, through searching the environment, or indirectly, through the social processes that distribute information among individual decision-makers (Moore 1983; Stephens and Krebs 1986). In fact, because information is critical for navigating risk, the control of information may pose a challenge to maintaining the hunter-gatherer "egalitarian ethic." For example, Harvey Feit (1994) finds that among the Waswanipi Cree, power is manifested in "future knowledge;" that is the ability to plan for the future based upon knowledge of past and present resource structure (also see Andrews 1994; Barnard and Woodburn 1988; Laughlin 1968). Likewise, Wiessner (2002b:427) comments that "the influence of good hunters persisted for years after they ceased hunting" because of the knowledge and competence they had developed over years of successful hunting and manipulating the sharing of meat. Clearly, strategies for dealing with resource variation and potential risk, which require the continual processing of information, exert a strong influence on hunter-gatherer organization (e.g., Cashdan 1983; Colson 1979; Halstead and O'Shea 1989; Hamilton et al. 2007; Minc 1986; Morgan 2009; O'Shea and Halstead 1989; Perlman 1985; Sobel and Bettles 2000).

Mobility, while influenced by environmental variability, may serve, in and of itself, as a risk abatement strategy (e.g., Morgan 2009; Odell 1994; Veth 2005, 2006), and is also one way to gather the information needed to determine the appropriate strategy for coping with environmental variability (e.g., Cavalli-Sforza and Hewlett 1982; Grove 2010; Hewlett et al. 1982; Przywolnik 2005; Shackley 2002). For example, random search strategies and larger catchments have been found to generate optimal solutions to finding disparate or randomly distributed resources, thus high rates of mobility may be the best way of coping with unpredictable resources, especially when information on resource distributions and abundance is poor (Armsworth and Roughgarden 2003; Brantingham 2006). Similarly, Grove (2010:1914) recently suggested that variance in food returns, especially in relation to hunting, may be overcome through logistical mobility, by which hunter-gatherers may "increase the probability of detecting both neighbors and prey." The costs of directly tracking in order to obtain information about the environment can be offset through the development and maintenance of social networks that facilitate the exchange of information between groups (e.g. Katare and West 2006). Security comes from knowledge of the environment and enables more successful exploitation of resources; therefore, the maintenance of such networks can be adaptively advantageous (e.g. Davidson 1990; Minc 1986; Rautman 1993; Silberbauer 1972; Spielmann 1982:Table 3, Table 6; Tindale 1974, 1976; Tonkinson 1988; Yengoyan 1968, 1972, 1976).

Thus, Robert Whallon (2006) defines informational mobility (movement in which the gathering or refreshing of information is primary) and network mobility (movement undertaken for social reasons) as two types of "non-utilitarian mobility." Whallon (2006) observes that the infrequent, long-distance movement of exotic raw materials and decorative items in the European Late Paleolithic and Mesolithic suggests that the acquisition and circulation of these items had little to do with subsistence or other utilitarian activities (for a classic Australian example, see Gould 1980; cf., Binford and Stone 1985; also see discussion in Davidson 1988). Rather, these items are the material correlates of non-utilitarian mobility, which serves to maintain hunter-gatherer social and informational networks.

In the conclusion to a recent paper on hunter-gatherer mobility, Matt Grove (2009b) posits that non-utilitarian mobility is concerned primarily with delayed returns, citing the example of Nunamiut men gathering information on caribou movements in order to plan future hunting strategies. This example connects informational mobility to Binford's (1982:8) extended range, "about which [hunter-gatherers] attempt to keep informed with respect to resource distributions and changes in production, although they may not be exploiting the area at the time of observation." While broadly consistent with Whallon's (2006) definition, if we imagine informational mobility as *only* those forays into unexploited (and, therefore, presumably unoccupied) areas in order to lay better plans for future subsistence pursuits, I think we fall short of his goal to move beyond utilitarian concerns. Instead, if we place Whallon's (2006) concept of non-utilitarian mobility in the context of a landscape populated by many hunter-gatherer bands, then informational and network mobility may frequently coincide, and such mobility may frequently provide information of immediate utility (e.g., Binford 1978:169; Kelly 1983a:299). Perhaps the best hunter-gatherer examples of the coincidence of informational and network mobility are periodic aggregations. David Hurst Thomas (1972), for example, describes fandangos as "clearing houses of information." The ethnographic record is full of similar examples of trade fairs, corroborees, fandangos, ceremonial, and other periodic aggregations that promote the pooling and exchange of resources and information (as emphasized by Wiessner 1982b) and the redistribution of people through marriage and other social relations (e.g., Barnard and Woodburn 1988; Befu 1977; Berndt 1972; Burch 1970, 1981a, 1988; Couture et al. 1986:Figure 3; Earle and Ericson 1977; Flood 1976; Heffley 1981; Hill 1978; Horne and Aiston 1924; Hughes and Bennyhoff 1986; Morrison 1991; Rose 1968; Tindale 1972, 1974; Wedgwood 1930; Wobst 1993; Woodburn 1968a; Yengoyan 1972).

After all, it is not enough for hunter-gatherers to gather information only about the natural environment if they wish to remain viable. As Nicolas Peterson (1986:33) writes, "It is [also] important and efficient for people in one area to have a fair idea of where their neighbors are so that if they move to exploit a particular resource they can be certain that it will not have been worked out without their knowledge." In this light, the close correspondence between resources (both food and non-food) and the name of the group occupying the area where those resources are available is particularly noteworthy (e.g., Clemmer 1990, 1991; Fowler 1982). Moreover, monitoring where other social groups are located prevents the development of exclusive rights of access (e.g., Hiatt 1968; Lee and DeVore 1968), promotes the network mobility required to remain culturally and biologically viable, and facilitates the mobilization of social relations, which are the most powerful of cultural mechanisms to cope with risk (Halstead and O'Shea 1989; e.g., Blundell 1989; Clemmer 1991; Fowler 1982; Morphy 1988; Sackett 1976; Sobel and Bettles 2000; Wilkins et al. 2010). Indeed, if human ecosystems are viewed as systems of exchanges of matter, energy, and information between people and their environments, social interaction, which often includes the direct (rather than down-the-line) exchange of goods (i.e., immediate returns, contrary to Grove 2009), significantly contributes to the information component (Flannery 1972a; also see Earle 1982; Ford 1972; Irwin-Williams 1977; Renfrew 1975; Wilmsen 1972; Winterhalder 1996). Prior to providing some ethnographic examples of non-utilitarian mobility and exchange, I first present the dominant Paleoindian perspective against which these ethnographic examples so markedly contrast.

Paleoindians and the "Risk" of Relying on Exchange for Critical Resources

Most Paleoindianists disregard resource procurement and transport that is not embedded in subsistence pursuits. Paleoindianists tend to believe that exchange, for example, played a minor role in the acquisition of toolstone, accepting Mark Basgall's (1989:111) argument that "among many hunter-gatherer populations lithic procurement is a fundamental component of subsistence settlement organization and occurs primarily or wholly within that context." Jones and colleagues (2003:9) push Basgall's (1989) argument further, stating that "exclusive reliance on exchange to provision a critical resource like lithic material…entails great risk. Difficulties in coordinating exchanges between groups, especially under conditions of low population density as seen in the TP-EH, would increase the likelihood that the exchange would fail to convey the resources to the groups needing them." The predictable nature of toolstone sources in time and space may also suggest the primacy of direct procurement of toolstone (e.g. Sheppard 1996; Spielmann 1986; Thacker 2006; Wright 1967). Thus, Paleoindianists overwhelmingly assume that the acquisition and circulation of toolstone reflects direct procurement embedded in subsistence pursuits.

This sentiment can be traced to Lewis Binford (1979:259, emphasis in original), who wrote:

> Raw materials used in the manufacture of implements are normally obtained incidental to the execution of basic subsistence tasks. Put another way, procurement of raw materials is embedded in basic subsistence schedules. *Very rarely, and then only when things have gone wrong, does one go out into the environment for the express and exclusive purpose of obtaining raw material for tools.*

Moving beyond this oft-quoted statement reveals a significant inconsistency between Paleoindianists' and Binford's (1979) notion of 'embedded procurement.' At the center of Binford's (1979:261) discussion of 'embedded procurement' is a concern for reducing the effort needed to procure toolstone, a position he explicitly contrasts with "most analysts of lithic remains[, who] assume a direct set of procurement strategies for lithic materials; that is, parties going out for the expressed and exclusive purpose of obtaining lithic raw materials." A full appreciation of Binford's (1979) notion of 'embedded procurement,' admittedly hindered by his, at times, awkward prose, includes procurement in the context of subsistence *and social exchange* (Duke and Steele 2010). In fact, Binford (1979:260) provides an example of late-nineteenth century Eskimos obtaining toolstone from the Killik or Kobuk rivers through social mechanisms such as gifts or trading partners, as a "procurement strategy…embedded within some other strategy." As such, Binford's (1979) notion of 'embedded procurement' actually includes direct and indirect procurement of toolstone, as defined by Angela Close (2000). For present purposes, it suffices to say that much understanding of Paleoindian mobility builds on the first quote (Binford 1979:259), whereby the procurement of toolstone is embedded in subsistence pursuits and, in turn, reflects the annual or territorial range of Paleoindians. The significant and frequently cited work of Albert Goodyear (1979, 1989) and David Meltzer (1984-195, 1989), in particular, has reinforced this view.

David Meltzer (1984-1985, 1989) has devoted much thought to the question of distinguishing direct and indirect procurement among Paleoindians, though ultimately reaching the intellectually unsatisfying conclusion that these processes are hopelessly intertangled due to the problem of equifinality. At least in eastern North America, Meltzer (1989) finds that fluted point assemblages were typically manufactured from a single toolstone type that had been procured from a primary outcrop. Of 29 eastern Paleoindian assemblages, Meltzer (1989) finds that only three even hint at indirect acquisition. In fact, in some cases, exotic stone dominates the assemblage, which, at least for Meltzer (1989), precludes exchange and implies direct, cyclical acquisition from primary outcrops (compare to Deller 1989; for interesting examples to the contrary, although from later contexts, see Molyneaux 2002:147; Shackley 2002:69). Furthermore, Meltzer (1984-1985:5) suggests that "to prove that trade took place requires demonstrating that [Paleoindians] were territorial." As a consequence, patterns of toolstone use in eastern Paleoindian assemblages are interpreted by Meltzer (1984-1985, 1989; also see Ellis 1989; Ruggles 2001) to reflect direct procurement by highly mobile residential groups.

The ethnographic examples considered later in this chapter, however, belie both of Meltzer's (1984-1985, 1989) conditions: (a) exchange, at least a directed exchange, *can* account for the introduction of large quantities of nonlocal material into an archaeological site (also see Carr 2005; Spielmann 2008), especially if assisted by dogs (e.g., Fiedel 2005; Henderson 1994:150; Spielmann 1982:196-201; Vance 2011:14;

Wheat 1972:119-120) or boats (e.g., Blair 2010; Engelbrecht and Seyfert 1994; Gaertner 1994:105); and (b) territoriality, at least in a sufficiently rigid sense to deny acquisition of certain toolstone types, *is not* a prerequisite to exchange. The latter does not mean that all peoples had uninhibited access to all toolstone sources, however (e.g., Gould 1977; Patton 1994; Ross et al. 2003). Indeed, if Paleoindians used smaller ranges than typically thought, then we may have to reconsider the possibility that Paleoindians were territorial, especially given the decreasing cost of boundary defense as territory perimeter decreases (e.g., Janson 1992); this aside is not pursued further here. Instead, I wish simply to point out that rules restricting direct access to a quarry often promoted a variety of social interactions near the quarry site in order to obtain the desired toolstone, rather than preventing its acquisition (for similar conclusions regarding other resources, see Fowler 1982; Keen 1988; Myers 1982, 1986, 1988). As one example from Australia, Anne Ross and colleagues (2003:79) write that:

> traders would come to Cape Moreton seeking to obtain stone raw materials and to participate in various alliance forming ceremonial activities associated with exchange. Traders would be shown cobbles of raw material brought by those able to collect them from the headland. Traders would test these samples and then enter into exchange negotiations with the individual families that owned the stone selected. This activity was supported by ceremonial practices and by the sharing of certain foods.

In short, although Meltzer (1989:30, italics in original; also see Hughes and Bennyhoff 1986) is certainly right to suggest that "*any* assertion that [direct or indirect acquisition] was responsible for bringing stone to a site, particularly assertions unsupported by consideration of alternative possibilities and evidence for [the] same, are empirically unacceptable," his seminal work on this topic has had the unfortunate, I suspect unintended, effect of stifling significant consideration of indirect procurement in Paleoindian contexts, an irony alluded to earlier.

To be fair, some Paleoindianists have developed multi-tiered models of Paleoindian settlement patterns. For example, Stuart Fiedel (2000) uses the insights of Joseph Birdsell (1968) and H. Martin Wobst (1976) on hunter-gatherer social systems to build a multi-tiered model of the Paleoindian social landscape, with microbands of 25 people in 5200 sq. km territories, seasonally aggregating in macrobands of 100-150 people. In turn, four to six macrobands, distributed over a territory of 100,000 sq. km, might form a network of about 500 people participating in marriage and exchange. Similarly, Joseph McAvoy (1992) suggests a 13,000 sq. km territory occupied by 75 people based on the distribution of Clovis points made of Williamson quarry chert in southeastern Virginia. Likewise, David Anderson (1995) hypothesizes the existence of 15 Middle Paleoindian macrobands, each occupying a territory of 20,000-80,000 sq. km. Yet, Paleoindianists have not explored the full implications of these reconstructions of the Paleoindian social landscape. Repeating Meltzer's (1984-1985, 1989) conclusions, Fiedel (2000) asserts that it is improbable that exchanges between neighboring bands would account for the high percentages of chert derived from distant sources at sites such as Gainey in southeastern Michigan (Simons et al. 1984), Paleo Crossing in north-central Ohio (Brose 1994; Stothers 1996), the Bostrom site in southwestern Illinois (Tankersley 1998), and Bull Brook in Massachusetts (Spiess et al. 1998:204). Fiedel (2000) does allow that the long-distance transport of toolstone reflects the periodic expeditions of special-purpose task groups (e.g., Spiess et al. 1998), though he concludes that we cannot distinguish this alternative from toolstone procurement "embedded" in the subsistence round. As such, current Paleoindian literature increasingly emphasizes the maintenance of far-flung mating networks during Paleoindian times (e.g., MacDonald 1998), especially during the process of colonizing the Americas (e.g., Meltzer 2003, 2004), paired with a rejection of the processes and material correlates associated with the maintenance of these networks (notable exceptions include Collins 2002; Deller 1989; Dillehay et al. 2003; Flegenheimer et al. 2003; Hayden 1982; Robinson et al. 2009; Speth et al. 2012; Tankersley 1989; Walthall and Koldehoff 1998; Wilmsen 1973; Wright 1981; Wyckoff and Bartlett 1995).

In the Great Basin, this preference is exacerbated by the legacy of Julian Steward. Aram Yengoyan (2004), for example, suggests that the contrast between the cultural core and the "rest of culture," which was so critical to Julian Steward's work, made culture an epiphenomenon which had little or no bearing on the core (also see C. Fowler 1977, 1999; Myers 2004). In this tradition, Christopher Raven (1990:135-136) can conclude that:

> the importance of non-economic interests in the formation of the archaeological record of the Carson Desert must always have been relatively slight, since we have succeeded on purely economic grounds in predicting most of the variability

> in local archaeological patterns. We concede, however, that what cannot be modeled by the approach adopted here are those settlement shifts and expenditures of effort mounted in the interest of the numerous structural and superstructural whims by which all foragers, everywhere, enrich, but complicate, their otherwise neatly economical behavior.

While I agree with Raven's (1990) conclusion that many archaeological patterns (e.g., camp location) can be predicted on economic grounds, the sources of toolstone utilized by Paleoarchaic groups and the methods by which toolstone was acquired may have had much more to do with social and ideological considerations than Raven (1990) admits.

As it stands, we actually know very little about how hunter-gatherer populations incorporate toolstone procurement into subsistence-settlement organization. This does not mean that the significant methodological and theoretical contributions of numerous lithic analysts are unimportant; however, the centrality of lithic analysis for understanding prehistory, derived simply from the predominance of stone tools and detritus in the archaeological record (Andrefsky 2009), makes it very easy to overstate the centrality of toolstone procurement in hunter-gatherer societies (e.g., Jennings 1957:279, quoted in Chapter 2). The fact of the matter is that we have few first-hand observations of stone tool use as an integral part of hunter-gatherer daily life (Cross 1983; Jochim 1989; Kelly 1994, 2001:67), and many of the cases ethnography provides suggest that stone tools are not critical to subsistence-settlement organization. For example, Brian Hayden suggests that, among Australian Aborigines, chipped stone tools were insignificant for plant procurement and processing, and the procurement of small animals. Additionally, Hayden (1978) notes that no lithic equipment is required for exploiting water procurement sites, and as such, little in the way of specialized lithic debris is expected to be left behind, yet these locations are the principal foci of base camp placements in the Western Desert. Similarly, J. Peter White (1967) notes that New Guineans do not treat a stone tool as a type – they do not make tools to regular morphological patterns. Rather, a "stone tool" is simply a piece of stone that may be used to perform a given function (White 1967). As such, the need for a particular stone tool imparts only very general limits on toolstone procurement. Additionally, Alan Bryan (2004) notes that material culture studies of northern interior natives indicate that bone, hide, sinew, and other perishables were more important than stone (e.g., Osgood 1970; Rogers 1967). Likewise, the material cultures of several lowland South American groups show that lithics were much less important than bone, wood, fiber, cordage, basketry, and featherwork (e.g., Albisetti and Venturelli 1962, cited in Bryan 2004; for a similar conclusion regarding the Mbuti, see Sugawara 2004).

In fact, when toolstone was utilized, it seems unlikely that its procurement was central to subsistence-settlement patterns. Barbara Luedtke (1979a), for example, estimates that the modest lithic demands of Great Lakes Late Woodland peoples, though perhaps less than Paleoindians, could be satisfied in few trips to a quarry. George Frison (1972; emphasis added) also suggests that it was a *yearly pattern* for post-Altithermal (2750-1500 BC) and Late Prehistoric bison hunters of the Northern Plains to spend *a few days* near a stone source in order to make enough tools for the communal buffalo hunt (for a comparable take on Middle Archaic obsidian use in the southern Southwest, see Shackley 2002:69). Finally, if we add to this equation the observation that projectile points made of high-quality toolstone may have been unnecessary for killing animal prey or people, as attested to archaeologically (e.g., Bryan and Gruhn 2003; Cochran et al. 1990; Dinnis et al. 2009; Ellis 1997; Gaudzinski 2004; Honegger 2008; Lyman et al. 2009; Odell 2000; Thieme 1997, 2005; Wendorf 1968; Wilson 1901; Zeanah and Elston 2001), ethnographically (e.g., Weitzner 1979; White 1977), and experimentally (e.g., Holmberg 1994; Hunzicker 2008; Medicine Crow 1978; Odell and Cowan 1986; Sisk and Shea 2009; Smith 2003; van Gurp et al. 1990; Waguespack et al. 2009), then the use of exquisite stone projectile points, in and of itself, may have been a social and/or symbolic act (e.g., Bamforth and Hicks 2008; Bradley 1993; Bradley et al. 2010; Cunnar et al. 2009; Fiedel 2004b, 2006b; Frison and Bradley 1981, 1982; Gero 1989; González-Ruibal et al. 2011; Hickson 1967; Hill and Lange 1982, cited in Harper and Andrefsky 2008; Speth et al. 2012; Taçon 1991).

In sum, these findings suggest that although prehistoric peoples may have planned toolstone procurement into their annual rounds, their economic centrality may be overstated (e.g., Brumm 2004, 2010; Bouey and Basgall 1984; Hughes 1978; Molyneaux 2002, 2006). This is not to deny the archaeological evidence for significant quarrying in various archaeological contexts (e.g., Bamforth 2006; Holen 1991; Reher 1991), but, again, I wonder if the primary motivation for these efforts was strictly economic. In fact, when ethnographers describe the procurement of resources, especially toolstone and other inorganic resources, these resources and the locations from which they originate are frequently imbued with social and ideological significances (e.g., Binford and O'Connell 1984; Burton 1984; Eliade 1967; Dillian and White 2010; Gould 1977; Hiatt and Jones 1988; Howitt 1887; Jones and White 1988; Kratz 1988; Leach 1993; Levi 1978; Parkman 1983:144-146; Paton 1994; Powers 1982; Powers 1986; Ross et al. 2003; Ross and Davidson 2006; Saunders 2004; Speth et al. 2012; Whitaker et al. 2008; Whitley et al. 1999). For example, Horne and Aiston (1924) describe several kinds of nonlocal stone that carry mystical powers: a yellow stone called Morra's *yakarra* (or teeth) was kept as a charm; a semi-transparent chalcedony, resembling Moora's (ancestor's) toenails, was procured from more than 200 miles away; small white quartz pebbles (*kunchera warroo*), obtained by barter or as gifts from the Dieri people, were planted where the wirra tree was wanted; *yelka* was a stone used to ensure a plentiful supply of yauas (*Cyperus rotundus*); and clear gypsum was used to make rain-stone figurines for some versions of the rain-making ceremony. Horne and Aiston (1924) also provide an Australian example of emu hunting using obsidian "bombs." Closer to home, obsidian figures prominently in western Native American myth and ritual (Fowler and Fowler 1971:57; Hodgson 2007; Rust 1905; Smith 1972; Zigmond 1972). In many cases, the distance traveled to obtain the item, as well as the trip itself, was valued (e.g., McBryde 2000; Tindale 1985). There are also tantalizing hints in Great Basin, Paleoindian, and other early archaeological contexts that toolstone and other inorganic resources (e.g., ochre), even for the production of mundane tools, were of more than just utilitarian significance (e.g., Ackerman 1996; Amick 2004a, 2004b; Brady and Prufer 1999; Cornell et al. 1992:159; Deller and Ellis 2001; Dillian 2002; Ellis 1994, 2009; Frison et al. 1996; Gould and Saggers 1985; Jones 1996; Koerper et al. 2002; Mithen et al 2005; Mullett 2009; Needham 2001; Pearson 2003; Reher and Frison 1991; Roper 1989; Speth et al. 2012; Stafford et al. 2003; Stanford 2005; Taçon 1991; Tankersley et al. 1995; Torrence 1986; Torrence et al. 1996; Tuohy 1984; Whittaker and Kaldahl 2001; Zedeño 2009), though these insights have not been incorporated into any systematic attempt to rebuild models of Great Basin or Paleoindian toolstone procurement and mobility.

Yet, again, I do not wish to promote a new dichotomy between utilitarian and non-utilitarian pursuits. As John Robb (1998:311) writes:

> In many ways, the question is not whether we can find symbols archaeologically, but whether we can find anything cultural that is not symbolic. Many powerful symbols in any culture are the commonest things: bread, water, houses, the river, and the hills beyond (also see Dobres 2000, 2001; Goodale 1982; Sinclair 1995; Wurz 1999, 2008).

None of the social and ideological significances alluded to above negate the utility of ochre, obsidian, or other inorganic resources for more mundane tasks (for an illustrative Great Basin disagreement, consider Minor and Toepel [1989] and Scott et al. [1986, 1989] in this light). In fact, the insights provided by lithic technological organization, the analytical perspective utilized in Chapter 4, may all still apply, even after we allow that toolstone "quality" may include more than just utility. Indeed, a fundamental contribution of systems theory was to emphasize the interrelationships between all cultural institutions, thereby rejecting ideology as mere epiphenomena (Demarest 1989; Flannery 1968, 1972b). In other words, the social and ideological pursuits of hunter-gatherers are certainly more than "structural and superstructural whims" (Raven 1990:135-136). As Anthony Sinclair (1995:51) writes, there is:

> much more to the lives of gathering and hunting societies than a simple need to adapt to the environment. The practical and the symbolic sides to these societies are intimately bound together as a coherent whole. The archaeological evidence of prehistoric technologies that we study is just as likely to be related to these 'non-adaptive' actions as not (also see Adams 1977; Fowler and Turner 1999; Parkman 1983:146; Peterson 1968; Reynolds 2009; Speth et al. 2012; Walker 1998; Warren and Neighbour 2004).

In many cases, the pursuit of 'non-adaptive' actions (visiting, aggregations, vision questions) are critical for the acquisition, circulation, and maintenance of information, as well as the maintenance of social networks, as demonstrated by the examples of non-utilitarian mobility and exchange provided below.

Some Examples of Hunter-Gatherer Non-Utilitarian Mobility and Exchange

Australian aborigines provide several examples where information and network mobility serve to articulate disparate social groups in order to alleviate risk of resource shortfalls. The Western Desert of Australia is crisscrossed by meandering tracks of ancestral beings that tend to follow the known distribution of permanent and impermanent waterholes (Berndt 1941, 1959-60, 1972). These tracks connect a number of local groups who hold in common certain totemic beings by their "ownership" of sites along the tracks of that being (Berndt 1959-1960, 1972). In times of severe drought it was possible for a stricken group to travel hundreds of miles if necessary and still be assured of the hospitality of a local group, as ancestral tracks regularly linked areas as far apart as 1440 km (900 miles), well beyond the limits of a local group's normal territory (Hiatt 1968; Lévi-Strauss 1963; Long 1971; Meggitt 1965; Stanner 1965b; Strehlow 1965, 1970; Turner 1976). Aborigines, by permission, could visit and forage in estates of other clans with which they had secondary rights of access either through the wanderings of their clan totem or their conception totems. Additionally, Australian aborigines could manipulate these ancestral connections in order to make claims to specific areas or extend groupings to facilitate greater exchange relations (Keen 1995). In short, these totemic connections formed an adaptively advantageous social network that allowed for the mitigation of risk over the variable environment, providing points of articulation between members of different, and often distant, social groups (for similar examples from the Arctic see Andrews 1994; Burch 1981a, 1981b; Ray 1967, 1975).

The maintenance of ideological links to the ritualized landscape and social links to other aboriginal groups often takes the form of long-distance forays in which the procurement of non-food resources is central. Edward Curr (1886:70-72, cited in Mulvaney 1976:79-80; also see Peterson and Lampert 1985:6) provides an example of a 300-mile-long trek undertaken annually in order to procure red ochre, an item of great symbolic importance to Australian Aborigines. Curr writes that the party travels about twenty miles a day, seldom resting a day while on the journey. After arriving at the mine, each member procures his own ochre. Loaded down with 70 lbs. of ochre per person, a testament to the loads hunter-gatherers could carry on these long-distance forays (also see Bunn 2007; Hilton and Greaves 2008), the party returns home, a trip which often takes 6-8 weeks to complete. Alfred Howitt (1891:77-78; 1904:710-712; Thomas 1886:342) provides a similar example of the annual expeditions undertaken by subgroups of the Dieri, some for the procurement of ochre, others for gathering *pitcheri* or *pituri* (*Duboisia hopwoodii*; McBryde 1987:258-261), a prized narcotic. Again, the distance travelled might be as much as 300 miles, with a party of 70-80 men armed to fight, and weighed down with ochre cakes weighing 70-80 lbs. Likewise, Horne and Aiston (1924:130) write "then, loaded each with 50 lbs of red ochre; they began their toilsome way homewards. Over 300 miles…" Finally, Morgan (1852:73-74; also see Smyth 1878:359) records a three hundred mile trek of "resolute fighting men" to obtain black stone to make groundstone axes or hatchets. With these anecdotes in mind, C. Vance Haynes's (1980:118) observation that "the figure of 300 km (200 mi) for the maximum distance from lithic sources turns up repeatedly in the literature" takes on a different tenor.

Significantly, many of these resources were also obtained by exchange, often as direct exchange during visits rather than down-the-line exchange. Horne and Aiston (1924) document gifts, such as bean-wood shields, spear shafts, and boomerangs, being given to the Blinman aborigines in return for permission to mine the Beltara ochre deposit, which is considered the "proper" ochre and is always used despite several ochre deposits being located hundreds of miles closer. Horne and Aiston (1924) also note that Lake Eyre groups would obtain stone axes by barter from southeastern tribes (also see McBryde 1978, 1984a). Likewise, Norman Tindale (1985) records trade in *tjimbila* (bifacially pressure-flaked spear points of jasper, chert, and other quartz rocks). Moreover, Tindale (1985) notes that there was prestige among the Kokatja in having Kimberley points, which they must receive through trade. Significantly, Tindale (1985) finds that (a) value increased as the points were carried farther from their point of origin (often over distances greater than 150 km), and (b) some spear points were only prepared in a preliminary fashion before being traded. Additionally, exchange is not relegated to only those most rare, or otherwise unique, items (e.g., Chatwin 1987; Davidson 2010; Hiatt 2004; McBryde 1984b; Mulvaney 2002; Wilkins et al. 2010). Nicolas Peterson (1968), for example, finds that aboriginal residents at Mirrngadja would obtain black pebbles from the coast via exchange for use as pestles by women in the preparation of vegetable foods. As Robert Paton (1994:181) writes:

> there is little evidence to support the propositions that either the leilira blades or the boomerangs are intrinsically valuable either as utilitarian items or as a raw materials [sic] which are later used to manufacture more functional tools. There is no substantive evidence that either class of artefact was used, or that either raw material would be difficult to obtain if it were desired for day-to-day tool

manufacture. The real value of these artefacts lies in the socially indispensable messages they help communicate (also see Clarkson 2008).

Polly Wiessner's (1977, 1982b, 1986, 1998, 2002b) research on the Ju/'hoansi (!Kung) of the Dobe-/Kae/kae area of northeast Botswana provides perhaps the best-known example whereby exchange serves to maintain a large social network that, in turn, allows for the pooling of risk. The Ju/'hoansi are integrated into a larger social network by exchange with others through hxaro. Hxaro relationships involve a balanced delayed exchange of gifts, whose continuous flow gives both partners information about the underlying status of the relationship (Wiessner 1982b). Hxaro builds a network of social relations, which allows people to redistribute themselves over the resources of the region, whereas ties of food sharing through kinship networks create connections among people living in one place (Wiessner 1977, 1982b, 1986, 1998). Ju/'hoan kinship networks are dense, allowing for the classification, whether actual or fictitious, of a very wide range of individuals. Hxaro, in contrast, is sparse, simplifying the kinship network by specifying the regional relations for which one is responsible, thereby creating more definite obligations. Hxaro functions, then, as a system of pooling risk through the system of sharing of information about social and natural resources, which connects individuals across the region (i.e., some 2000 Ju/'hoansi within a radius of ~200 km; Harpending 1976; Wiessner 1981; 1982b) in order to cope with environmental variability, and provides points of articulation with the economies of surrounding populations (Wiessner 1998). These connections were reinforced by marriage, as parents often sought spouses for their children among the offspring of their hxaro partners, sometimes from as far as 300 km away (Wiessner 1994, 2009). Interestingly, Wiessner (1977, 1982b) finds that the number of hxaro partners increases with distance from ego's camp, with 18% of partners residing in ego's camp, 24% in neighboring camps 1-15 km away, 25% in camps 16-50 km away, and 33% in camps between 51-200 km away. And although Wiessner (1982b, 2002b) emphasizes the access to information provided by hxaro, hxaro also served to supply families with arrows, clothing, beadwork, and many other items. In fact, in 1974 69% of the possessions of the Ju/'hoansi at /Kae/kae were obtained through hxaro (Wiessner 1986). Finally, hxaro also structured meat sharing outside the camp (Wiessner 2002b).

Among Great Basin and California populations, Richard Hughes and James Bennyhoff (1986:Tables 1-4) note that perishable resources were the most commonly exchanged items, especially prior to the introduction of the horse (also see Kelly 1964; Layton 1981). Perhaps the most widely-accepted, archaeologically-visible Great Basin exchange network involved shell derived, for the most part, from the Pacific Coast and Gulf of California (Hughes and Bennyhoff 1986:Figure 1; also see Bennyhoff and Heizer 1958; Bennyhoff and Hughes 1987). Hughes and Bennyhoff (1986) note that the different species of shell indicate that (especially western) Great Basin groups participated in five major exchange networks involving Pacific shells and ornaments. These exchange networks are particularly apparent during the Middle Archaic and later contexts (e.g., Jackson 1984, 1988; Singer and Ericson 1977), though some evidence exists for shell exchange during the Early Holocene (Jenkins et al. 2004). Additionally, it seems likely that obsidian accompanied shell through the same Middle Archaic trans-Sierran network, but because these obsidian objects are often found in contexts suggesting intensification and surplus production in association with increasing sociopolitical complexity (e.g., Bouey and Basgall 1984; Hughes 1978; though see Jackson 1988), obsidian exchange has not been pushed back in time with shell exchange. Indeed, I would suggest that the strong connection between surplus obsidian production for exchange and the development of sociopolitical complexity in the archaeological and ethnographic study of native California groups may hinder the serious consideration of obsidian exchange among "simpler" societies of this region. Interestingly, Katherine Spielmann (1982:71) turns this chicken-and-egg problem around, proposing that "regular access in the context of stable habitats… permitted the high population densities [and concomitant changes in social relations] that characterized aboriginal California." In fact, Spielmann (1982) goes on to suggest that regular inter-ecosystem mobility and exchange is associated with regions characterized by highly productive but temporally and spatially variable subsistence resources; the applicability of this relationship to the Paleoarchaic context is considered in the conclusion to this chapter.

In sum, intergroup interaction, including non-utilitarian mobility and exchange, is a ubiquitous aspect of hunter-gatherer society (e.g., Dalton 1977; Earle 2005; Hiatt 2004; Kuhn and Stiner 2001; Spielmann 1986). To this end, although we may quibble over whether hunter-gatherers as recorded in ethnography are a distinct societal type or the marginalized, impoverished product of ever-encroaching pastoralists and agriculturalists, it may be more telling that exchange accompanies all of these contacts (e.g., Earle 2005; Bailey 1937; Leacock 1954, 1969; Meyer 1971; Morrison 1991; Morrison 2007; Ogawa 2009; papers in Spielmann 1991; Stefansson 1914; Trigger 1976). In short, the idea that indigenous peoples did not interact in any meaningful way with each other prior to Western contact is an anthropological "illusion born of the Western self-consciousness of civilization" (Sahlins 1999:ii).

Patterns and Implications

David Hurst Thomas (1976:131) in his discussion of the "heirloom hypothesis," suggests that:

> Too many archaeologists mistakenly assume that the hypothesis-testing strategy so lovingly nurtured by 'new' archaeologists is relevant only to matters of settlement pattern, technology, and cultural ecology. This is not so. A cultural materialistic framework can be used to explain a very wide range of behavior—including religion and ceremonials (also see Walker 1998).

To his list, I would add non-utilitarian mobility and exchange. Among many archaeologists focusing on hunter-gatherers, these processes have taken on a mystical quality that has placed them outside the purview of the "hypothesis-testing strategy" of the new archaeology, as Thomas (1976) describes it. Although, it may be tempting to dismiss the "non-utilitarian" processes discussed here as exceptions to the rule of direct procurement embedded in subsistence pursuits—what Yellen (1977) terms "spoilers" in his discussion of ethnographic analogy—these examples should be viewed as the tip of the iceberg, rather than just a catalogue of insignificant isolates. After all, reconstructing prehistoric mobility is a middle-range problem, and the long-distance transport of toolstone does not, by itself, indicate mobility at all, let alone the default position of direct procurement embedded in subsistence pursuits (e.g., Dillian et al. 2006; Hughes 1998). The widespread, though often tacit, acceptance of this position, though perhaps correct in many cases, ignores the difficult problem of identifying relevant archaeological proxies for the movement of people and materials—which need not correspond—and, in turn, ignores a host of other significant cultural processes. Rather than ignore these processes, Thomas (1976:131; also see Torrence 1994), challenges us to test them outright.

Meeting this challenge requires we reconsider the material correlates of these different types of resource acquisition. The ethnographic examples considered here suggest that non-utilitarian mobility and exchange: (a) may mitigate risk rather than be inherently risky (compare to Jones et al. 2003); (b) can account for the presence of large quantities of nonlocal toolstone within an archaeological assemblage (compare to Curran and Grimes 1989; Koerper et al. 1989; Loosle 2000; Meltzer 1984-1985, 1989; Morrow and Jeffries 1989; Roth and Dibble 1998; Spiess and Wilson 1989); (c) do not require surplus production, at least not to a degree that would relegate these processes to more complex societies (Burton 1984; Trinkaus 1985; compare to Amick 2004a; Jones et al. 2003); (d) are not dependent upon a rigid territoriality (e.g., Spielmann 1986; compare to Meltzer 1984-1985, 1989); (e) are not marked solely by the circulation of complete (i.e., finished) tool forms (e.g., Tindale 1985; compare to Koerper et al. 1992; Roth 2000; Shackley 1996); and (f) are not marked solely by the circulation of symbolic, ceremonial, or otherwise extraordinary items (compare to Chatters 1987:349; Morrow and Jeffries 1989; and, again, see Robb 1998; Sinclair 1995). The ethnographic and ethnohistoric records are full of examples of non-utilitarian mobility and exchange, often involving the procurement and transport of large quantities of resources, many for everyday use, over much longer distances than utilized for subsistence pursuits. As such, we may have to face the fact that the best archaeological correlate left to distinguish these alternative types of mobility and resource acquisition, at least for lithic assemblages attributable to prehistoric hunter-gatherers, is distance of toolstone transport. This does not mean that local exchange or visiting did not occur, however; exchange and non-utilitarian mobility may themselves be viewed as multi-tiered as well (e.g., Halstead and O'Shea 1989; Mitchell1974; Sobel and Bettles 2000; Zvelebil 2006). Yet when we document the transport of materials over incredibly long-distances, it is increasingly likely that such behaviors are motivated by social and/or ideological concerns (e.g., Mulvaney 1976; Peterson 1976b; Tuohy 1984; Weniger 1987). With this in mind, we may also have to conclude that in many cases distinguishing direct and indirect procurement is an interesting, but perhaps more difficult and less significant problem, than distinguishing procurement embedded in subsistence pursuits from procurement embedded in social and/or ideological pursuits (also see Bamforth 2006).

What we end up with in considering the myriad examples presented here is a multidimensional, multi-tiered model of mobility, much as Binford (1983b) and others developed years ago, but with attention paid more explicitly to interaction with neighboring social groups through informational mobility, network mobility, and/or exchange. The trick, of course, is to use these insights to reconstitute the models provided by Jones and colleagues (2003) and Madsen (2007) in an archaeologically testable way. To begin with, a subsistence-settlement pattern tethered to riverine, lake, and marsh settings may have promoted varying degrees of residential mobility, dependent upon the type, diversity, productivity, and reliability of the resources provided by these settings, as well as the resource opportunities provided by the associated hinterlands (Nicholas 1998; Oetting 1999; Raven 1992). As such, the subsistence-settlement models of Jones et al. (2003) and Madsen (2007) are not opposed to each other but may be viewed as viable alternatives, dependent upon the particular environmental context. Even so, it seems unlikely that the OCZs represent the area exploited by Paleoarchaic groups in their annual or decadal pursuit of subsistence, whether through residential or logistical mobility. Instead, the spatial distribution of obsidian may subsume the annual ranges of several Paleoarchaic groups, perhaps reflecting any number of social and/or ideological linkages (e.g., McBryde 1984a, 2000; Whitaker et al. 2008). If so, these smaller ranges may be reflected in the technological organization and provenance of tools manufactured from other toolstone, as discussed in Chapters 4 and 5.

Significantly, the disparity in water distribution and the impact of short-term climatic changes on TP/EH Great Basin paleoenvironments (Madsen 2007) would have promoted the maintenance of Paleoarchaic informational and social networks (also see Ericson 1977; Hegmon and Fisher 1991; Plog 1980). While subsistence exchange may be rare in societies maintaining low population densities (Spielmann 1982), these same societies should engage in network mobility, which is often accompanied by the exchange of non-food items. Although more mobile Paleoarchaic groups may have engaged in casual interaction and exchange in a variety of settings, the ability of even a small number of interspersed sedentary settlements to disrupt a seasonal round (e.g., Moore 1985) and, in turn, the acquisition of resources and information (e.g., Trinkaus 1985), may have promoted the periodic aggregation of Paleoarchaic social groups at ecologically rich localities and/or toolstone sources (e.g., Molyneaux 2002, 2006; Park 2010:48-53; Parkman 1983; Robinson et al. 2009; Ross et al. 2003).

Wetlands may have been a comparatively stable resource base during the TP/EH because they usually provide year-round water availability, even during times of drought, as well as a high degree of floral and faunal diversity (Crowe et al. 2004; Nicholas 1998). It is also worth noting that the same features that render a location suitable for a central place from which to forage also render such a location suitable as a meeting place for different groups (e.g., Berndt 1941:4). For example, Frederick Rose (1968) finds that abundant food in a limited area was a prerequisite for the carrying out of large scale initiation and increase rituals by Australian Aborigines. Likewise, in his consideration of southwest Germany during the Mesolithic, Michael Jochim (2006) finds that while each large lake may have served as a central locus for a distinct pattern of movement and affiliation, the lakes were also central to a regional nexus of interaction. Similarly, Ju/'hoansi holding land at permanent waters were focal in exchange networks, both among other Ju/'hoansi (Lee 1976) and broader southern African trading networks (Wiessner 1994; Wilmsen 1989). Finally, Marilyn Couture and colleagues (1986:154) note that "the concentration of resources at Malheur Lake fostered social gatherings." Given the potential volatility of Great Basin TP/EH environments, we may expect the periodic aggregation of Paleoarchaic populations and, in turn, the exchange of toolstone and other goods (a possibility that Madsen [2007] does briefly consider).

Paired with the toolstone preferences documented for Paleoarchaic assemblages, which suggest that different types of tools were utilized for different activities presumably by different subsets of a Paleoarchaic group (see Chapter 2), it is tempting to build a multi-tiered model of mobility in which local toolstone used expediently reflects the less mobile subset of the Paleoarchaic group (i.e., women, children, elderly) and nonlocal toolstone used for tools exhibiting greater curation reflects the more mobile subset of the Paleoarchaic group (i.e., men, particularly young men) (also see Arakawa 2000; Beck and Head 1990; Binford and Binford 1969:81; Bird 1993; Gero 1991; Jarvenpa and Brumbach 2009:Tables 3-6; Leach 1999; Walsh 2000). This expectation is consistent with central-place foraging models of resource transport strategies, which predict that food resources that travel the farthest will yield high energetic returns (Jones and Madsen 1989; Winterhalder 1981). This expectation is also consistent with the observation that simple movable property tends to be personally owned, with people often making their own tools and entitled to the yield of their own labor (Barnard and Woodburn 1988), even if that “labor” involves several different activities performed by different people (e.g., Jarvenpa and Brumbach 2009).

More specifically, we might imagine a scenario in which the chert utilized for gravers and scrapers reflects the localized processing activities of women and other occupants of a camp, fine-grained volcanic and high-quality chert bifaces and projectile points reflect the logistical hunting forays of men, and at least some obsidian (and, perhaps, some high-quality chert) bifaces and projectile points reflect long-distance non-utilitarian mobility and/or exchange to maintain informational and social networks. Again, this model is not offered in advance of a new dichotomy between utilitarian and “non-utilitarian” pursuits. None of the social and ideological processes considered here negate the use of obsidian for functional purposes and these long-distance non-utilitarian forays, by necessity, include subsistence pursuits. What changes is the primary motivation for the long-distance forays and, in the Paleoarchaic context, what the scale of OCZs actually reflects in terms of human behavior. In fact, the distribution of obsidian around the perimeter of the Great Basin may, in and of itself, suggest the use of direct procurement embedded in network or informational mobility (Duke and Steele 2010), at least to provision Paleoarchaic groups in the central Great Basin. Accordingly, we might expect Paleoarchaic peoples to bypass serviceable toolstone sources located within their annual range (e.g., Cottrell 1985:838), but in an effort to obtain information or engage other social groups rather than because of the “pull” of high-quality toolstone sources. In a similar vein, evidence of obsidian caches in sections of the Great Basin where obsidian outcrops are fairly abundant (especially the northern Great Basin; e.g., Amick 2004a, 2004b; Scott et al. 1986, 1989) may hint at the social and/or ideological significance of obsidian in prehistoric contexts. Evaluation of these hypotheses, in an attempt to build a multi-tiered, multi-dimensional model of Paleoarchaic adaptation, requires a fuller understanding of the technological variability represented in Paleoarchaic lithic assemblages and the toolstone sources present on the Paleoarchaic lithic landscape, as considered in Chapters 4 and 5.

Chapter 4: Using Lithic Technological Organization to Build a Multi-tiered Model of Paleoarchaic Mobility and Inter-Group Interaction in the Eastern Nevada Study Area

In this chapter I present the technological analysis of artifacts recovered from several Paleoarchaic localities in east-central Nevada. The toolstone preferences exhibited in many Paleoarchaic lithic assemblages suggest that Paleoarchaic hunter-gatherers may have introduced, circulated, and utilized obsidian, fine-grained volcanics (FGVs; e.g., andesite and dacite), and chert differently, although comparison of the technological attributes of these different toolstone types within Paleoarchaic assemblages is often not made explicit. This chapter presents basic comparisons between sub-assemblages defined on the basis of toolstone types in an effort to connect these toolstone types to different spheres of mobility and, perhaps, means of acquisition. Debitage is particularly informative on this matter, as it has proven to be a very useful proxy for understanding the distribution of stone tool production activities across the landscape (e.g., Ahler 1989; Amick and Mauldin 1989; Amick et al. 1988; Ammerman and Andrefsky 1982; Andrefsky 2001; Beck et al. 2002; Beck 2008; Bloomer 1991; Collins 1975; Crabtree 1972; Eerkens, Ferguson, et al. 2007; Henry 1989; Ingbar et al. 1989; Kessler et al. 2009; Magne and Pokotylo 1981; Patterson and Sollberger 1978; Pecora 2001; Rasic and Andrefsky 2001; Sullivan 2001; Sullivan and Rozen 1985), while remaining relatively unaffected by the collection efforts of avocational archaeologists (Kelly 1983b, 2001). Thus, several comparisons focus on the size (i.e., weight) distribution of debitage by toolstone type as indicative of earlier or later stages of reduction and, in turn, relative distance to toolstone sources. These comparisons permit the contextualization of present knowledge of the procurement, transport, and utilization of obsidian within a comprehensive understanding of Paleoarchaic lithic technological organization (also see Amick 1999; Duke and Young 2007; Thacker 2006). In the present analysis, I privilege weight and presence/absence of cortex in order to avoid parameters that other lithic analysts suggest are of debatable reliability (e.g., various platform attributes; Andrefsky 1998; Cochrane 2003; Dibble 1997; Dibble and Bernard 1980; Kuhn 1990; number of dorsal flake scars; Marwick 2008; also see Steffen et al. 1998). As will be seen, these basic comparisons provide some interesting insights into Paleoarchaic technological organization and mobility in east-central Nevada.

Many of the results I present here have been suggested previously by Charlotte Beck and George T. Jones (1990a, 1990b), although I augment, reinterpret, and articulate them within a multi-tiered model of Paleoarchaic mobility and toolstone procurement, as discussed in Chapter 3. The most important novelty in the following presentation is the application of minimal analytical nodule analysis (MANA) to the chert artifacts within the Eastern Nevada Study Area. MANA provides a way to partition the chert sub-assemblage below the level of the whole (Larson 2004). More plainly, MANA allows the chert artifacts to be separated into macroscopically-similar subgroups (i.e., different chert types), facilitating further comparisons between the toolstone types within these assemblages. This analysis suggests that the tendency to treat chert en masse masks significant variability within these assemblages, including the potential to document distinct chert procurement ranges that operate within the obsidian conveyance zones (OCZs). As I demonstrate below, these technological analyses suggest that the annual or territorial ranges utilized by Paleoarchaic populations may be better reflected by chert or FGV provenance than by obsidian provenance. These findings are consistent with a multi-tiered model of Paleoarchaic mobility and exchange, as discussed at length in Chapter 3. This analysis also serves as a prelude to Chapter 5, in which I consider the possibility of sourcing cherts in east-central Nevada.

Lithic Technological Organization as an Analytical Framework

The analyses presented in this chapter are informed by the perspective of lithic technological organization. "Lithic technological organization refers to the manner in which human toolmakers and users organize their lives and activities with regard to lithic technology" (Andrefsky 2009:66), focusing most often on the adaptive strategies of hunter-gatherers. As such, many studies of lithic technological organization consider how tools are designed, produced, maintained, recycled, and discarded, especially in reference to the spatial and temporal relationship between toolstone procurement and the locations of tool use (Collins 1975; Nelson 1991:57), and as recorded by the transformations that lithic artifacts undergo during the course of their life histories (Andrefsky 2008a). Over the last forty years archaeologists have developed a number of theoretical models to relate the composition of lithic assemblages to toolstone procurement and mobility strategies, often informed by concepts such as risk and efficiency (e.g., Amick 1994; Andrefsky 1994a, 1994b, 2006; Bamforth 1986, 1990, 1991b; Basgall 1989; Beck et al. 2002; Binford 1979; Bleed 2001; Boydston 1989; Brantingham 2003, 2006; Brantingham and Kuhn 2001; Carr 1994; Clarkson 2008; Clarkson and Lamb 2005; Close 1996, 1999, 2000; Cowan 1999; Curran and Grimes 1989; Eerkens et al. 2008; Elston 1990; Hofman 1992; Jeske 1989; Jochim 1989; Jones et al. 2003; Kelly 1988; Kessler et al. 2009; Kuhn 1989, 1994, 1995; Lurie 1989; McCall 2009; McGuire 2002; Myers 1989a, 1989b; Nelson 1991; Odell 1994; Parry and Kelly 1987; Phillips 2003; Renfrew 1977; Ricklis and Cox 1993; Riel-Salvatore and Barton 2004; Roth 2000; Shott 1989, 1994; Smith 2007; Torrence 1983, 1989a, 1989b, 2001).

Although a number of these treatments embed toolstone procurement in subsistence pursuits, it is worth noting that lithic technological organization may also have been embedded in social pursuits (Andrefsky 2009:4), as discussed at length in Chapter 3. In fact, Kenneth Sassaman (1994) suggests that technology is socially constituted, and technical strategies of risk avoidance become necessary only when non-technical strategies are tenuous, unpredictable, or simply not possible. As such, technological organization should be viewed as a reflection of social organization rather than simply as the technical solution to economic problems (Sassman 1994; also see Torrence 1994). Nevertheless, as Anna Prentiss and David Clarke (2008:258) put it, most archaeologists:

> interested in the organization of lithic technology typically seek to explain variation in production, use, and transport of lithic tools… in the light of mobility regimes, subsistence resource conditions, and access to lithic sources. They generally argue that economic logic will strongly dictate the tactics chosen and that these can be predicted using general theoretical models often based (implicitly or explicitly) on the microeconomic logic of optimal foraging theory.

Lewis Binford's (1973, 1979) introduction of the curation concept to hunter-gatherer archaeology represents an early, significant attempt to articulate mobility, technological organization, and assemblage structure. Indeed, Binford's (1973, 1979) use of curation in association with different aspects of technological organization has engendered much discussion and disagreement, as well as a great deal of research aimed at clarifying this concept (e.g., Chatters 1987; Close 1996; Davis and Shea 1998; Dibble 1998; Douglass et al. 2008; Kuhn 1990; Nash 1996; Odell 1996; Quinn et al. 2008; Shott 1996; Shott and Nelson 2008; Torrence 2001). Some lithic analysts followed Binford (1973) in linking curation with transported tools (e.g., Bettinger 1987; Gramly 1980; Nelson 1991); others followed him in linking curation to efficiency of tool use. Douglas Bamforth ‘s (1986) oft-cited treatment of tool curation includes elements of both: (1) production in advance of use, (2) implement design for multiple purposes, (3) transport of tools to multiple locations, (4) maintenance of tools, and (5) recycling of tools.

Drawing on the connection between tool curation and tool transport, many lithic analysts suggest that a prevalence of highly-curated tools and associated refurbishment debris indicates frequent and/or lengthy residential or logistical movements, while a prevalence of expedient tools indicates infrequent residential moves (Kelly 1988, 2001; Kuhn 1991; Nelson 1991; Parry and Kelly 1987; Torrence 1983). According to these criteria, stemmed points, as well as the bifaces from which they are manufactured, frequently evidence high levels of curation (e.g., production in advance of use, implement design for multiple purposes, transport to multiple locations, maintenance, and recycling; e.g., Beck and Jones 1993; Bryan 1979) indicative of high levels of mobility—a supposition reinforced by obsidian and FGV provenance data. Yet as discussed in Chapter 3, we now know better than to dichotomize foragers and collectors, and lithic analysts have learned that curated and expedient tools are not associated exclusively with either type of mobility organization (Andrefsky 2008a, 2009; Blades 2008; Carr 1994; Kuhn 1990). In fact, lithic analysts now recognize curation as a process reflecting a tool’s actual use relative to its potential use—related to but not to be confused with tool use life (i.e., the length of service for which a tool is adopted; Andrefsky 2006, 2008b; Shott 1996; Shott and Sillitoe 2004, 2005). Significantly, the degree of curation seems intimately connected to toolstone availability: in toolstone-rich settings, the necessity of curating tools may decrease, while in toolstone-deficient settings, curation and tool refurbishment may increase to avoid tool depletion (MacDonald 2008).

As such, toolstone availability and abundance are central to studies of lithic technological organization for the simple reason that toolstone procurement places certain scheduling demands on stone tool users (Andrefsky 1994a, 1994b; also Amick 1994; Elston 1990; Holdaway et al. 2008; Johnson 1985; Wiant and Hassen 1985). William Andrefsky (1994b) gives the example of hunters pursuing aggregated ungulates. He (Andrefsky 1994b:376) observes that, though the same hunting and processing tasks would occur in each scenario, it:

> would not be uncommon to see expediently fashioned tools such as unmodified flake knives and cobble choppers at an ungulate processing location in regions where good quality raw materials were readily available. This would be in contrast to an area with no or poor-quality lithic raw materials, where the stone tool assemblage may consist of small resharpening flakes from a previously manufactured tool, made of nonlocally available material.

While Andrefsky's (1994b) example is provocative, we soon run up against an inconsistency in current thinking about lithic technological organization. Lithic analysts suggest that mobility strategies simultaneously dictate tool needs and access to toolstone, as movement toward one resource may often be movement away from another (Kelly 1988). As such, if movement toward a toolstone source is movement away from another critical resource, then the toolstone must be worth the trip, and so consideration of toolstone quality also becomes important (e.g., Andrefsky 1994a, 1994b; Beck et al. 2002). But if toolstone procurement is embedded (primarily) in subsistence pursuits, as the prevailing logic dictates, then movement toward a toolstone source, while it may be movement away from some resources, *is always also* movement toward other critical resources. Moreover, if we allow that stone tools are only one, perhaps minor, part of the material culture of hunter-gatherers, as discussed in Chapter 3, then here is one place where lithic analysts may easily overstate the centrality of toolstone procurement in a strictly economic understanding of subsistence-settlement patterns (also see Torrence 2001).

Even so, mobility may impose constraints on technological organization by creating carrying costs (Kuhn 1994; Shott 1986) that must be weighed against the expected utility (i.e., a tool's affect on the return rate of the activity in which it is to be used; Elston 1990, 1992; Kelly 2001) of the toolstone and tools carried (Shott 1989). For example, a reliance on hafted bifaces in many western North American contexts has been interpreted as a solution to the relatively high spatial and temporal unpredictability of tasks carried out away from residential bases, while also minimizing the amount of gear carried (e.g., Bamforth 1991b; Kelly 1988; Rasic and Andrefsky 2001). Of course, we may wonder at what point carrying costs actually become constraints on mobility. For example, it may take several hundred projectile points to equal the weight of one human infant, which women regularly schlep all over the landscape; this aside is not pursued further here. For the purposes of this analysis, I suppose that prehistoric hunter-gatherers did, in fact, weigh carrying costs against the expected utility of the toolstone and tools they carried.

As such, a common decision faced by hunter-gatherers is the trade-off between field processing and transport (Metcalfe and Barlow 1992). Field-processing is the act of dividing up a resource package into its constituent parts at or near the place of procurement with the goal of transporting only selected components for use elsewhere (Metcalfe and Barlow 1992). As extended to toolstone, factors such as quality, abundance, accessibility, intended use, and transportability would influence the decision to include toolstone or a manufactured tool within the toolkit (Beck et al. 2002; Kuhn 1994). If we pursue this parallel further, the utility curve for artifacts derived from a local toolstone source might look more like a "bulk curve" (with minimal effort spent field-processing toolstone prior to carrying it back to a site), while the utility curve for artifacts derived from a more distant toolstone source might look more like a "gourmet curve" (with greater effort spent field-processing toolstone prior to carrying it back to a site; after Binford 1978). In other words, toolstone derived from closer sources may arrive at a site having undergone less intensive field-processing than toolstone from more distant sources. A lithic assemblage produced closer to a toolstone source might contain bifaces in earlier stages of reduction, more cores and cortical flakes, larger flaking debris, and more artifacts of that toolstone source in general. Alternatively, lithic assemblages located farther from a toolstone source might contain more late-stage and retouched bifaces, fewer cores and cortical flakes, and smaller flaking debris associated with final stages of manufacture and subsequent tool maintenance (e.g., Andrefsky 2008b; Beck et al. 2002; Eerkens, Ferguson, et al. 2007; Elston 1990; Johnson 1989; Jones et al. 2003;

Kessler et al. 2009; Lothrop 1989; Rasic and Andrefsky 2001; Stanford and Patten 1984; Wilson and Andrefsky 2008).

Many of the analyses pursued here hinge on this distinction, as I use these well-founded expectations to discern different levels of mobility associated with the procurement, transport, and utilization of the different toolstone types that occur within the Paleoarchaic localities in the Eastern Nevada Study Area. As related specifically to the multi-tiered model of mobility and toolstone procurement presented in Chapter 3, I expect chert used for gravers and scrapers to derive from local sources. Thus, the sub-assemblage associated with these cherts should include artifacts in earlier stages of reduction, more cores and cortical flakes, larger flaking debris, and more artifacts, in general, than the FGV and obsidian sub-assemblages. I expect FGVs, obsidian, and high-quality chert used for bifaces and projectile points to derive from more distant sources. Thus, the sub-assemblages associated with these toolstone types should include more late-stage and retouched bifaces, fewer cores and cortical flakes, and smaller flaking debris than the local chert sub-assemblage. Before presenting these analyses, I first present some background information on the Paleoarchaic localities I consider here.

The Eastern Nevada Study Area

In this analysis, I consider more than 18,000 artifacts recovered from thirteen Paleoarchaic localities (i.e., surface lithic assemblages) within the Eastern Nevada Study Area, including: Combs Creek Localities (CCL) 1, 2, 3, 4, 5, 7, and 9; Hunter's Point Localities (HPL) 1, 2, 3, and 5; White Sage Well Locality (WSWL) 1; and Limestone Peak Locality (LPL) 1. Each locality has been named for the U.S.G.S. 7.5-minute quadrangle on which it occurs and abbreviated accordingly (Beck and Jones 1990a, 1990b). These localities, identified and collected by George T. Jones and Charlotte Beck in the late-1980s, occur in Butte and Jakes valleys (Figure 4.1, Table 4.1).

Butte Valley, a basin of ~1870 sq. km, lies north of Ely in White Pine County, Nevada, between the Egan and Cherry Creek ranges and Steptoe Valley to the east and the Butte Mountains and Long Valley to the west. Elevations range from 1900 m on the valley floor to over 3100 m in the Egan and Cherry Creek ranges. Butte Valley contains a dry lakebed and shoreline features associated with pluvial Lake Gale (Mifflin and Wheat

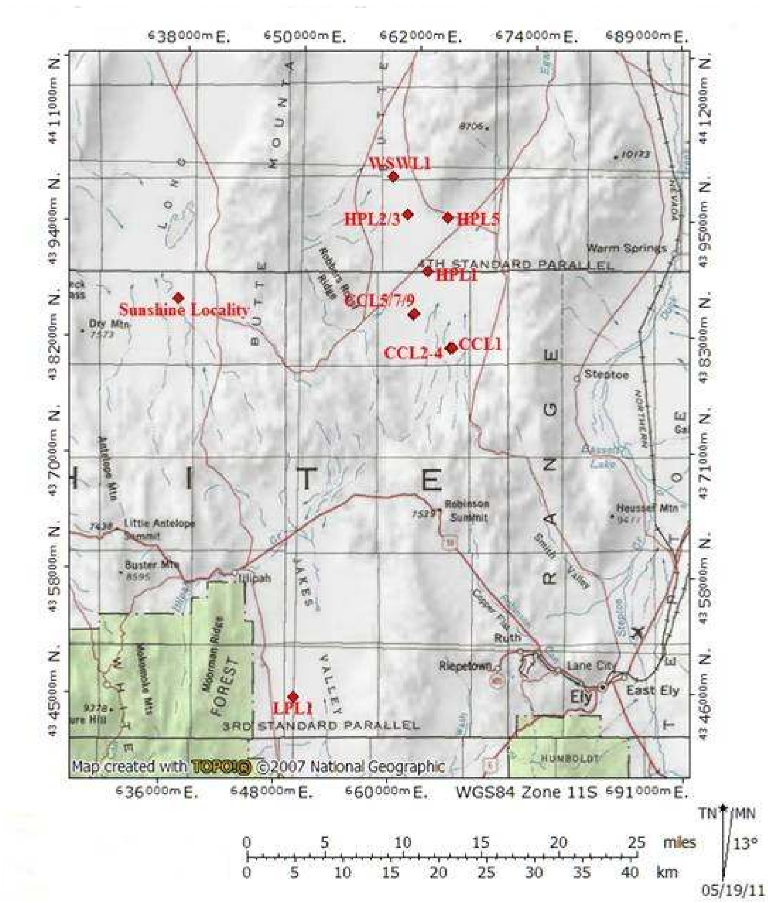

Figure 4.1: Map showing localities considered here. CCL = Combs Creek Locality; HPL = Hunter's Point Locality; WSWL = White Sage Well Locality; LPL = Limestone Peak Locality. The Sunshine Well Locality, located in Long Valley, is also indicated.

Table 4.1: Eastern Nevada Study Area Paleoarchaic lithic assemblage sizes.

Valley	State Site #	Locality	Assemblage Size(n)
Butte	5016	CCL1	324
Butte	5017	CCL2	64
Butte	5018	CCL3	167
Butte	4784	CCL4	499
Butte	5019	CCL5	2102
Butte	5692	CCL7	302
Butte	no number	CCL9	413
Butte	4786	WSWL1	294
Butte	4783	HPL1	195
Butte	4785	HPL2	971
Butte	5693	HPL3	2050
Butte	5694	HPL5	4210
Butte	*NA*	*Total*	*11,591*
Jakes	1844	LPL1	6797
Butte & Jakes	*NA*	*Total*	*18,388*

1979). As discussed in Chapter 2, radiocarbon-dated mollusks from shorelines in adjacent Long Valley and nearby Jakes Valley (Garcia and Stokes 2006; Young and McCoy 1984), and deep-water stands for Lake Franklin in Ruby Valley to the north (Benson and Thompson 1987a) suggest that pluvial events in eastern Nevada were broadly synchronous with Lahontan and Bonneville events. Thus, a final high stand of Lake Gale, which would have covered nearly 411 sq. km and reached a depth of 25 m (Mifflin and Wheat 1979), would date to ~12,500 ^{14}C yr BP. The shoreline features, along which many of the Paleoarchaic localities discussed below occur, may relate to a shallow Younger Dryas lake. The projectile points found in the Butte Valley localities, including Lake Mohave, Silver Lake, and Cougar Mountain types, support this date (Jones and Beck 1990a).

Charlotte Beck and George T. Jones, with scores of Hamilton College Field School students in tow, have conducted fieldwork in the southern end of Butte Valley, a catchment of approximately 600 sq. km, since the late-1980s (Beck and Jones 1988, 1990a, 1990b). Fieldwork focused especially in the southern sub-basin (below 1950 m), and included locating and collecting artifacts through systematic pedestrian survey."Sites" were identified on the basis of high artifact density (Beck and Jones 1990a; after Dunnell and Dancey 1983). In order to obtain a statistically reliable survey sample, Beck and Jones (1990a) stratified the valley floor into three zones by elevation: (1) the valley floor (< 1905 m), which includes areas below the lowest shoreline feature; (2) the lake shore zone (1905-1925 m); and (3) the alluvial fan zone (1925-1950 m). These strata were subdivided into 250 x 250 m quadrants for inspection. Forty-four of these units (2% of the project area) were surveyed in 1987 and 1989 (Beck and Jones 1990a:Table 1). Surveyors, distributed at 10 m intervals, searched a one-meter-wide path, keeping a record of landform and vegetation for each 25 m traverse. Artifacts were located as precisely as possible within the 25 m interval, collected, and assigned to grid square or given sequential field specimen numbers.

Survey yielded 263 artifacts collected from off-site contexts (Beck and Jones 1990a:Table 1), though such occurrences are relatively rare in Butte Valley—the average density for all strata is less than one artifact per hectare. More often, artifacts occur in relatively dense clusters (i.e., "localities"), the borders of which are defined by fairly dramatic changes in artifact density (Beck and Jones 1990a). Twelve localities were surface-collected in 1987 and 1989, yielding a total of 11,239 artifacts (Beck and Jones 1990a:Table 2). Western Stemmed Tradition localities occur on both pluvial and relic-alluvial landforms that likely date to the last stillstands of Lake Gale or a later Younger Dryas shallow lake (Beck and Jones 1988, 1990a, 1990b, 1992; Jones and Beck 1990a, 1990b). Three of these localities (HPL2, HPL3, and WSWL1) lie in the northern end of the sub-basin on well-developed spits. HLP2 and HPL3 lie on the Hunter's Point spit and both have Archaic components, suggesting prolonged use of this vicinity. WSWL1, located a little farther north, is associated with a lower spit (~1910 m); artifacts occur on top of the spit as well as on the south-facing slope and at the base. The artifact distribution at WSWL1 forms three clusters (WSWL1-A, WSWL1-B, WSWL1-C) with light scatters in between them. Although treated separately in some studies (e.g., Beck and Jones 1988, 1990b), there appears to be no temporal difference between these clusters and so they are treated here as a single assemblage. HPL1 and HPL5 are located on beach features in the northern part of the sub-basin. HPL1 is located on the 1912.5 m beach ridge in the northwest section of the sub-basin. HPL5, at an elevation of ca. 1917.5 m, lies about 6 km east of HPL2 and HPL3, near the eastern end of the same beach ridge as HPL1. Seven localities (CCL1-5, 7, 9) are located in the southwestern part of the valley at elevations ranging between 1915 and 1922.5 m—within the lake shore stratum (1905-1925 m), though located south of any clearly demarcated pluvial features. CCL2, CCL3, and CCL4 form a cluster along a north-south trending stream terrace. CCL1 lies east of this group on a still active floodplain. CCL5, CCL7, and CCL9 are located near to each other on a prominent alluvial terrace 4 km north of CCL1-4.

If we are to use these localities to assess OCZs as a coherent unit referable to some Paleoarchaic behavioral process, then we must assess the depositional context of these surface lithic assemblages. As Angela Close (1989; also Cowgill 1989) notes, assemblages of flaked stone artifacts, if they include more than a few tens of pieces, are usually mixtures of parts of several different occupations; however, this observation is mitigated by the tendency, documented ethnographically, for a site to be reoccupied by members of the same social group, even if not the same members on every occasion. Over the short-term, therefore, it is likely that lithic assemblages represent part of the output of members of a single, diachronic, social group during several different occupations. Over the long-term, it may take hundreds of years before two occupations attributable to two distinct groups behaving in distinct ways overlap in space, especially in open-air settings with plenty of room available for residence (Surovell 2008:109; also see Gregg et al. 1991; Tainter 1998). In any case, most of the Eastern Nevada Study Area localities are dominated by TP/EH diagnostics: ten localities appear to be of TP/EH age with minimal later points; two localities contain several Western Stemmed Tradition and later Archaic points (HPL2, HPL3), and one locality (HPL5) includes numerous Early Holocene points, which may suggest an intensive occupation slightly later than many of the other localities (Table 4.2).

Table 4.2: Distribution of temporally-diagnostic projectile point types (adapted from Jones et al. 2003:Table 2).

	Point Types Represented (n)			
Locality	**Western Stemmed Tradition**	**Early Holocene**	**Archaic**	**Indeterminate**
CCL1	5	0	0	0
CCL2	8	0	1	1
CCL3	7	1	0	1
CCL4	9	0	1	0
CCL5	40	0	0	0
CCL7	4	2	1	1
CCL9	15	0	0	3
WSWL1	11	1	2	0
HPL1	14	0	0	3
HPL2	14	4	11	1
HPL3	12	1	42	0
HPL5	15	33	14	7
LPL1	211	1	1	0

The distributions of obsidian hydration values also suggest complex occupational histories for some localities (Jones and Beck 1990b:95; Jones et al. 2003:Figure 5). For example, the distribution of Brown's Bench obsidian hydration values from CCL5 and HPL1 suggests discontinuous use, while the distribution of Butte Mountain obsidian hydration values from these same localities suggests continuous occupation (Jones and

Beck 1990b:Figure 5). Nevertheless, the similar range of obsidian hydration values and the numerical dominance of deeply hydrated specimens in each sample suggests, in agreement with the projectile points, that these localities date primarily to the TP/EH (Jones and Beck 1990a, 1990b). In the following analyses, therefore, I treat the localities within the Eastern Nevada Study Area as dating to the TP/EH, although I acknowledge that HPL2, HPL3, and HPL5 may belie this treatment.

The sample analyzed here also includes artifacts from Limestone Peak Locality 1 (LPL1), located at the playa edge in southwestern Jakes Valley (Figure 4.1). Jakes Valley is bounded by the Egan Range to the east and the Butte Mountains and White Pine Range to the west. A relatively small extensional basin (estimated area of approximately 1000 sq. km; Mifflin and Wheat 1979), Jakes Valley is one of the highest valleys in the Great Basin (basal elevation of 1920 m). During the late Pleistocene, Jakes Valley held comparatively small pluvial Jakes Lake, which is estimated to have reached a maximum area of 163 sq. km and a maximum depth of 25.9 m (Garcia and Stokes 2006). Garcia and Stokes (2005, 2006) have recently estimated the ages of lake stands from radiocarbon dates on snails and mollusks associated with shorelines in the southeastern section of Jakes Valley. They find that Jakes Lake reached a late glacial highstand about 13,800 ^{14}C yr ago (13,870 ± 50 ^{14}C yr BP, Beta 182377; Garcia and Stokes 2006:Table 2). Subsequent recession was interrupted by two stillstands (13,510 ± 40 ^{14}C yr BP, Beta 182376; 12,440 ± 50 ^{14}C yr BP, Beta 181801) prior to desiccation. Thus, the pluvial history of Jakes Lake roughly parallels other pluvial lakes in the Eastern Nevada Study Area and in the central Great Basin more generally.

The southern and western edges of pluvial Jakes Lake, in particular, are archaeologically rich (Jones et al. 2003), though Mark Estes (2009) has recently documented several Paleoarchaic localities north of the playa. LPL1 has been the subject of several archaeological investigations, including survey and surface artifact collection by Hamilton College field school students. Initially discovered during an archaeological reconnaissance of seismic lines (Polk 1982), LPL1 sits at the terminus of an alluvial fan that was probably created by sediment deposition from paleo-Hayden Wash and subsequently modified by pluvial Jakes Lake. Jones et al. (2003) suggest that fresh water emerging from the fan onto the valley floor at this location contributed to a marshy habitat that attracted Paleoarchaic hunter-gatherers. Polk (1982) estimated that LPL1 measured more than 5000 sq. m in area, though subsequent archaeological investigations by Hamilton College personnel demonstrated the site was far more extensive. As defined in 1991, LPL1 covered 30,600 sq. m and was collected in 7650 2 x 2 m grid squares, much as described above for the localities in Butte Valley. Although artifact density falls off significantly beyond the imposed boundaries of the collection area (measuring 180 m east-west and 190 m north-south), artifacts can be found as much as 100 m from the locality in most directions, especially to the northeast, east, and southeast. A total of 6932 artifacts were collected from LPL1 in 1991. This collection was supplemented by investigations in 2007, which recorded 312 artifacts; these are not considered in this analysis.

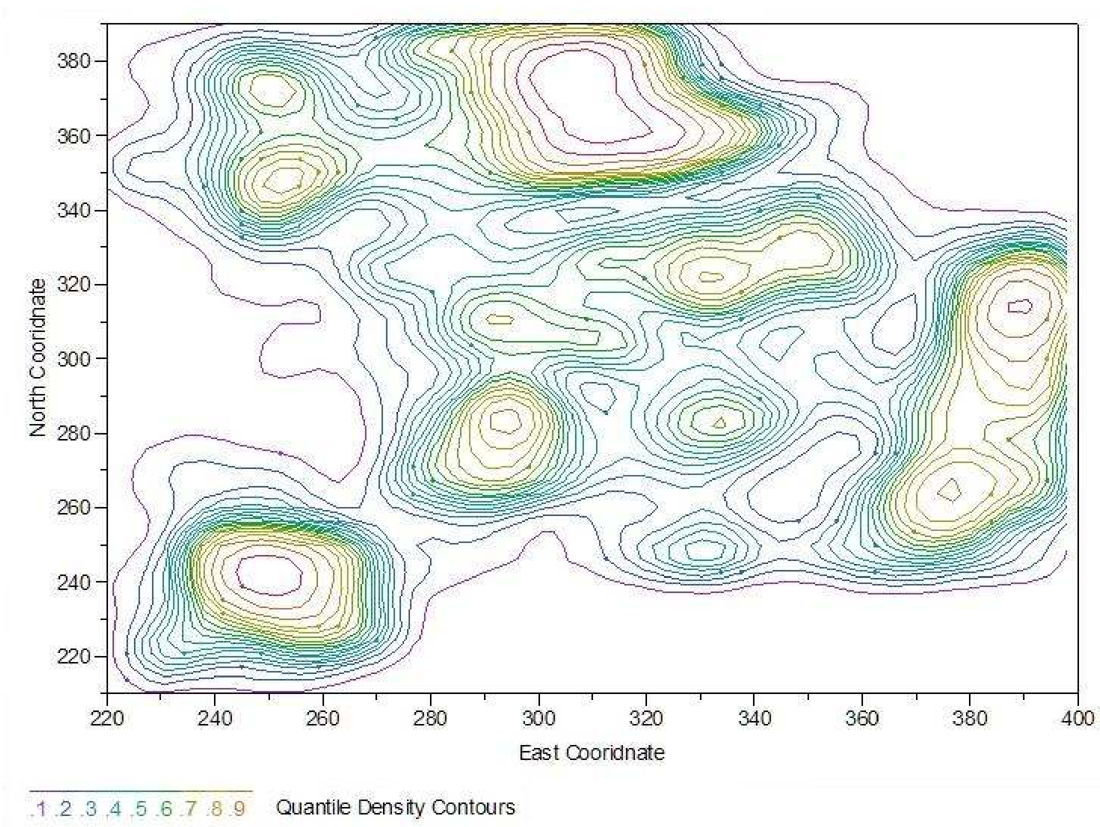

Figure 4.2: Nonparametric bivariate density model defined by the abundance of lithic artifacts at LPL1. The contour lines are quantile contours in 5% intervals.

Of additional significance, LPL1 appears to have had a complex history, including repeated occupation and the spatial segregation of activities, despite the fact that the projectile points recovered from LPL1 (one fluted point base and several Great Basin Stemmed Series points) are consistent with a TP/EH designation (Table 4.1). Figure 4.2, a nonparametric bivariate density model defined by the abundance of all lithic artifacts at LPL1, clearly depicts the presence of several lithic concentrations. Figure 4.3

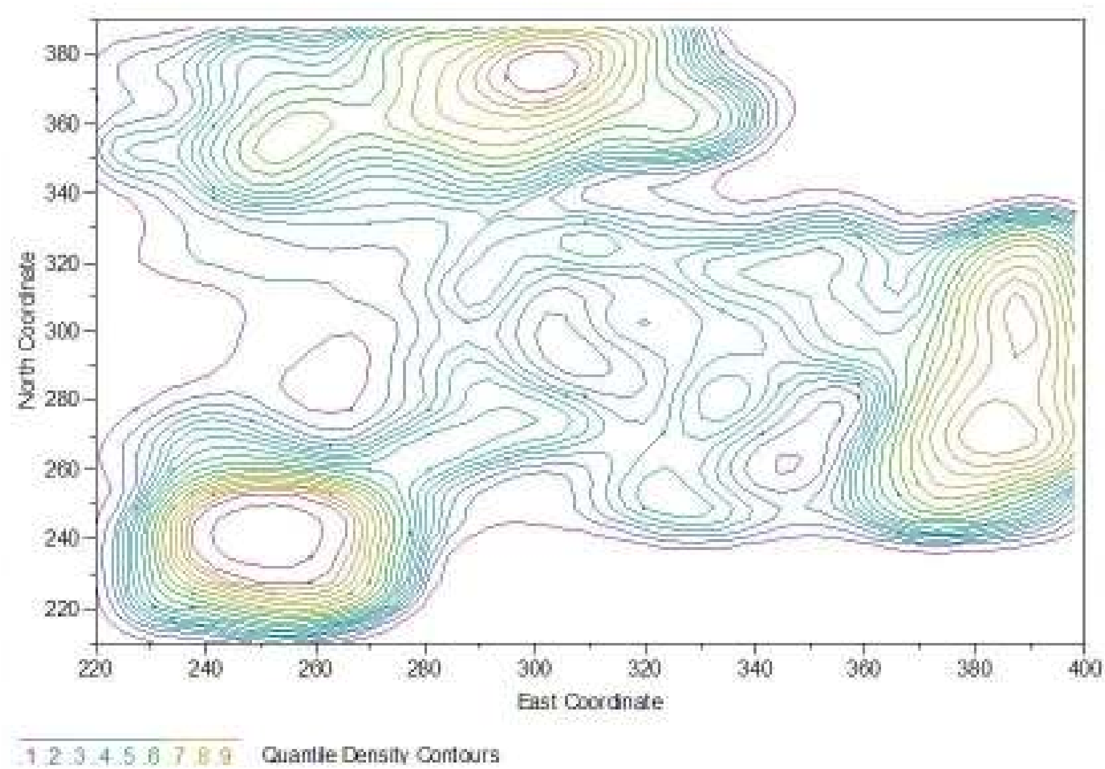

Figure 4.3: Nonparametric bivariate density model defined by the abundance of chert artifacts at LPL1. The contour lines are quantile contours in 5% intervals.

depicts a nonparametric bivariate density model defined by the abundance of chert artifacts at LPL1. Defined in this way, the lithic concentrations in the center of LPL1 are less apparent, although the three main concentrations located toward the perimeter of the locality remain. The relationship of these artifact clusters to each other, beyond the recognition that the locality, as a whole, seems to date to the TP/EH, is presently difficult to assess because: (1) the Great Basin Stemmed Series points do not provide sufficient temporal resolution; and (2) thus far, hydration dating has not been performed on a sufficient number of obsidian specimens to discern spatiotemporal patterning.

Previous Lithic Analyses of the Eastern Nevada Study Area, Augmented and Reinterpreted

Previous analysis of these lithic assemblages by Charlotte Beck and George T. Jones (1990a, 1990b) attests to the bifacial character of Paleoarchaic technology, documenting numerous bifaces derived from a reduction sequence (modeled after Pendleton 1979) related to the production of stemmed points. In fact, few bifaces not related to the stemmed point reduction sequence occur within these lithic assemblages (Beck and Jones 1990b:Table 6). The majority of bifaces in this sequence, as well as associated biface reduction flakes (BRFs; Beck and Jones 1990a:Table 3, 1990b:Table 7), are made from FGVs, which could be obtained from several sources located within 60-80 km of these Paleoarchaic localities (see Figure 4.8 below). Provenance analysis (Jones et al. 2003) combined with the lack of exhausted obsidian cores and broken blanks (Beck and Jones 1990b:241-242), indicates that much of the obsidian within these assemblages was transported over long distances as finished tools rather than as raw material. In support of this view, the distribution of obsidian and FGV bifaces over the reduction sequence suggests only late-stage manufacture and maintenance in obsidian and full-scale manufacture in FGVs (Beck and Jones 1990a:Table 5, 1990b:Table 15). If we suppose that a biface (which may, itself, have been used as a core; Kelly 1988) or core will continue to undergo reduction as it remains in the toolkit, we may expect FGV and chert bifaces and cores to be larger (i.e., to weigh more) than obsidian bifaces and cores (cores are included in this comparison because of the paucity of chert bifaces), in support of the longer distances over which obsidian was transported. When we compare the size (weight in grams) of cores and bifaces by toolstone type (Table 4.3), we see that obsidian bifaces and cores tend to weigh significantly less than FGV and chert bifaces and cores, in accordance with the reduction sequence data.

Mass (weight), as a general measure of size, may be a particularly useful indicator of reduction stages (Amick et al. 1988; Eerkens et al. 2008; Magne and Pokotylo 1981; though see Marwick 2008; Mauldin and Amick 1989; Shott 1991), especially given the constraints imposed by tool and toolstone transport. Additionally, lithic analysts agree on how to measure weight, unlike many other technological attributes (Shott and Nelson 2008:18; Teltser 1991:367). Thus, I utilize weight in many of the comparisons presented

Table 4.3: Comparison of average biface and core weight (g) by toolstone type for each locality. FGV and chert bifaces and cores do not exhibit significantly different weights in all cases, hence the insignificant F-ratio for some localities.

	Average Core & Biface Weight (g)			**ANOVA**	
Locality	**Obsidian**	**FGV**	**Chert**	**F-Ratio**	**Prob.**
CCL1	2.82	14.07	26.46	2.55	0.13
CCL2	NA	4.25	4.76	0.01	0.93
CCL3	1.05	10.29	32.83	1.58	0.25
CCL4	NA	4.70	6.49	0.10	0.77
CCL5	7.53	14.83	10.70	0.99	0.41
CCL7	5.17	11.51	NA	0.76	0.41
CCL9	7.70	2.44	10.73	3.08	0.08
WSWL1	5.22	23.13	4.69	3.04	0.11
HPL1	NA	19.12	31.64	1.60	0.22
HPL2	3.22	10.54	9.59	7.84	0.001
HPL3	2.48	8.23	8.30	2.93	0.06
HPL5	2.75	11.92	10.93	4.13	0.02
Butte Valley Total	*3.68*	*11.91*	*11.21*	*11.02*	*<0.0001*
LPL1	4.05	12.09	17.44	11.18	<0.0001
Total	*3.80*	*11.99*	*14.65*	*20.95*	*<0.0001*

here. Note, however, that a straightforward comparison between biface and core mass by toolstone type assumes these different toolstone types were procured in similar packages (i.e., initial nodule size and shape was similar; Dibble et al. 2005; Elston 1990:156). Because we do not know that this was true, a simple comparison of core and biface weights may ultimately prove inappropriate (Bradbury et al. 2008; Bradbury and Franklin 2000). Indeed, lithic analysts have expended much effort recently in trying to predict original core, flake, and tool dimensions (e.g., mass) from lithic technological characteristics preserved in the archaeological record in an effort to avoid making this assumption (e.g., Clarkson 2002; Davis and Shea 1998; Dibble 1987; Dibble and Pelcin 1995; Hiscock and Clarkson 2005a, 2005b; Kuhn 1990; Quinn et al. 2008). If such a relationship can be established, the task of estimating the difference between potential and realized use, thereby quantifying curation without making potentially incorrect assumptions about original dimensions, becomes relatively simple.

Unfortunately, the low proportion of retouched flakes within the Eastern Nevada Study Area assemblages precludes the use of several of these indices, although ongoing analyses by Charlotte Beck, George T. Jones, and me will bring some indices of bifacial and unifacial reduction to bear on the artifacts within these assemblages in the future. At any rate, if transport constraints significantly affect lithic technological organization, then larger bifaces and cores presumably would impose greater transport constraints than smaller bifaces and cores. Thus, I maintain that larger bifaces and cores likely derive from closer sources. More specifically, I expect that chert and FGV bifaces and cores will be larger than obsidian bifaces and cores. As expected, the distribution of biface and core weight by toolstone type (Figure 4.4), in agreement with the biface reduction sequence data, certainly suggests obsidian entered east-central Nevada at a later-stage of reduction than FGVs and chert. Bearing in mind the caution noted above for comparing different

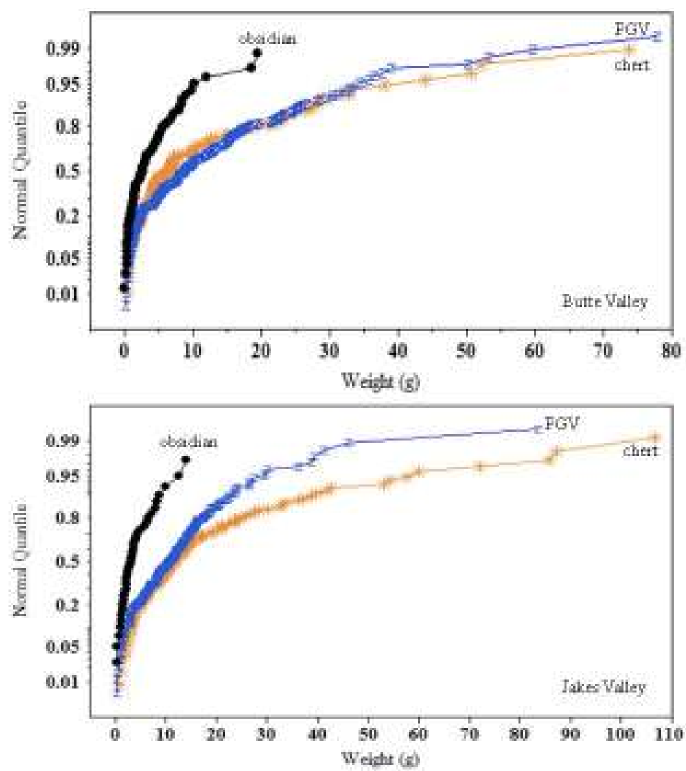

Figure 4.4: Normal quantile plot of biface and core weights by toolstone type for Butte Valley localities (top) and LPL1 in Jakes Valley (bottom).

Table 4.4: Comparison of average BRF weight (g) by toolstone type.

	Average BRF Weight (g)			ANOVA	
Valley	Obsidian	FGV	Chert	F Ratio	Prob.
Butte Valley	0.643	2.199	1.963	22.0045	<0.0001
Jakes Valley	0.641	1.991	3.474	26.2514	<0.0001

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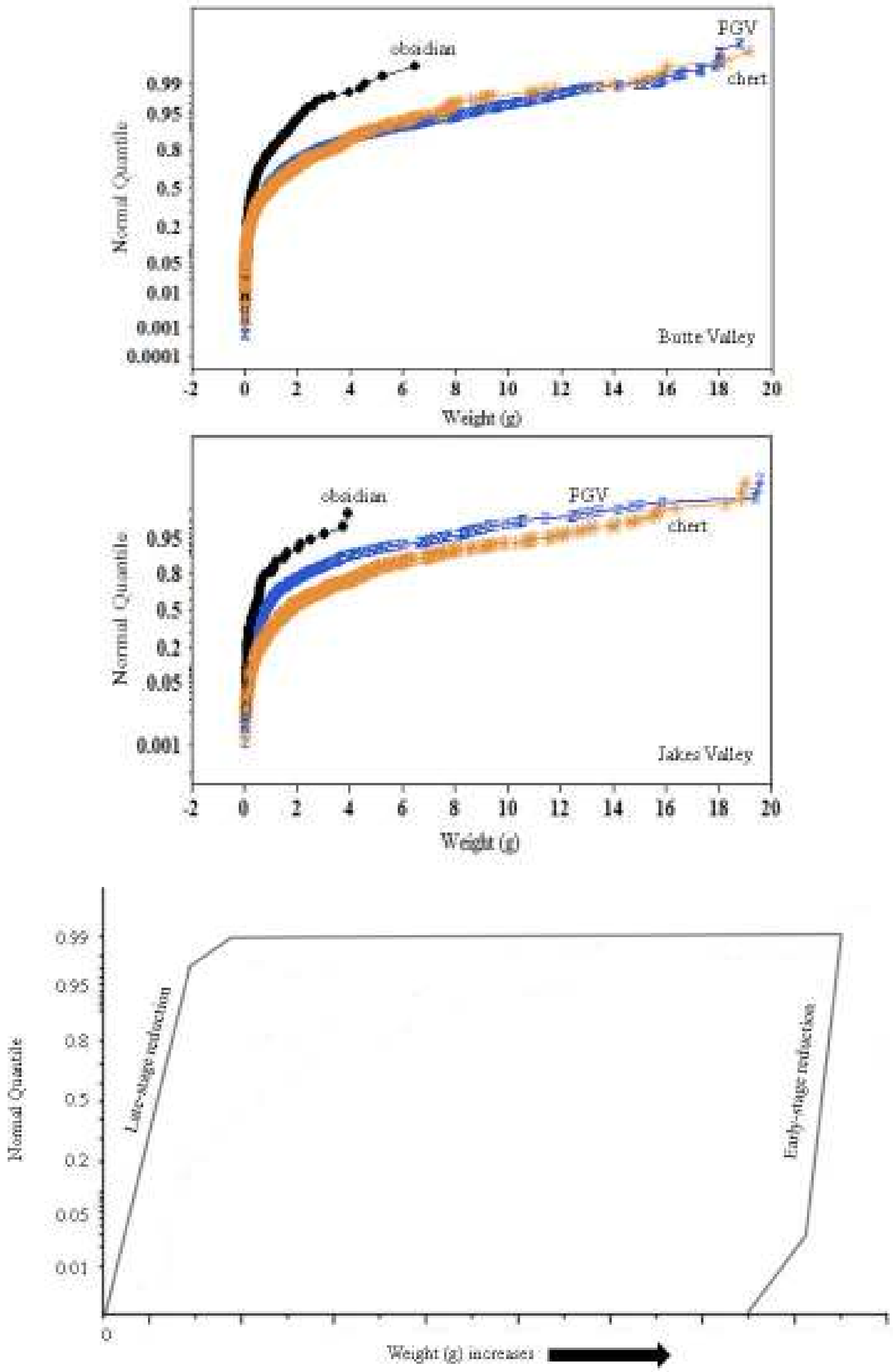


Figure 4.5: Normal quantile plot of BRF weights by toolstone type for Butte Valley localities (top) and LPL1 in Jakes Valley (middle), pared down by excluding weights greater than 20 g. An idealized size distribution of BRFs, distinguishing late-stage and early-stage reduction, is shown at the bottom (adapted from Beck and Jones 1990b:Figure 7A).

toolstone, the small size of obsidian BRFs compared to FGV and chert BRFs also supports this view (Table 4.4, Figure 4.5; Beck and Jones 1990a:Figure 3, 1990b:Figure 7).

These data, then, suggest that well-used, highly curated obsidian bifaces and points entered the Eastern Nevada Study Area as finished tools and were then replaced with FGVs once they became exhausted or were broken (Beck and Jones 1990a, 1990b; also see Smith 2007). Moreover, the size distributions for bifaces, cores, and BRFs are consistent with the expectation that FGVs and cherts derive from closer sources than obsidian, as demonstrated by the provenance analyses introduced in earlier chapters and discussed in more detail here.

George T. Jones and colleagues (2003) selected 840 obsidian specimens for geochemical analysis from more than 3000 obsidian artifacts in the Eastern Nevada Study Area assemblages. Energy-dispersive x-ray fluorescence (XRF) spectrometry of these artifacts identified 40 geochemical types in this sample, 21 of which represent known sources (Figure 4.6). Four geochemical types, Butte Mountain, Brown's Bench, Panaca Summit, and source B (now known as Tempiute Mountain), dominate the sample, representing approximately 75% of the artifacts analyzed. (Note that these percentages are derived from artifact counts, rather than weight, unless specified otherwise). The richness of geochemical types in the eastern Nevada Study Area is surprising given the lack of geologic sources of obsidian in the central Great Basin. As noted in Chapter 2, volcanism in the central Great Basin is much older than along the Great Basin perimeter and, therefore, obsidian, if present at all, occurs as small nodules or pebbles (i.e., Apache tears; Stewart 1980). Indeed, despite nearly 25 years of research in eastern Nevada George T. Jones and Charlotte Beck have not identified any sources of large obsidian nodules in this region, although localized pebble sources occur south of the project area (Jones et al. 2003).

Although unknown sources are common in the obsidian sample, their numerical contribution is relatively small: only 7 of the 40 geochemical types occur in frequencies greater than 2%. Furthermore, except for Butte Mountain, a pebble source derived from alluvial fan surfaces along western Butte Valley, none of the predominant obsidian types represented in these assemblages originate from an identified source closer than 150 km.

The most common nonlocal obsidian, the Brown's Bench group (28.9%), occurs over a large area of northeastern Nevada and southern Idaho about 250 km north of the project area; Tempiute Mountain and Panaca Summit obsidian originate 220 km to the south and southeast of the project area.

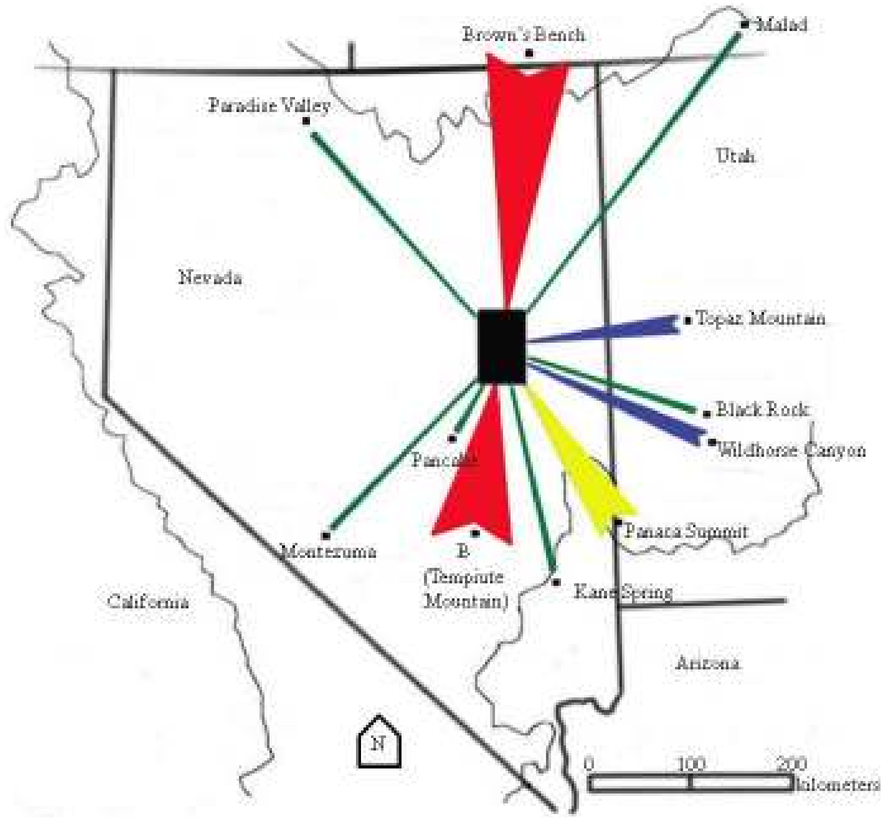


Figure 4.6: Obsidian sources represented in the Eastern Nevada Study Area lithic assemblages. Arrow color and size depicts relative frequency: large red (>15%), medium yellow (5-15%), medium blue (2-5%), small green (<2%) (adapted from Jones et al. 2003:Figure 6).

Interestingly, the Eastern Nevada Study Area sample lacks artifacts made from western and northern Great Basin obsidian sources. Discounting the Sunshine Locality sample, only two (0.2%) artifacts were manufactured from a western source (in this case, the Paradise Valley source). These results are particularly surprising given that some of the obsidian sources, such as Paradise Valley and Double H Mountains, are no farther from the Eastern Nevada Study Area than the sources that dominate the sample (though see Estes 2009). Julie Francis (1991) documents a similar pattern on the northwestern

High Plains, where each major basin seems to define a settlement system and the mountain ranges act as barriers between them (though see McGonagle 1979). It is noteworthy, however, that Francis (1991:313) suggests that lack of interaction between these basins seems inconceivable; rather, she suggests that lithic materials may not have been used as a medium of exchange or groups were sufficiently familiar with toolstone sources that there was no need to transport large quantities of material over great distances. Some of these ideas have been discussed in Chapter 3; others are taken up later in this chapter and in Chapter 5. As it stands, the obsidian provenance data from the Eastern Nevada Study Area suggest to Jones et al. (2003:Figure 8) the Paleoarchaic territory depicted in Figure 4.7.

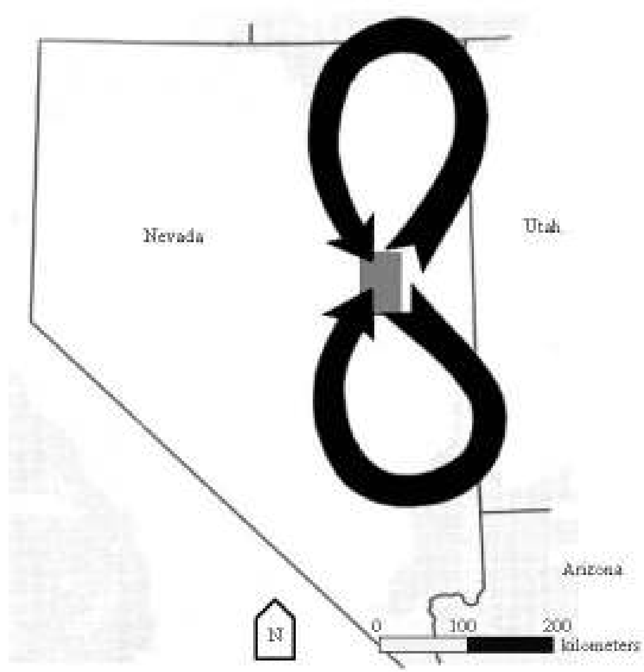


Figure 4.7: Hypothesized territory of Paleoarchaic hunter-gatherers defined by obsidian provenance analyses from the Eastern Nevada Study Area (adapted from Jones et al. 2003:Figure 8).

The provenance analysis of obsidian from other early sites in Jakes Valley is also broadly consistent with the territory depicted in Figure 4.7, although southern obsidian sources predominate (Estes 2009:Figure 5.6, Table 5.20). More recent provenance analyses of obsidian from Paleoarchaic lithic assemblages in Coal Valley, located farther south in eastern Nevada, suggest that the northern and southern loops may, in fact, represent distinct OCZs (Jones and Beck 2010; Jones et al. 2012; also see Estes 2009:219). In order to improve our understanding of Paleoarchaic mobility and toolstone procurement within these OCZs, however defined, we must increase our knowledge of the lithic technological organization and provenance of FGVs and chert.

To this end, a number of current and former Hamilton College students, me included, have pursued complementary technological and provenance analyses of FGV artifacts from the Eastern Nevada Study Area (e.g., Hubbard 2004; Innes 1996; Kirby 1991; Knight 2003; Newlander 2004; Okuno 1997; Snover 1992; Wickman 2002). These analyses follow Jones et al. (1997), who found that FGV sources within the Eastern Nevada Study Area (Figure 4.8) can be clearly differentiated on the basis of major element oxide composition (e.g., MgO, K_2O, P_2O_5). Accounting for the provenance analysis of more than 200 FGV artifacts, these studies indicate that the Paleoarchaic

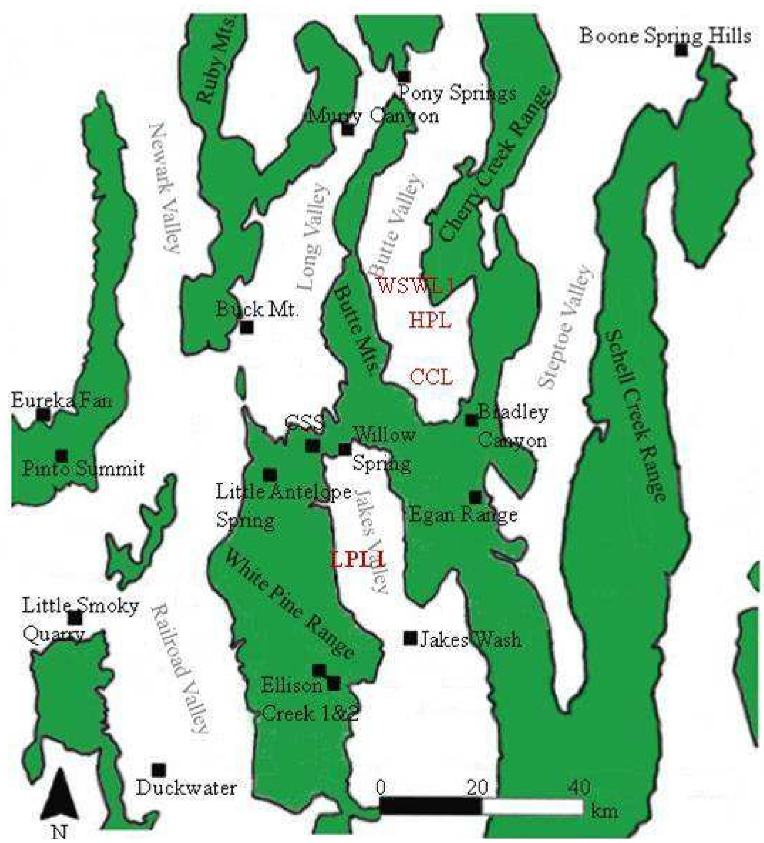
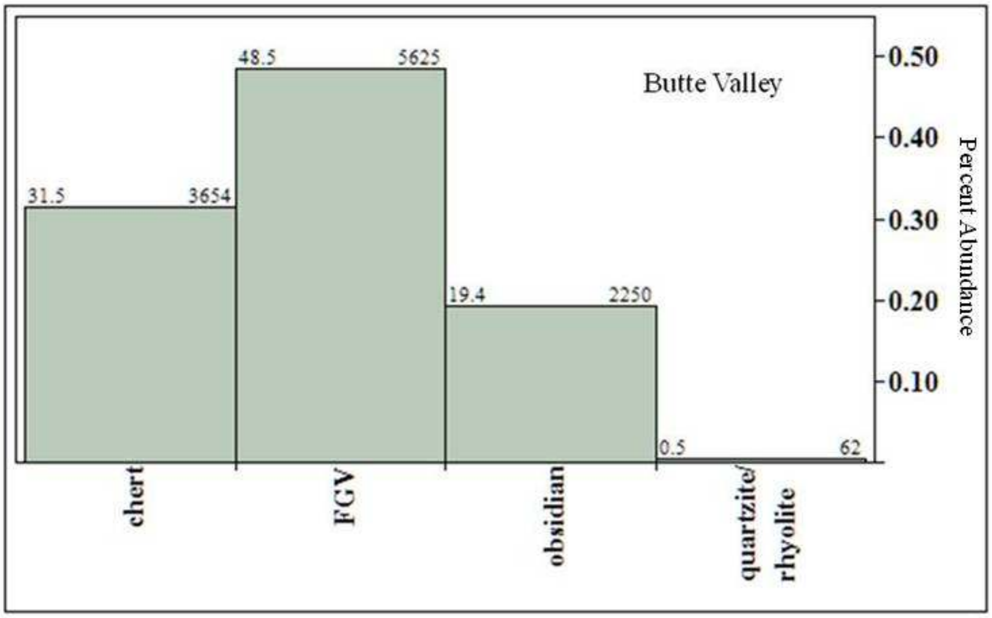


Figure 4.8: Map indicating the location of FGV sources and Paleoarchaic localities in the Eastern Nevada Study Area. CCL = Combs Creek localities. HPL = Hunter's Point localities. WSWL1 = White Sage Well Locality 1. LPL1 = Limestone Peak Locality 1.

inhabitants of the Combs Creek localities preferred FGVs from Jakes Wash (~50 km south) and Little Smoky Quarry (~85 km southwest), rather than locally available FGVs from Bradley Canyon (~12 km southeast). Paleoarchaic inhabitants of the Hunter's Point localities also preferred FGVs from Jakes Wash (~65 km south). Finally, LPL1 suggests the preferential utilization of FGVs from Jakes Wash (~15 km southwest) and Little Smoky Quarry (~60 km west) over other nearby FGV sources (e.g., Ellison Creek 1 and 2, located ~22 km south).

While Paleoarchaic hunter-gatherers in the Eastern Nevada Study Area did utilize more distant FGV sources (e.g., Combs Creek and Hunter's Point localities include FGVs from the Duckwater source, located ~100 km southwest; LPL1 includes FGVs from Murry Canyon, located ~90 km north), the majority of FGV artifacts originate from sources no more than 60-80 km distant. For comparison, recall from Chapter 3 that the task-specific journeys of the Reese River Valley Shoshone rarely exceeded 60-80 km. Moreover, when the FGV sources represented within these assemblages are used to define FGV procurement ranges, the areas so-defined are about a quarter of the size of even the revised, smaller OCZs: 6362 sq. km for the Combs Creek localities, 8247 sq. km for the Hunter's Point localities, and 6892 sq km. for LPL1. Combined with these provenance data, the sheer abundance of FGVs in the Eastern Nevada Study Area assemblages (Figure 4.9) suggests the regular utilization of a much smaller range than that implied by obsidian provenance.

We see in Figure 4.9 that FGV and chert artifacts are much more common than obsidian artifacts in the aggregated Butte Valley localities and at LPL1 in Jakes Valley. Table 4.5, which shows the distribution of toolstone types by locality, reinforces this pattern. These data indicate that the Eastern Nevada Study Area assemblages, as a whole, include three times as many FGV and twice as many chert artifacts as obsidian artifacts, though the toolstone ratio does not favor FGVs and chert quite as much in Butte Valley as in Jakes Valley (LPL1). Obsidian rarely accounts for more than one-quarter of these assemblages, although obsidian artifacts outnumber chert artifacts in some Butte Valley assemblages (CCL1, CCL5, CCL7, HPL2, and HPL3) and are nearly equivalent in another (CCL9). FGV artifacts are outnumbered by obsidian artifacts in only two



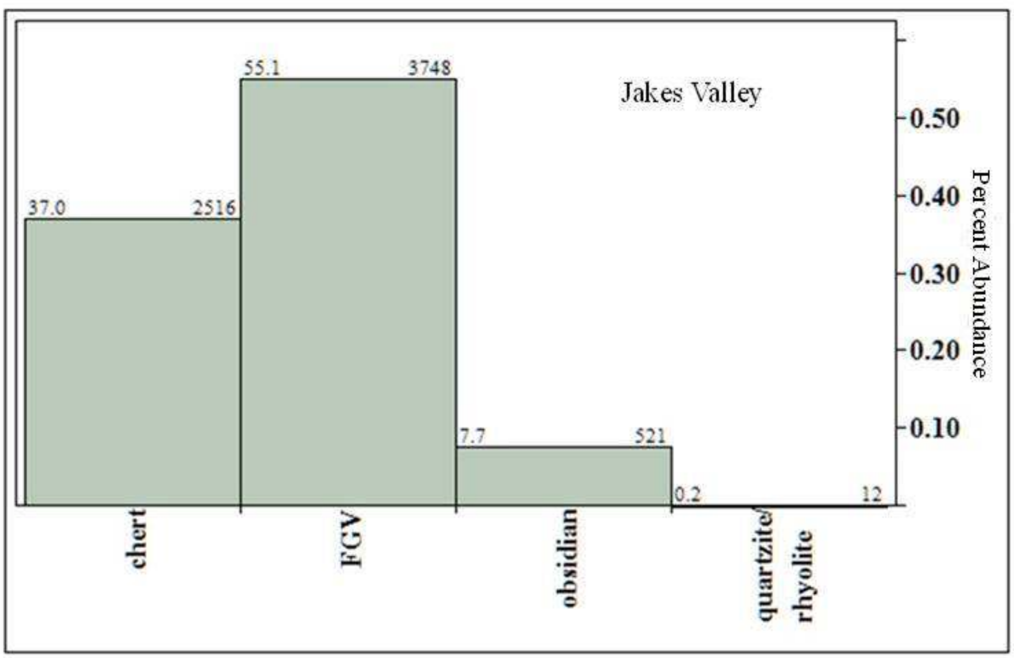


Figure 4.9: Abundance of toolstone types within the aggregated Butte Valley localities (top, n = 11,591) and LPL1 in Jakes Valley (bottom, n = 6797). The number on the left of the bars indicates percent abundance, while the number on the right of the bars indicates count.

Table 4.5: Abundance of toolstone types by locality, with percentage of the total in parentheses.

Locality	Obsidian	FGV	Chert
CCL1	30 (9.26)	271 (83.64)	23 (7.10)
CCL2	5 (7.81)	47 (73.44)	12 (18.75)
CCL3	13 (7.83)	123 (74.10)	30 (18.07)
CCL4	9 (1.80)	394 (78.96)	96 (19.24)
CCL5	337 (16.04)	1504 (71.58)	237 (11.28)
CCL7	220 (72.85)	71 (23.51)	11 (3.64)
CCL9	139 (33.66)	111 (26.88)	163 (39.47)
WSWL1	48 (16.38)	144 (49.15)	100 (34.13)
HPL1	12 (6.15)	65 (33.33)	117 (60.00)
HPL2	246 (25.33)	516 (53.14)	203 (20.91)
HPL3	569 (27.76)	1074 (52.39)	402 (19.61)
HPL5	622 (14.76)	1305 (30.98)	2260 (53.64)
Butte Valley Total	*2250 (19.41)*	*5625 (48.53)*	*3654 (31.52)*
LPL1	521 (7.67)	3748 (55.15)	2516 (37.02)
Total	*2771 (15.07)*	*9373 (50.98)*	*6170 (33.56)*

Table 4.6: Abundance of toolstone types within each locality, measured as weight (g). Percentage of the total is in parentheses.

Locality	Obsidian	FGV	Chert
CCL1	46.37 (4.83)	754.80 (78.65)	158.52 (16.52)
CCL2	7.22 (3.35)	166.24 (77.12)	42.09 (19.53)
CCL3	15.54 (2.71)	448.15 (78.25)	105.52 (18.42)
CCL4	4.85 (1.14)	247.57 (58.35)	171.85 (40.50)
CCL5	395.70 (8.13)	3695.02 (75.92)	712.25 (14.63)
CCL7	379.80 (46.56)	351.27 (43.06)	84.66 (10.38)
CCL9	327.43 (23.35)	191.86 (13.68)	883.00 (62.97)
WSWL1	57.93 (6.47)	512.07 (57.19)	313.82 (35.05)
HPL1	11.17 (0.96)	512.56 (44.23)	633.73 (54.69)
HPL2	354.89 (11.58)	1868.34 (60.98)	829.21 (27.06)
HPL3	580.46 (18.76)	1772.68 (57.29)	714.50 (23.09)
HPL5	419.58 (4.70)	3967.76 (44.41)	4475.40 (50.09)
Butte Valley Total	*2600.94 (9.85)*	*14,488.32 (54.87)*	*9124.55 (34.56)*
LPL1	750.58 (3.08)	10,140.39 (41.60)	13,266.22 (54.42)
Total	*3351.52 (6.60)*	*26,628.71 (52.44)*	*22,390.77 (44.09)*

assemblages (CCL9, CCL7). Measuring toolstone abundance as weight (grams) of the total assemblage (Table 4.6) and weight of total debitage (Table 4.7, Elston's [1990] "Material Index"), which may be more appropriate given aforementioned concerns regarding transport costs, augments the patterns documented on the basis of artifact count. Again, FGV and chert artifacts dominate these assemblages, with obsidian accounting for less than 20% of all but two assemblages (CCL7, CCL9), and outweighing chert in only one assemblage (CCL7). Obsidian outweighs FGVs in two assemblages (CCL7, CCL9). By weight, the Butte Valley assemblages include approximately 5.5 times more FGVs and 3.5 times more chert than obsidian. LPL1 in Jakes Valley includes approximately 13.5 times more FGVs and 17.5 times more chert than obsidian.

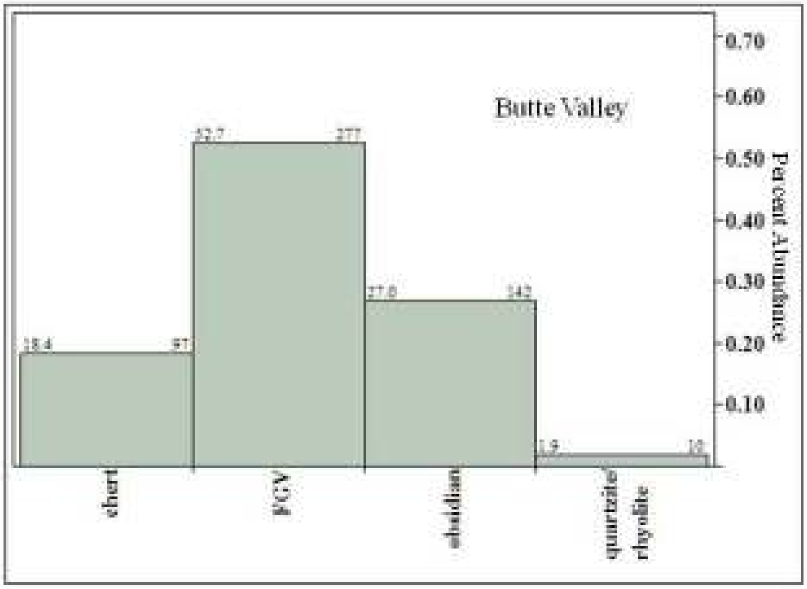
Table 4.7: Abundance of toolstone types within each locality, measured as weight (g) of debitage. Percentage of the total is in parentheses.

	Debitage Weight (g)		
Locality	**Obsidian**	**FGV**	**Chert**
CCL1	34.35 (4.90)	583.16 (83.45)	83.02 (11.85)
CCL2	5.20 (3.95)	88.64 (67.31)	37.84 (28.74)
CCL3	5.20 (1.49)	266.49 (76.60)	72.69 (20.89)
CCL4	3.06 (0.95)	153.87 (47.81)	164.89 (51.24)
CCL5	225.09 (5.88)	2959.52 (77.26)	598.34 (15.62)
CCL7	303.93 (57.65)	193.88 (36.78)	29.36 (5.57)
CCL9	209.06 (25.77)	97.74 (12.05)	504.57 (62.19)
WSWL1	38.52 (5.77)	363.73 (54.50)	264.41 (39.62)
HPL1	10.16 (1.58)	107.59 (16.74)	523.63 (81.46)
HPL2	211.01 (8.85)	1484.82 (62.30)	685.11 (28.75)
HPL3	402.50 (17.05)	1399.33 (59.29)	544.22 (23.06)
HPL5	291.30 (4.30)	3163.67 (46.68)	3271.91 (48.28)
Butte Valley Total	*1739.38 (8.92)*	*10,862.44 (55.70)*	*6779.99 (34.77)*
LPL1	9020.85 (2.03)	6772.37 (41.97)	328.13 (55.90)
Total	*10,760.23 (5.80)*	*17,634.81 (49.48)*	*7108.12 (44.34)*

As suggested earlier, I expect a lithic assemblage produced closer to a toolstone source to contain bifaces in earlier stages of reduction, more cores and cortical flakes, larger flaking debris, and more artifacts of that toolstone source in general. Alternatively, I expect lithic assemblages located farther from a toolstone source to contain more late-stage and retouched bifaces, fewer cores and cortical flakes, and smaller flaking debris associated with final stages of manufacture and subsequent tool maintenance. Accordingly, the sheer abundance of FGV and chert artifacts within the Eastern Nevada Study Area supports the notion that these toolstone types are derived from closer sources than obsidian, as we already know to be the case for FGVs and as we speculate is the case for at least some cherts (for other examples of the preferential use of local toolstone in early Great Basin contexts, see Goebel 2007; Warren and Phagan 1988; Zancanella 1988).

These data suggest that the annual or territorial ranges utilized by Paleoarchaic populations may be better reflected by chert or FGV provenance than by obsidian provenance. In fact, the use of FGVs for tools otherwise made of obsidian and chert (see Figures 10 and 11 below) may suggest that FGV toolstone was the closest, most important (in terms of utility) toolstone available to the Paleoarchaic inhabitants of the Eastern Nevada Study Area (after MacDonald 2008), again in support of the regular utilization of a range encompassing the FGV sources depicted in Figure 4.8. Yet, it is precisely in this space that we may posit highly mobile Paleoarchaic hunter-gatherers—the areas circumscribed by FGV provenance are still larger than most ethnographically-known hunter-gatherers (Figure 3.3; Kelly 2007:Table 4-1)—while simultaneously entertaining the possibility that the procurement and long-distance transport of obsidian reflects something more than simply subsistence pursuits. Indeed, George T. Jones and Charlotte Beck (1999) previously have suggested that the frequent substitution of FGVs for obsidian in the manufacture of projectile points may indicate that the preferential utilization of obsidian and FGVs for projectile points is only partly related to mechanical suitability (e.g., sharpness, ease of flaking). With this in mind, it is worth noting that the introduction of obsidian into the Eastern Nevada Study Area as finished tools may be consistent with embedded procurement during subsistence pursuits, or procurement through non-utilitarian mobility and exchange (Morrow and Jeffries 1989; though see Beck and Jones 1990a:294-295).

Not all tool types contain an equal level of information about mobility, however (e.g., Keeley 1991; Odell 1989a; Sellet 2006; Yerkes 1989). While provenance data and the preferential use of FGVs and obsidian for bifaces and stemmed points suggest the long-distance movement of these tools and toolstone types, perhaps in association with a more mobile subset of a Paleoarchaic group (e.g., young adult men), Paleoarchaic hunter-gatherers seemed to have used chert quite differently, perhaps in association with a different subset of the group utilizing a different sphere of mobility. As C. Melvin Aikens (1970) wrote in his well-known report on Hogup Cave, it seems that chert was preferred



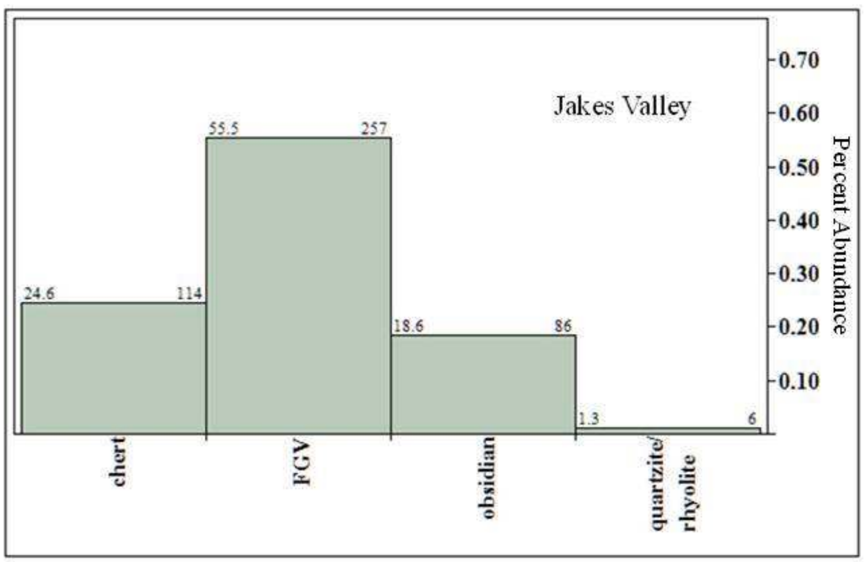
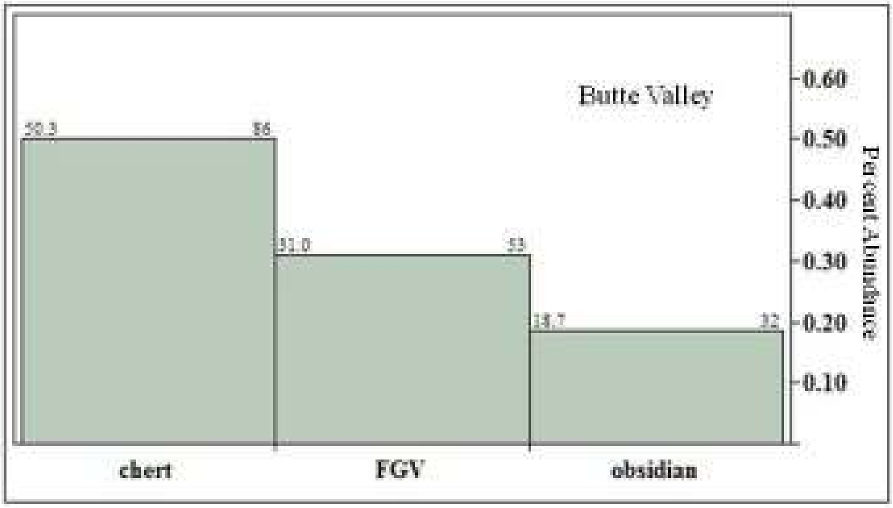


Figure 4.10: Distribution of bifaces and projectile points across the toolstone types in the aggregated Butte Valley localities (top, n = 526) and LPL1 in Jakes Valley (bottom, n = 463). The number on the left of the bars indicates percent, while the number on the right of the bars indicates count. The Butte Valley assemblages have been aggregated to accommodate the small sample sizes associated with specific artifact types in some assemblages.



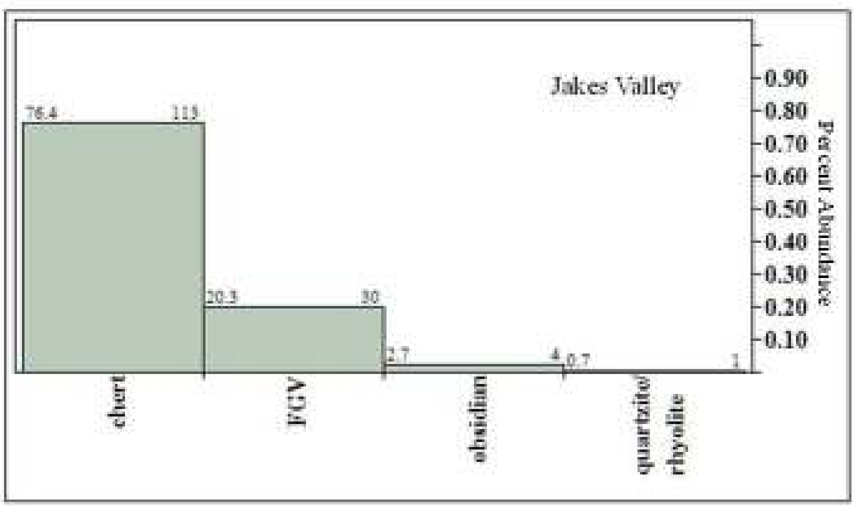


Figure 4.11: Distribution of unifaces across the toolstone types in the aggregated Butte Valley localities (top, n = 171) and LPL1 in Jakes Valley (bottom, n = 148). The number on the left of the bars indicates percent, while the number on the right of the bars indicates count. The Butte Valley assemblages have been aggregated to accommodate the small sample sizes associated with specific artifact types in some assemblages.

for tools in which toughness was required, such as gravers, scrapers, and crescents (i.e., unifaces), while obsidian was preferred for projectile points, presumably because of its "high quality" (especially its sharpness and the ease with which it can be flaked). When we consider the distribution of toolstone types across these artifact types in the Eastern Nevada Study Area (Figures 4.10, 4.11), we see that obsidian and chert were used for different tools, consistent with Aikens's (1970) suggestion (Beck and Jones 1990a, 1990b, 1997; Jones and Beck 1999). Yet we also see an abundance of FGV bifaces and projectile points, perhaps reflecting toolstone selection for strength or durability, rather than just sharpness and ease of flaking. This toolstone preference would seem particularly appropriate if Paleoarchaic people intended to use their FGV bifaces as cores (Kelly 1988) from which they could manufacture a variety of tools and their FGV stemmed points as multi-purpose tools (Beck and Jones 1993).

Consideration of a contingency table of artifact types by toolstone types in the Butte Valley assemblages indicates that there are significantly: (a) fewer chert bifaces, (b) fewer chert projectile points, (c) more chert unifaces, (d) more FGV bifaces, (e) fewer FGV unifaces, and (f) more obsidian projectile points than expected by chance (X^2 = 980.093, $p < 0.0001$, df = 36). Similarly, consideration of a contingency table of artifact types by toolstone types for LPL1 in Jakes Valley indicates that there are significantly: (a) fewer chert projectile points, (b) more chert unifaces, (c) fewer FGV unifaces, (d) more obsidian projectile points, (e) more obsidian bifaces, and (f) fewer obsidian unifaces than expected by chance (X^2 = 915.226, $p < 0.0001$, df = 24). In short, unifaces were preferentially manufactured from chert, while projectile points and bifaces were preferentially manufactured from FGVs and obsidian. Again, this preference has been previously reported by Great Basinists, although, to my knowledge, the supporting statistical tests have not.

Chert shows an abbreviated reduction sequence in which bifacial cores were reduced to large tabular flake blanks to be used as expedient flake tools or modified as unifaces (Beck and Jones 1990a, 1990b:Table 15). This conclusion is based on the prevalence of chert unifaces in comparison to obsidian and FGVs (Figure 4.11), as well as the lower number of chert bifaces (Figure 4.10), despite the fact that several assemblages contain large numbers of chert BRFs (Beck and Jones 1990a:Table 4, 1990b:Tables 9 and 14). In fact, Beck and Jones (1990b:255) find that "all Butte Valley chert unifaces appear to have been manufactured from large tabular flakes; of these, 93.3% with platforms remaining are biface-reduction flakes.” Another ~10% of chert BRFs in Butte Valley and ~16% of chert BRFs in Jakes Valley show evidence of use as flake tools (Table 4.8).

Table 4.8: Number (percent) of BRFs showing evidence of use-wear by toolstone type (updated from Beck and Jones 1990a:293).

Valley	Obsidian	FGV	Chert
Butte	34 (11.53)	85 (5.26)	88 (10.34)
Jakes	7 (9.33)	45 (5.49)	96 (16.49)

The use of chert bifaces for the manufacture of unifacial tools may suggest that chert was part of the Paleoarchaic mobile toolkit. Yet the preferential use of chert for tools that may be less likely to travel over the distances recorded for projectile points has led to the (often implicit) expectation that chert was procured from more local sources, and, in turn, was not subject to the same transport constraints and degree of curation seen for obsidian and FGVs. If truly derived from local sources, I expect that chert was introduced into the Eastern Nevada Study Area having undergone less intensive field-processing than FGVs and obsidian. In other words, the chert-sub-assemblage should include more evidence of earlier stages of reduction (e.g., more and larger cores and cortical flakes, larger flaking debris) than the FGV and obsidian sub-assemblages, which should include more evidence of later stages of reduction (e.g., less and smaller cores and cortical flakes, smaller flaking debris). The large amount of chert within these assemblages, as well as the previously presented larger size of chert cores, bifaces, and BRFs, lends support to this view. Table 4.9 and Figure 4.12 present a comparison of the size distributions of chert, FGV, and obsidian core reduction flakes (CRFs), in parallel to the comparison of BRF size distributions presented earlier. CRFs, which are much less numerous than BRFs in these assemblages, are defined as unmodified cortical and

Table 4.9: Comparison of average CRF weight (g) by toolstone type.

	Average CRF Weight (g)			ANOVA	
Valley	Obsidian	FGV	Chert	F Ratio	Prob.
Butte Valley	1.921	4.329	4.429	25.2471	<0.0001
Jakes Valley	3.597	8.991	9.621	1.6280	0.1978

interior flakes possessing platforms that do not derive from biface manufacture. As expected, obsidian CRFs weigh significantly less than FGV and chert CRFs in the Butte Valley assemblages and LPL1 in Jakes Valley, although FGV and chert CRFs do not weigh significantly different (Table 4.9). Nevertheless, a pair-by-pair comparison of each mean using a Student's t test demonstrates that obsidian is significantly smaller than FGV and chert CRFs ($\alpha = 0.05$) in both the Butte Valley assemblages and LPL1, as exemplified by the normal quantile plots presented in Figure 4.12.

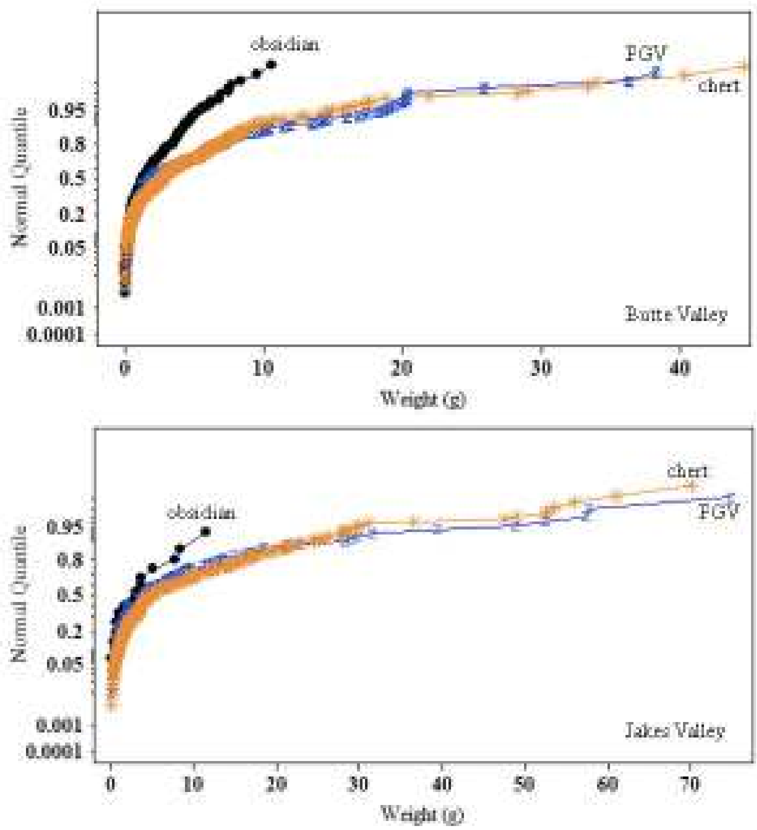


Figure 4.12: Normal quantile plot of CRF weights (g) by toolstone type for the aggregated Butte Valley localities (top) and LPL1 in Jakes Valley (bottom). Butte Valley assemblages have been aggregated to accommodate the small amount of CRF in some assemblages.

The proportion of cortex in an archaeological assemblage may be another indicator of different levels of mobility associated with the procurement of different toolstone types. In theory, the amount of cortex retained on cores is directly related to the degree to which they have been reduced, and this relationship may be used to infer the intensity of reduction at a particular locality, especially early reduction which would be expected to occur closer to a source (Amick et al. 1988; Cowan 1999; Dibble et al. 1995, 2005; Douglass et al. 2008; Lin et al. 2010; Magne and Pokotylo 1981; Marwick 2008; Mauldin and Amick 1989; Morrow 1984; Odell 1989b). As a core remains in the mobile toolkit and continues to undergo reduction, a higher proportion of noncortical flakes are produced (Dibble et al. 2005). Thus, I expect that if chert derives from closer toolstone sources, then cortical flakes should comprise a greater proportion of chert flakes than is the case for FGVs and obsidian. Evaluation of this expectation is rendered difficult, however, by the fact that cortical flakes are an infrequent product of bifacial reduction (e.g., Amick et al. 1988). Additionally, because debate continues regarding how to appropriately quantify cortex (see discussion in Dibble et al. 2005), cortex has been treated here simply as present (cortical flakes) or absent (interior flakes) (Beck and Jones 1990b:Table 3). While these factors limit the comparisons that may be conducted, it is telling that, although obsidian constitutes a greater proportion of the cortical flakes within the Eastern Nevada Study Area assemblages than chert by count (likely due to the Butte Mountain pebble source), it accounts for a much lower proportion of the cortical flakes than chert by weight (Table 4.10). This observation accords well with the larger size of chert bifaces, cores, and flake types, and supports the notion that early stages of chert reduction are recorded within these assemblages, as may be expected if chert truly derives from closer sources than FGVs and obsidian.

Table 4.10: Percentage of cortical flakes by count and weight (g) within the aggregated Butte Valley localities and LPL1 in Jakes Valley.

	Obsidian		**FGV**		**Chert**	
Valley	**Count**	**Weight**	**Count**	**Weight**	**Count**	**Weight**
Butte	43.47	22.84	35.40	50.04	20.96	27.12
Jakes	3.73	0.96	50.93	45.37	45.33	53.67
Total	34.17	13.85	39.04	48.19	26.67	38.03

In combination with the marked toolstone preferences exhibited for particular artifact types, the analyses presented here support a multi--tiered model of Paleoarchaic mobility in east-central Nevada. These data repeatedly suggest that chert entered the Eastern Nevada Study Area having undergone less reduction than obsidian, as may be expected if chert does indeed derive from closer toolstone sources, perhaps in association with a less-mobile subset of the Paleoarchaic group(s) inhabiting this area. Yet these analyses also repeatedly demonstrate that FGVs and chert were treated fairly similarly. If biface, core, BRF, and CRF size distributions are taken as broadly indicative of reduction stages (Figure 4.5, bottom), then the FGVs and chert sub-assemblages are similarly distributed over the reduction sequences utilized by the Paleoarchaic inhabitants of the study area (Figures 4.5 and 4.12; Beck and Jones 1990b:Figure 7B). Supposing, in turn, that reduction stage indicates distance from source (i.e., early-stage reduction occurs close to a toolstone source; late-stage reduction occurs farther from a toolstone source), then FGVs and cherts seem to derive from similarly distant toolstone sources. Thus, it may be that at least some cherts were transported over distances comparable to that recorded for FGVs (i.e., 60-80 km, Figure 4.8).

To push the Butte Valley data even further, the few chert bifaces, all of which are late-stage, may suggest that at least some chert derives from more distant sources than the FGVs, which include many early-stage bifaces (Beck and Jones 1990b:Table 15). Similarly, we may expect high-quality chert utilized to manufacture lanceolate points to derive from more distant sources and be curated much the same way high-quality chert projectile points from other Paleoindian contexts are. In fact, using the Student's t test ($\alpha = 0.05$) to conduct a pair-by-pair comparison of mean projectile point weight for each toolstone type does not demonstrate significant differences between chert and obsidian in either the aggregated Butte Valley assemblages or in LPL1, which may suggest provenance at comparable distances. To this end, Jones and Beck (1999) suggest that the chert nodules available within east-central Nevada were simply not big enough for the manufacture of projectile points. Finally, if high-quality cherts were brought into east-central Nevada from distances comparable to those documented for FGVs and obsidian, then the preferential utilization of obsidian, especially nonlocal obsidian, for projectile points may itself suggest the social and/or ideological significances obsidian embodied. Accordingly, the large areas defined on the basis of obsidian provenance, as well as the diversity of obsidian sources represented in these assemblages (after Molyneaux 2002), may reflect non-utilitarian mobility and/or exchange to maintain informational and social networks that linked multiple Paleoarchaic groups.

In sum, these data suggest that we revisit the expectations regarding the differential procurement and utilization of chert, FGVs, and obsidian that arise from the toolstone preferences documented in these and other Paleoarchaic lithic assemblages. For one, if functional concerns are paramount, obsidian may not be as well-suited for use as projectile points as many Great Basinists maintain. In a well-known paper, Albert Goodyear (1979, 1989; also see Bordaz 1970; Holmes 1900; MacCurdy 1900) disparages obsidian because it is brittle, dulls quickly, and is prone to breakage—it may not have been a reliable toolstone for Paleoindians. Similarly, Susan Hughes (1998) notes that chert is a better all-around material than obsidian because it carries a sharp edge and embodies both compressional and tensile strength. Additionally, the use of stemmed points for tough tasks that would shorten tool use lives may work against a high rate of curation and, in turn, long-distance transport of obsidian. In short, the brittleness of obsidian may suggest that it was not the best material for stemmed points if guided strictly by functional considerations, especially if those functions included scraping and cutting. Finally, Elston (1990) suggests that if we understand quality to be a description of the intrinsic utility (service time per unit weight) of toolstone, then the net utility (i.e., subtracting time for travel, search, extraction, and processing from intrinsic utility) of the highest quality toolstone may fall below the utility of lower quality toolstone simply as a function of distance to source (also see Beck et al. 2002; Thacker 2006). Again, these factors lead me to the possibility that nonlocal obsidian may often have entered east-central Nevada through non-utilitarian mobility and/or exchange.

Beck and Jones (1990a:294-295) pose two significant questions regarding this possibility: (1) "if obsidian was preferred for projectile point manufacture, why were exhausted specimens not replaced using other obsidian garnered through exchange rather than using the more "locally" available basalt [i.e., FGVs]?"; (2) "if basalt was a viable alternative to obsidian for many tool categories, including projectile points, why do obsidian artifacts appear in the record at all? What economic advantage lies in the exchange for extralocal obsidian toolstone?" Beck and Jones (1990a:294) go on to provide what may be an appropriate answer to the first question, noting that exchange simply may not have taken place near the Butte Valley localities at the time they were occupied. I would add to this that exhausted obsidian specimens may have been replaced by FGVs because, speaking strictly in relation to function, obsidian was not the best toolstone for the tasks requiring bifaces and stemmed points. As such, and in answer to the second question, obsidian artifacts may appear in the Paleoarchaic record of east-central Nevada not because of any economic advantage, but because of the social and/or ideological significances obsidian embodied.

While testing many of these propositions may prove difficult, an initial assessment of the variability present within the chert sub-assemblages of the Eastern Nevada Study Area may be possible. This pursuit may allow an understanding of Paleoarchaic adaptation to be built out from local, small-scale processes, as recorded by locally-procured cherts, to nonlocal, large-scale processes, as recorded by obsidian and, perhaps, high-quality cherts. For example, if cherts utilized to manufacture unifaces derive from local sources, then variability in the cherts present within these assemblages may suggest the operation of distinct ranges operating at a smaller scale than the zones defined by the procurement of FGVs and obsidian. If cherts utilized to manufacture lanceolate points and late-stage bifaces originate from more distant sources, then specimens derived from these sources should be present in lower abundance and evidence later stages of reduction. To explore these hypotheses, I partition the chert sub-assemblages using minimum analytical nodule analysis (MANA).

Minimum Analytical Nodule Analysis

As I use it here, minimum analytical nodule analysis (MANA) involves the partitioning of a lithic assemblage into macroscopically-similar subgroups (i.e., “analytical nodules”) in order to tease out variability that may be masked when the assemblage is treated as a whole (Larson 2004). Because of the variable uses of cherts, as mentioned earlier, I use MANA to define different chert subgroups (i.e., chert analytical nodules), each of which may be derived from a different source. By partitioning the lithic assemblage in this way, I can recognize differences in the use and procurement of different types of cherts (e.g., Hall 2004; Kelly 1985, 2001; Larson 1990, 1994; Larson and Finley 2004; Larson and Kornfeld 1997). Knell (2007), for example, suggests that analytical nodules associated with on-site tool manufacture may include a used core, associated flake tools, and a suite of different sized debitage, while analytical nodules associated with a tool that was brought to a site but not produced there may include only resharpening debitage (e.g., small, noncortical flakes). Similarly, Larson (1994) suggests that large nodules with many members (i.e., subgroups that include many artifacts) are expected where tool production occurs, while single flake or single tool nodules (i.e., subgroups that include few artifacts) are expected where an item or tool of that material was not included in production activities at that location (for a similar perspective regarding lithic refitting, see Morrow 1996). If we posit that earlier stages of core reduction and tool production will occur closer to a toolstone source than later stages of core reduction, use, and maintenance of those tools, then larger nodules may be expected closer to the toolstone source from which they are derived than smaller nodules. In turn, the amount of debitage in general, the proportion of cortical flakes, and the size (weight) distribution of debitage may be indicative of the relative distances over which particular analytical nodules have travelled. If these suppositions prove accurate, then MANA may provide a more detailed picture of Paleoarchaic technological organization than can be achieved by treating toolstone types en masse (i.e., obsidian vs. FGVs vs. chert).

I defined chert analytical nodules on the basis of similarities in color, texture, translucency, luster, structure, and cortex characteristics from over 2500 pieces of debitage collected from the Paleoarchaic localities within the Eastern Nevada Study Area. For several of these localities, I analyzed all of the chert debitage that had been collected by George T. Jones, Charlotte Beck, and the Hamilton College Field School students. For some localities, however, I could not locate all of the chert flakes; in these cases, the amount of chert debitage used to define the analytical nodules will be slightly lower than the total amount of chert debitage that was collected (Table 4.11). For HPL5 I randomly sampled 20% of the chert debitage, though this sample was inflated because of the method of artifact collection. Collection and subsequent storage of artifacts at HPL5 occurred in 2x2 m grid squares, with many grid squares including multiple artifacts. Because I decided to consider all of the artifacts associated and stored with a sampled artifact within a grid square, the resulting sample actually represents 36.6% of the HPL5 chert debitage. I also randomly sampled 20% of the grid squares containing chert debitage occurring within two areas of highest chert artifact density at LPL1 (220-280 East and 210-260 North; 370-400 East and 250-340 North; Figure 4.3). A third area of high artifact density (290-340 East, 350-390 North) is not considered here because it does not contain as abundant chert artifacts in as large an area as the two areas I sampled. As

Table 4.11: Number of chert artifacts considered in MANA.

Locality	MANA Sample Size
CCL1	17
CCL2	11
CCL3	28
CCL4	91
CCL5	221
CCL7	8
CCL9	100
WSWL1	91
HPL1	73
HPL2	176
HPL3	360
HPL5	787
LPL1	601

with HPL5, many 2x2 m grid squares at LPL1 contained multiple artifacts, all of which were considered; therefore, the resulting sample (n = 601) accounts for 61.4% of the chert artifacts present within these two clusters (n = 979), and 26.4% of the chert debitage present within the LPL1 assemblage as a whole (n = 2277).

I measure color using the 2009 edition of the Munsell Geological Rock-Color Chart. As Barbara Luedtke (1992) notes, all cherts are translucent, although this property may only be apparent in very thin flakes or sections. I record diaphaneity (or translucency) following Ahler (1983:4). I held flakes at the edge of the shade of a desk lamp, 8 cm from a 75-watt bulb. A relatively clear line marks where the chert changes from translucent to opaque, and I measured the thickness of the flake at that point. Luster (i.e., the appearance of light reflected from a material's surface) is a function of the mineralogy and surface characteristics of a material and is typically described by a number of subjective terms (e.g., silky, greasy, pearly, waxy). Luedtke (1992:65) notes difficulty in quantifying luster and so she falls back on qualitative terms of shiny, medium, and dull in describing cherts (see Luedtke 1992:Appendix B); I follow her lead here. I record texture (or "fracture surface;" Luedtke 1992:65) as fine, coarse, or medium (see Luedtke 1992:Appendix B). Structure (or fabric or pattern) refers to the uneven distribution of color, luster, texture, and translucency within a chert, resulting from the replacement of features present in the original sediments or from diagenesis. The terminology for describing rock structure has not been standardized. Here I use Luedtke's (1992:66) terms (striped or banded, spotted, streaked, and irregularly splotched or mottled). I also record features (e.g., clasts) visible macroscopically and with a hand-lens at 10x magnification (e.g., Stow 2009:118-119), and indicate their distribution using a comparator chert for estimating sorting in sediments (e.g., Stow 2009: Figure 3.29). I document cortex similarly, especially noting color, texture, and other significant features. Given the inconsistent application of nomenclature in both the archaeological and geological literature (e.g., Holland 2004-2006; Luedtke 1992:5), I do not trouble, in most cases, with naming varieties of chert (e.g., agate, jasper, opalite).

From these observations I grouped the chert debitage into 43 minimum analytical nodules (MAN A to MAN QQ), with some residual (i.e., ungrouped) flakes deemed "isolates." I then reconsidered each of these analytical nodules more closely, in some cases teasing out further variability, in other cases absorbing the members of one analytical nodule within another. Although the heterogeneity of chert may, at times, blur the distinctions between different analytical nodules, it is this same variability that makes the chert artifacts present within the Eastern Nevada Study Area ideal for MANA (Andrefsky 2009:86). While subsequent analysis may refine the analytical nodules defined here, as I have anticipated below, I treat these analytical nodules separately in the following analyses, in accordance with the goal of MANA to define the smallest related parts of a lithic assemblage (Larson 1994).

MINIMUM ANALYTICAL NODULES

<u>MAN A</u>: Examples: HPL2 #709; HPL5 286, 220; HPL5 250, 178. Color is primarily light brown (5YR 5/6) to moderate brown (5YR 4/4). Specimens exhibit few, moderately-sorted volcanic and carbonaceous clasts. Texture is fine. Luster is medium to shiny. Specimens are fairly translucent (4-9 mm). Cortex is a coarse, very pale orange (10YR 8/2) to dark yellowish orange (10YR 6/6). Specimens do not exhibit a discernible ultraviolet fluorescent response. This analytical nodule represents an archetypal "brown

chert," which may grade into other MANs. For example, MAN DD may simply be a coarser variant of MAN A, MAN J may be a pinker, more translucent variant (see the two specimens on the left in Figure 4.13), MAN Q may be a more clearly streaked and/or banded variant of MAN A (see the specimen on the top right in Figure 4.13), and MAN A may also grade into some yellower cherts, such as MAN T.

Figure 4.13: MAN A. Scale in cm.

<u>MAN B</u>: Examples: MAN B: HPL3 162, 216; CCL5 312, 302; MAN B2: HPL5 232, 148; CCL9 #102; MAN B3: HPL3 198, 260; HPL5 234, 156; MAN B4: LPL1 380, 280; WSWL1 A #69. This analytical nodule is composed of "red' flakes, separated into several sub-varieties which, in turn, may align with other MANs. The primary colors for all of these varieties are moderate reddish brown (10R 4/6) to dark reddish brown (10R 3/4), though MAN B3 grades into light red (5R 6/6) to moderate red (5R 5/4). MAN B (across the bottom of Figure 4.14) is shiny, with a translucency of ~5 mm, fine texture, and moderately-sorted quartz clasts. MAN B grades into MAN B2 (on the diagonal in Figure 4.14). MAN B2 also has a fine texture and is shiny, but it is less translucent (< 1.5 mm) than MAN B and often exhibits moderately-sorted quartz and carbonaceous clasts. MAN B3 (the column on the right side of Figure 4.14) is fine to medium in texture, dull, not very translucent (0.5-2 mm), exhibits moderately-sorted carbonaceous clasts, and light gray (N7) banding or mottling. MAN B4 (the column on the left side of Figure 4.14) is fine to medium in texture, medium to shiny in luster, exhibits little translucency (2-3 mm), and has dark yellowish orange (10YR 6/6) banding. Cortex, when it occurs, is a coarse, very pale orange (10YR 8/2). None of these cherts exhibit a discernible ultraviolet fluorescent response. To further indicate the difficulty with differentiating these red

cherts, the specimen in the top right corner of the picture, presently identified as MAN B3, also exhibits dark yellowish orange (10YR 6/6) banding on the side opposite than pictured. It may very well be that all of these sub-varieties represent variations within a single type of red chert. Alternatively, it may be that these sub-varieties are better treated in combination with other MANs. For example MAN B may grade into MAN J, MAN B3 may grade into MAN L, and MAN B4 may grade into MAN A. If these red chert sub-varieties grade into some of the brownish MANs (A, J, Q), then this may suggest, based simply on macroscopic properties, that these cherts derive from Mahoney Canyon where light brown/orange, red, gray, and purple cherts all occur at the same outcrop.

Figure 4.14: MAN B. Scale in cm.

MAN C: Examples: LPL1 226, 260; CCL5 274, 228; CCL4 38, 22. Color is grayish black (N2) to black (N1), often with light brown (5YR 5/6) mottling, spots, and/or streaks. Some specimens also exhibit few, moderately-sorted quartz clasts. Luster varies from dull to shiny as texture becomes finer. Translucency is 4-5 mm on the light brown sections and minimal in the darker sections. Cortex is a coarse, medium light gray (N6).

Figure 4.15: MAN C. Scale in cm

Brown sections of fresh surfaces typically exhibit light green fluorescence under shortwave ultraviolet light. So defined, this analytical nodule absorbs MAN PP. It also seems likely that this analytical nodule grades into MAN M, as exemplified especially by the two specimens on the left of Figure 4.15.

MAN D: Example: CCL5 292, 220. This analytical nodule may be a variant of MAN C. It is distinguished from MAN C by a tendency toward grayness; that is, the primary color is medium dark gray (N4) rather than black, and it does not exhibit the light brown (5YR 5/6) mottling, spots, and streaks of MAN C. Specimens include moderately-sorted, spots of light gray (N7) macroscopic quartz. Texture is fine. Luster is dull to medium. Translucency is 1-1.5 mm, especially on light gray sections. Cortex is not present on these specimens. Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 4.16: MAN D. Scale in cm.

MAN E: Examples: HPL5 266, 128; HPL1 #50. Primary colors include moderate brown (5YR 4/4 and 5YR 3/4), grayish brown (5YR 3/2), and dusky brown (5YR 2/2), often distributed as bands or mottled. Some specimens also exhibit few, well-sorted quartz clasts. Texture is fine. Luster is medium to shiny. Translucency is low (< 1.5 mm). Cortex is a coarse, grayish brown (5YR 3/2). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 4.17: MAN E. Scale in cm.

MAN F: Examples: HPL5 260, 172; LPL1 392, 306. Primary color is a grayish red (5R 4/2) mottled with moderate reddish brown (10R 4/6) and moderate brown (5YR 3/4). More homogeneous specimens grade into blackish red (5R 2/2), pale red (5R 6/2), and very dusky purple (5RP 2/2). Though quite variable in color, the specimens all emote "purple" (grayish red, blackish red, and pale red are all purplish) and grade into each other as exemplified by the two specimens second from the right in Figure 4.18. Specimens also exhibit moderately-sorted quartz and feldspar clasts. Texture varies from fine in more homogenous flakes to medium in more heterogeneous flakes. Luster is shiny. Translucency is similarly variable, from 2.5 mm in darker, homogeneous specimens to 8 mm in lighter specimens. Cortex is a coarse, very pale orange (10YR 8/2). Specimens do not exhibit a discernible ultraviolet fluorescent response. This analytical nodule may grade into MAN L. More translucent sections of MAN F may also grade into MAN EE and MAN U.

Figure 4.18: MAN F. Scale in cm.

MAN G: Example: HPL5 274, 134. Color is pale olive (10Y 6/2). Structure is fairly homogeneous, though some specimens exhibit moderately- to well-sorted quartz and volcanic clasts. Texture is medium. Luster is dull. Translucency is 1 mm. Cortex is a coarse, moderate brown (5YR 3/4). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 4.19: MAN G. Scale in cm.

MAN H: Example: HPL5 264, 134. Color is dusky yellow green (5GY 5/2), often with grayish yellow green (5GY 7/2) streaks or banding. Texture is fine, luster is shiny. Translucency is 1.5 mm. A sub-variety (MAN H2) is darker (grayish olive green, 5GY 3/2 or dusky yellowish green, 10GY 3/2), though many pieces still exhibit the same grayish yellow green (5GY 7/2) streaking and banding. MAN H2 is typically coarser and even less translucent (0.5 mm) than MAN H. Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 4.20: MAN H. Scale in cm.

MAN I: Example: HPL5 268, 178. Color is dark yellowish orange (10YR 6/6) to moderate yellowish brown (10YR 5/4), sometimes mottled with pale yellowish brown (10YR 6/2) which provides a “cloudy” appearance to these specimens. Many specimens exhibit moderately-sorted quartz clasts. Texture is fine to medium. Luster is medium to shiny. Translucency is 4-6 mm; many specimens are almost completely transparent. Cortex is coarse, white (N9). Light brown sections of fresh surfaces typically exhibit light green fluorescence under shortwave ultraviolet light. This analytical nodule may be a more yellow variety of MAN U and/or MAN J.

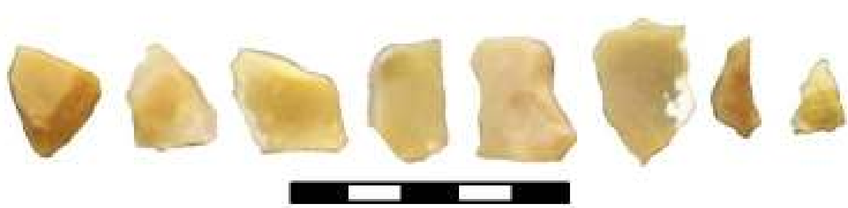


Figure 4.21: MAN I. Scale in cm.

MAN J: Example: CCL5 294, 260. Primary colors include light brown (5YR 5/6) and moderate reddish brown (10R 4/6). Many specimens exhibit poorly sorted quartz clasts that appear to be "floating" within the otherwise, mostly translucent matrix. Texture is fine. Luster is shiny. Many specimens are completely translucent and, as measured on thicker specimens, translucency is 12-14 mm on brown sections, though only 3-4 mm on redder sections. Cortex is a medium coarse, very pale orange (10YR 8/2) or white (N9). Specimens do not exhibit a discernible ultraviolet fluorescent response. This analytical nodule may be a variant of MAN A, though it is distinguished from MAN A and MAN I by a tendency toward red, which may suggest that it actually grades into MAN B (see the top middle specimen Figure 4.22).

Figure 4.22: MAN J. Scale in cm.

MAN K: Example: HPL5 256, 186. Color is medium light gray (N6) to yellowish gray, with moderate red (5R 5/4) and light brown (5YR 6/4 and 5YR 5/6) streaks. Some specimens exhibit dark yellowish orange (10YR 6/6) and/or dark reddish brown (10R 3/4) mottling. Texture is fine. Luster is medium. Translucency is 1-2 mm. Cortex is a medium coarse, very pale orange (10YR 8/2). Fresh surfaces typically exhibit faint green fluorescence under shortwave ultraviolet light. The macroscopic properties are suggestive of Long Valley "Wonderstone." MAN K and MAN AA may be sub-varieties of the same chert.

Figure 4.23: MAN K. Scale in cm.

MAN L: Examples: HPL2 #323; LPL1 396, 292. Color varies from moderate pink (5R 7/4) to grayish red (5R 4/2). Specimens typically exhibit very pale orange (10YR 8/2) banding and/or poorly-sorted quartz clasts. Specimens in which banding is evident are typically more homogeneous than those in which banding is not evident, though the specimen in the top center of Figure 4.24 exhibits both structural characteristics. Texture is fine to medium. Luster is medium to shiny. Translucency is 3-5 mm. Cortex is a coarse, grayish orange (10YR 7/4). Specimens do not exhibit a discernible ultraviolet fluorescent response. This analytical nodule may be a "pinker" variant of MAN F and may grade into MAN B3.

Figure 4.24: MAN L. Scale in cm.

MAN M: Example: HPL5 230, 142. This chert is an amalgamation of browns with varying translucencies. Primary colors include pale yellowish brown (10YR 6/2), light brown (5YR 5/6), moderate brown (5YR 4/4), dark yellowish brown (10YR 4/2), and dusky yellowish brown (10YR 2/2). Translucency varies from minimal (0.5 mm) on

Figure 4.25: MAN M. Scale in cm.

darker sections to 9 mm on lighter sections. Specimens often exhibit moderately-sorted, carbonaceous clasts, which render translucent sections "cloudy" and are suggestive perhaps of a moss agate. Luster is medium to shiny. Texture is fine to medium. Cortex is a coarse, very pale orange (10YR 8/2), often exhibiting iron staining. Specimens do not exhibit a discernible ultraviolet fluorescent response. While this analytical nodule may grade into other brown MANs (e.g., MAN A or MAN Q), these other MANs do not exhibit the same conglomeration of colors and translucencies as MAN M.

MAN O: Example: HPL5 270, 116. Primary color is dark yellowish orange (10YR 5/4). Some specimens exhibit few, moderately-sorted quartz and volcanic clasts. Texture is fine. Luster is dull to medium. Translucency is 1.5-2 mm. Cortex is a medium coarse, moderate brown (5YR 4/4). Specimens do not exhibit a discernible ultraviolet fluorescent response. This analytical nodule may also be a variant of MAN A, though it is less lustrous and translucent.

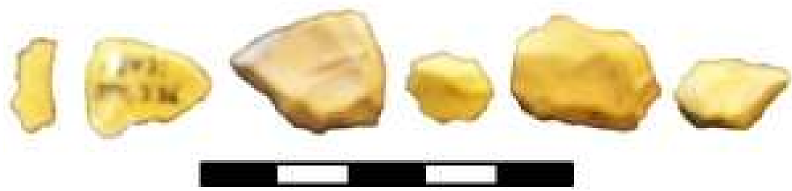


Figure 4.26: MAN O. Scale in cm.

MAN P: Example: CCL4 52, 28. Colors include alternating bands of grayish olive (10Y 4/2), moderate brown (5YR 4/4 and 5YR 3/4), dark reddish brown (10R 3/4), and pale yellowish orange (10YR 8/6). Some specimens exhibit few, well-sorted quartz clasts. Texture is medium. Luster is medium to shiny. Translucency is 1.5-2 mm, with lighter colors more translucent. None of the flakes have cortex. Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 4.27: MAN P. Scale in cm.

MAN Q: Example: HPL5 250, 164. Primary color is moderate brown (5YR 4/4 to 5YR 3/4), often with grayish orange (10YR 7/4) to dark yellowish orange banding and abundant carbonaceous clasts, often distributed parallel to the banding. Few specimens also exhibit streaks of very dark red (5R 2/6). Texture is fine to medium. Luster is dull to medium. Translucency is 2-4 mm. Cortex is a coarse, very pale orange (10YR 8/2). Fresh surfaces typically exhibit light green fluorescence under shortwave ultraviolet light and orange fluorescence under longwave ultraviolet light. Though this analytical nodule may grade into other brown MANs (e.g., MAN A or MAN M), it is distinguished by the more obvious banding it exhibits.

Figure 4.28: MAN Q. Scale in cm.

MAN R: Example: HPL5 278, 128. The primary color is yellowish gray (5Y 8/1), with streaks of grayish red purple (5RP 4/2), pale pink (5RP 8/2), moderate orange pink (10R 7/4), pale yellowish orange (10YR 8/6), and dark yellowish orange (10YR 6/6) Texture is coarse. Luster is dull. Translucency is 4-6 mm. Cortex is pinkish gray (5YR 8/1). Light gray sections of fresh surfaces typically exhibit light green fluorescence under shortwave ultraviolet light. MAN R is perhaps better characterized as quartzite. This analytical nodule may be a sub-variety of MAN U. Several specimens within this MAN may have been heat-treated, as suggested by the red coloring (Luedtke 1991:94).

Figure 4.29: MAN R. Scale in cm.

MAN S: Example: HPL5 234, 164. Color is medium dark gray (N4). Texture is fine to medium. Luster is dull to medium. Translucency is 1.5-3 mm. Specimens exhibit numerous medium- to well-sorted volcanic, quartz, and feldspar clasts. Cortex is coarse, very pale orange (10YR 8/6). Specimens do not exhibit a discernible ultraviolet fluorescent response.

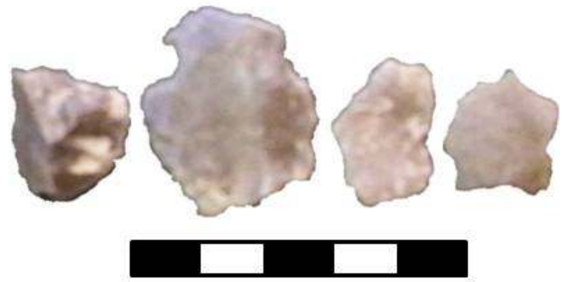


Figure 4.30: MAN S. Scale in cm.

MAN T: Examples: CCL5 320, 270; CCL5 302; 280. Primary color is pale yellowish brown (10YR 6/2), with dark yellowish orange (10YR 6/6) bands and dark yellowish brown (10YR 4/2) mottling. Specimens exhibit moderately-sorted quartz clasts. Texture is fine. Luster is dull. Translucency is 3-5 mm. Cortex is absent on these specimens. Specimens do not exhibit a discernible ultraviolet fluorescent response. This analytical nodule may be a variant of MAN A and/or MAN I.

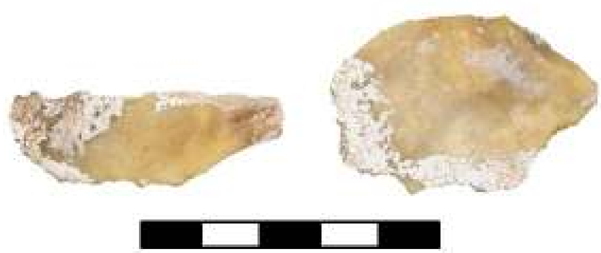


Figure 4.31: MAN T. Scale in cm.

MAN U: Example: HPL5 244, 132. This MAN represents the grading of a fine, shiny, translucent (6-9 mm) light brownish gray (5YR 6/1) chert to a coarse, dull, less translucent (3-4 mm), white (N9) chert, perhaps better described as quartzite. The middle specimen in Figure 4.32 embodies both of these varieties, one on each side. Both varieties exhibit moderately-sorted quartz clasts and some specimens exhibit minor iron staining. Cortex is a coarse, yellowish gray (5Y 8/1). Fresh surfaces typically exhibit light green fluorescence under shortwave ultraviolet light and orange fluorescence under longwave ultraviolet light. This analytical nodule may be a variant of MAN R.

Figure 4.32: MAN U. Scale in cm.

<u>MAN V</u>: Example: HPL5 250, 190. Primary color is moderate yellowish brown (10YR 5/4) with dark yellowish orange (10YR 6/6) streaking and mottling. Specimens often exhibit carbonaceous clasts, though less well-organized than in MAN Q. Some specimens also exhibit poorly-sorted quartz and lithic (siltstone) clasts, as well as very dark red (5R 2/6) coloring that may suggest heat-treating (Luedtke 1992:94). Texture is medium to coarse. Luster is medium. Translucency is 1-2.5 mm. Specimens do not exhibit a discernible ultraviolet fluorescent response. This analytical nodule may be a coarser, less well-organized variant of MAN Q.

Figure 4.33: MAN V. Scale in cm.

<u>MAN X</u>: Example: HPL5 342, 226. Color is grayish green (5GY 6/1) or light greenish gray (5GY 8/1) to pale blue (5PB 7/2) with pale olive (10Y 6/2) or yellowish gray (5Y 8/1) banding. Some specimens exhibit minor iron-staining. Texture is usually fine, though few specimens are coarser. Luster is dull, though lighter-colored specimens are

shinier. Translucency is low (1.5-2 mm). Cortex is moderate brown (5YR 3/4). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 4.34: MAN X. Scale in cm.

<u>MAN Y</u>: Example: HPL5 336, 230. Color is dark yellowish orange (10YR 6/6) to dark yellowish brown (10YR 4/2). Specimens include moderately-sorted quartz, schist, and volcanic clasts. Some specimens exhibit faint, light olive gray (5Y 5/2) banding. Texture is coarse. Luster is medium to shiny. Translucency is low (1-2 mm). Cortex is a coarse, pale yellowish orange (10YR 8/6). Specimens do not exhibit a discernible ultraviolet fluorescent response. This analytical nodule may be a variant of MAN HH.

Figure 4.35: MAN Y. Scale in cm.

<u>MAN Z</u>: Examples: CCL5 344, 344; HPL3 352, 208; LPL1 264, 246. This MAN exhibits variable colors, often within a single flake, including grayish orange (10YR 7/4), very pale orange (10YR 8/2), dusky yellowish brown (10YR 2/2), grayish orange pink (5YR 7/2), and pale yellowish brown (10YR 6/2). These specimens are grouped together on the basis of medium to fine texture, shiny (greasy) luster, and, in particular, poorly-sorted carbonaceous clasts, suggestive of moss agate. Lighter-colored sections are quite translucent (5-12 mm). The specimens also share a similar cortex, which is a soft,

medium-textured white (N9). Fresh surfaces typically exhibit light green fluorescence under shortwave ultraviolet light.

Figure 4.36: MAN Z. Scale in cm.

<u>MAN AA</u>: Example: HPL5 254, 204. Primary color is grayish orange (10YR 7/4) to pale yellowish brown (10YR 6/2), mottled with dark yellowish orange (10YR 6/6). Structure is fairly homogeneous. Texture is fine. Luster is shiny. Translucency is 1.5-2 mm. None of these specimens have cortex. Specimens do not exhibit a discernible ultraviolet fluorescent response.

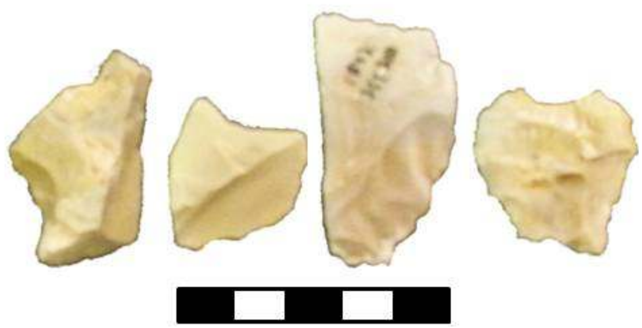


Figure 4.37: MAN AA. Scale in cm.

<u>MAN BB</u>: Example: HPL5 236, 162. Color is very pale orange (10YR 8/2) to pale yellowish orange (10YR 8/6).Some specimens exhibit few, moderately-sorted volcanic clasts. Texture is fine to medium. Luster is dull to medium. Translucency is low (<1.5 mm). Cortex is a medium coarse, yellowish gray (5Y 8/1) to very pale orange (10YR 8/2). Specimens do not exhibit a discernible ultraviolet fluorescent response.

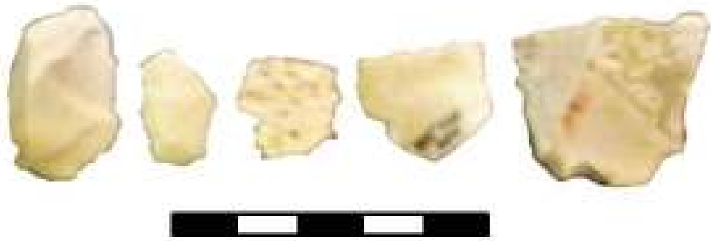


Figure 4.38: MAN BB. Scale in cm.

MAN CC: Example: HPL5 274, 110. Color is pale yellowish brown (10YR 6/2).Many specimens exhibit very pale orange (10YR 8/2) to grayish orange (10YR 7/4) banding, as well as moderately-sorted quartz clasts and circular crinoid ossicles. Texture is fine. Luster is medium. Translucency is 3-6 mm. Cortex is a coarse, very pale orange (10YR 8/2) to grayish orange (10YR 7/4) to yellowish gray (5Y 8/1). Fresh surfaces typically exhibit light green fluorescence under shortwave ultraviolet light. MAN MM may represent a variant of this analytical nodule.

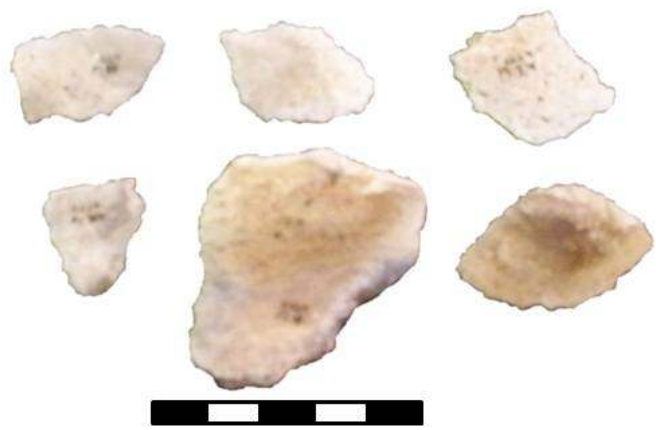


Figure 4.39: MAN CC. Scale in cm.

MAN DD: Example: CCL9 #14. This MAN is coarser, less translucent, and more homogeneous than MAN A. The primary color is light brown (5YR 5/6) to moderate brown (5YR 4/4). Some specimens exhibit well-sorted quartz clasts, as well as larger, isolated schist clasts. Texture is medium. Luster is medium to shiny. Translucency is 2-3 mm. Cortex is a coarse, very pale orange (10YR 8/2). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 4.40: MAN DD. Scale in cm.

<u>MAN EE</u>: Example: CCL9 #27. Primary color is brownish gray (5YR 4/1), though specimens also are pale yellowish brown (10YR 6/2). Specimens exhibit moderately-sorted quartz clasts and many also include circular crinoid ossicles. Texture is fine. Luster is shiny. Translucency is 6-9 mm. Cortex is fine, dark yellowish orange (10YR 6/6). Specimens do not exhibit a discernible ultraviolet fluorescent response. This MAN may grade into more translucent examples of MAN F.

Figure 4.41: MAN EE. Scale in cm.

<u>MAN FF</u>: Example: CCL9 #107. Specimens exhibit alternating bands of pale yellowish brown (10YR 6/2) and very pale orange (10YR 8/2). Texture is fine, luster is shiny. Many specimens exhibit well-sorted quartz and schist clasts. Translucency is 3-5 mm, exhibited especially on the lighter bands. Cortex is medium-coarse and very pale orange (10YR 8/2), suggestive of a white chert that outcrops south of Jakes Valley. Some specimens are slightly darker (dark yellowish brown, 10YR 4/2) with medium light gray (N6) bands, indicating that this analytical nodule may grade into MAN EE. Likewise, lighter specimens may also grade into MAN GG. Fresh surfaces typically exhibit light green fluorescence under shortwave ultraviolet light and orange fluorescence under longwave ultraviolet light.

Figure 4.42: MAN FF. Scale in cm.

MAN GG: Example: CCL9 #355. Color is typically grayish orange pink (5YR 7/2) and very pale orange (10YR 8/2) structured as wide bands, though some specimens represent only one of these colors. Specimens exhibit few moderately- to well-sorted quartz and feldspar clasts. Texture is fine. Luster is shiny. Translucency is 3-6 mm. Cortex is a medium coarse, grayish orange (10YR 7/4). Fresh surfaces typically exhibit light green fluorescence under shortwave ultraviolet light and orange fluorescence under longwave ultraviolet light. This analytical nodule may represent a sub-variety of MAN EE.

Figure 4.43: MAN GG. Scale in cm.

MAN HH: Examples: CCL9 # 385, #96. Color is light brown (5YR 5/6) to moderate brown (5YR 3/4), with some specimens exhibiting these colors as distinct bands. In banded specimens, the moderate brown bands are coarser than the light brown bands. Specimens also exhibit moderately-sorted quartz and feldspar clasts; in fact, these specimens may be better characterized as quartzites. Texture is medium to coarse. Luster is dull to medium. Translucency is low (1-2 mm). Specimens do not exhibit cortex. Light brown bands on fresh surfaces typically exhibit dark green fluorescence under shortwave ultraviolet light.

Figure 4.44: MAN HH. Scale in cm.

MAN II: Example: CCL9 #25. Primary color is grayish orange (10YR 7/4), though this varies within single flakes from very pale orange (10 YR 8/2) to dark yellowish orange (10 YR 6/6) to dark yellowish brown (10YR 4/2). A few flakes have moderate reddish brown (10R 4/6) to dark reddish brown (10R 3/4) streaks. Flakes often include moderately-sorted quartz clasts. Texture tends to be coarse. Luster is dull. Translucency is 2-4 mm. Specimens do not exhibit a discernible ultraviolet fluorescent response. The coloring of some specimens suggests heat-treating, which may indicate that this analytical nodule is a variant of MAN R.

Figure 4.45: MAN II. Scale in cm.

MAN JJ: Examples: CCL5 276, 264; CCL3 54, 104. Color is dark gray (N3). Some specimens exhibit moderately-sorted quartz clasts and/or medium gray (N5) streaks. A sub-variety (MAN JJ2) is greener (dark greenish gray, 5GY 4/1) with greenish gray (5GY 6/1) mottling. Both varieties have medium to fine texture and have dull luster. MAN JJ is more translucent (1-3 mm) than MAN JJ2 (0.5 mm). Only MAN JJ2 includes flakes with cortex, a coarse, pale olive (10Y 6/2). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 4.46: MAN JJ. Scale in cm.

MAN LL: Examples: CCL5 292, 200; CCL5 364, 288. Color is dark yellowish brown (10YR4/2) to dusky yellowish brown (10YR 2/2). Specimens typically exhibit well-sorted quartz and schist clasts, as well as dusky brown (5YR 2/2) spots. One specimen exhibits dark yellowish orange (10YR 6/6) banding. Texture is fine to medium. Luster is dull. Translucency is minimal (< 1 mm). Cortex is a coarse, dark yellowish orange (10YR 6/6). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 4.47: MAN LL. Scale in cm.

MAN MM: Example: LPL1 230, 220. Color is pale yellowish brown (10YR 6/2). Specimens exhibit poorly-sorted quartz clasts. Texture is medium to coarse. Luster is dull to medium. Translucency is 3 to 6 mm. Cortex is coarse, very pale orange (10YR 8/2). Fresh surfaces typically exhibit orange/red fluorescence under longwave ultraviolet light. This analytical nodule may grade into MAN CC.

Figure 4.48: MAN MM. Scale in cm.

MAN NN: Examples: HPL1 #67; HPL1 #69. Primary color is grayish orange (10YR 7/4). Specimens exhibit large, poorly-sorted quartz clasts and fewer, smaller feldspar and schist clasts, as well as streaks of light brown (5YR 6/4). Texture is medium. Luster is shiny. Translucency is 3-5 mm. Specimens do not exhibit a discernible ultraviolet fluorescent response. This analytical nodule is restricted to HPL1.

Figure 4.49: MAN NN. Scale in cm.

MAN QQ: Example: HPL1 #78. This analytical nodule is composed of flakes of petrified wood. Colors include very dark red (5R 2/6), light red (5R 6/6), pale yellowish orange (10YR 8/6), light brown (5YR 5/6), and pale yellowish brown (10YR 6/2). The banding that constitutes the woody structure is clearly visible in these specimens. Texture is fine, though one can feel the woody banding. Luster is medium (greasy) to shiny. Translucency is 2-6 mm; lighter colored sections are more translucent than darker colored sections. The cortex also clearly demonstrates the banded, woody structure, and includes very pale orange (10YR 8/2), dusky yellowish brown (10YR 2/2), and dark reddish brown (10R 3/4). Light banding on fresh surfaces typically exhibits bright green fluorescence under shortwave ultraviolet light.

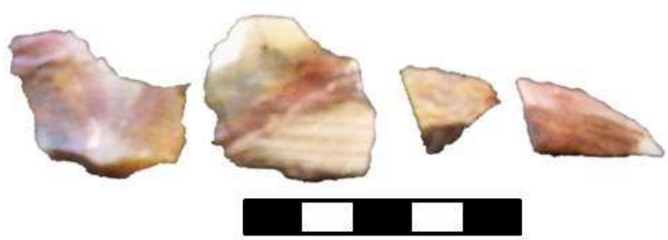


Figure 4.50: MAN QQ. Scale in cm.

Minimum Analytical Nodules and Chert Procurement

The analytical nodules defined in the previous section permit a variety of comparisons regarding the procurement and utilization of chert; in turn, these analyses help to contextualize FGV and obsidian technological and provenance analyses within a comprehensive understanding of Paleoarchaic technology. First of all, a simple comparison of the analytical nodules present within the Eastern Nevada Study Area may allow “chert procurement ranges” to be identified within the ranges defined by FGV and obsidian provenance.

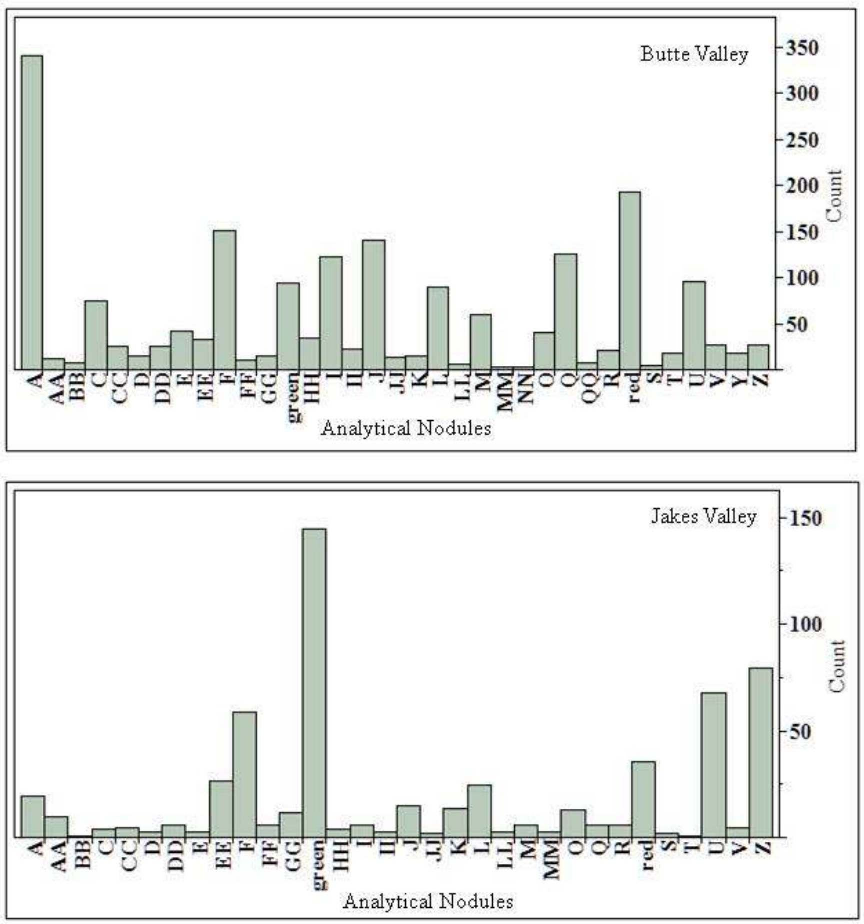


Figure 4.51: Abundance of MAN within the aggregated Butte Valley localities (top) and LPL1 in Jakes Valley (bottom).

Because of small sample sizes, I aggregated the Butte Valley assemblages for comparison with LPL1. This comparison demonstrates the prevalence of different analytical nodules within Butte and Jakes valleys. Consideration of a contingency table reveals that the Butte Valley assemblages include significantly more specimens of MANs A, C, I, J, and Q, and fewer specimens of MANs EE, U, Z, and the green analytical nodules (e.g., MAN G and H) than expected by chance; LPL1 in Jakes Valley includes significantly more specimens of MANs EE, GG, K, U, Z, and the green analytical nodules, and fewer specimens of MANs A, B, C, E, I, J, M, Q, and Y than expected by chance ($X^2 = 604.360$, $p < 0.0001$, df = 34). Even if many of the analytical nodules defined above do grade into each other, these data still indicate that at a gross level brown/orange (e.g., MANs A, I, Q) cherts are over-represented, and white/gray (e.g., MANs U and Z) and green (e.g., MANs G and H) cherts are under-represented within the Butte Valley assemblages. LPL1 exhibits the opposite composition. The differential distribution of these analytical nodules clearly suggests the operation of different "chert procurement ranges" within the Eastern Nevada Study Area. To give a more precise, though still hypothetical example, the only green chert source known within the study area, affectionately dubbed Long Valley "Jade" (referred to as "Sample Locality 21" in Chapter 5), occurs in an ash flow unit located a little northwest of the CSS FGV source (Figure 4.8) in southern Long Valley. Although the Paleoarchaic inhabitants of Butte Valley did utilize green chert, it is much more abundant at LPL1 (Figure 4.51). These data, then, may indicate two slightly overlapping, yet distinct ranges of chert procurement operating within the areas defined by FGV and obsidian provenance. Interestingly, Steward (1938:254; also Shackely 2002:62) notes that the overlapping of territories served to promote information and food sharing, thereby alleviating subsistence stress.

The logic previously used to compare obsidian, FGVs, and chert may be used for further inter-valley comparisons of these analytical nodules. If we suppose that large analytical nodules (i.e., chert subgroups that include many artifacts) within Butte Valley derive from chert sources closer to this valley (after Larson 1994), then I expect those nodules to include more evidence of earlier stages of reduction than their smaller counterparts (i.e., chert subgroups that include few artifacts) in Jakes Valley. The same expectation should hold for large analytical nodules in Jakes Valley. For example, I expect more cortical flakes within MAN A in Butte Valley than within MAN A in Jakes Valley. Table 4.12 indicates that this expectation is met in several cases in Butte Valley. Although this expectation is not met for the Jakes Valley analytical nodules, the fact that it is even close for some of these analytical nodules is striking when we note the low number of cortical flakes within the Jakes Valley MANA sample (n = 32) compared to the Butte Valley MANA sample (n = 165).

Table 4.12: Comparison of the percentage (number) of cortical flakes present within abundant analytical nodules between lithic assemblages in Butte and Jakes valleys.

MAN	More Cortical Flakes Expected to Occur in:	% (n) of Cortical Flakes in Butte Valley	% (n) of Cortical Flakes in Jakes Valley
A	Butte Valley	7.92 (27)	5.00 (1)
C	Butte Valley	12.00 (9)	25.00 (1)
I	Butte Valley	8.06 (10)	16.67 (1)
J	Butte Valley	5.67 (8)	0
Q	Butte Valley	10.32 (13)	0
B (red)	Butte Valley	5.18 (10)	2.78 (1)
E	Butte Valley	11.9 (5)	0
M	Butte Valley	8.33 (5)	0
K	Jakes Valley	6.25 (1)	0
U	Jakes Valley	5.21 (7)	0
Z	Jakes Valley	22.22 (5)	8.75 (7)
EE	Jakes Valley	18.18 (6)	2
GG	Jakes Valley	12.50 (2)	8.33 (1)
Green cherts	Jakes Valley	10.53 (10)	9.66 (14)

Yet, I also suggested that some high-quality cherts may be derived from distant sources, much as obsidian. MANA may allow this possibility to be assessed as well (e.g., Knell 2007; Larson 1994). If large analytical nodules are associated with initial core reduction and tool production, which presumably occurs closer to a toolstone source, then these nodules should include more evidence of early stages of reduction (e.g., larger flakes, more cortex). Alternatively, if small analytical nodules are associated with subsequent tool resharpening, which presumably occurs farther from a toolstone source, then these nodules should include more evidence of later stages of reduction (e.g., smaller flakes, less cortex). As noted earlier, the MANA sample includes a low number of cortical flakes; nevertheless, 82.04% of the cortical flakes in Butte Valley and 90.63% of the cortical flakes in Jakes Valley are associated with large analytical nodules.

The weight data do not behave as expected, however. In both Butte and Jakes valleys, small analytical nodules often include BRFs that weigh, on average, more than BRFs contained within large analytical nodules (Table 4.13). A closer examination of mean BRF weight by analytical nodule demonstrates that this pattern results, at least in part, from several small analytical nodules which include BRFs that are markedly larger than the average BRFs for large and small analytical nodules (Table 4.14).

Table 4.13: Mean BRF weight (g) for large and small analytical nodules within the aggregated Butte Valley localities and LPL1 in Jakes Valley. FGV and obsidian are included for comparison.

Valley	Large Nodules	Small Nodules	FGV	Obsidian
Butte	1.67	3.77	2.20	0.64
Jakes	2.71	4.02	1.99	2.71

Table 4.14: Examples of small analytical nodules with large constituents.

Valley	Analytical Nodule	Average Weight (g)	n
Butte	EE	7.02	5
	FF	8.40	4
	GG	6.25	2
	HH	7.53	12
	II	3.83	5
	LL	5.00	3
	T	7.58	3
Jakes	GG	12.64	1
	R	10.65	1
	S	4.29	1

Actually, this finding may not be particularly surprising if we remember that many of the chert unifaces and flake tools were manufactured from BRFs, even though only a few late-stage chert bifaces occur within these assemblages (Beck and Jones 1990a, 1990b). In this case, perhaps the large analytical nodules relate to the late-stage reduction, production, and maintenance of chert unifaces, while at least some small analytical nodules relate to the field-processing (i.e., early-stage reduction) of locally procured chert that was then transported elsewhere. Accordingly, I would expect unifaces to fall within the large analytical nodules, while the small analytical nodules may not subsume any formal chert tools. This expectation will be evaluated after Charlotte Beck's initial analysis of the unifaces is complete.

A more fruitful pursuit than this gross comparison of large and small analytical nodules may be to look at the size distribution of the BRFs within each analytical nodule. This distribution may provide a better indication of the reduction stages represented by each analytical nodule and, through a comparison with the size distribution of FGV and obsidian BRFs, may also provide some clues as to the distances over which these analytical nodules were transported. Figure 4.52 provides examples of the BRF size distributions represented by the chert analytical nodules present in the Eastern Nevada Study Area. Several analytical nodules (MAN E, EE, HH, II, K, R, Q, and V) exhibit a size distribution suggesting earlier stages of reduction than those exhibited by FGVs; therefore, these analytical nodules may represent the chert sources that occur closest to the assemblages within the Eastern Nevada Study Area.

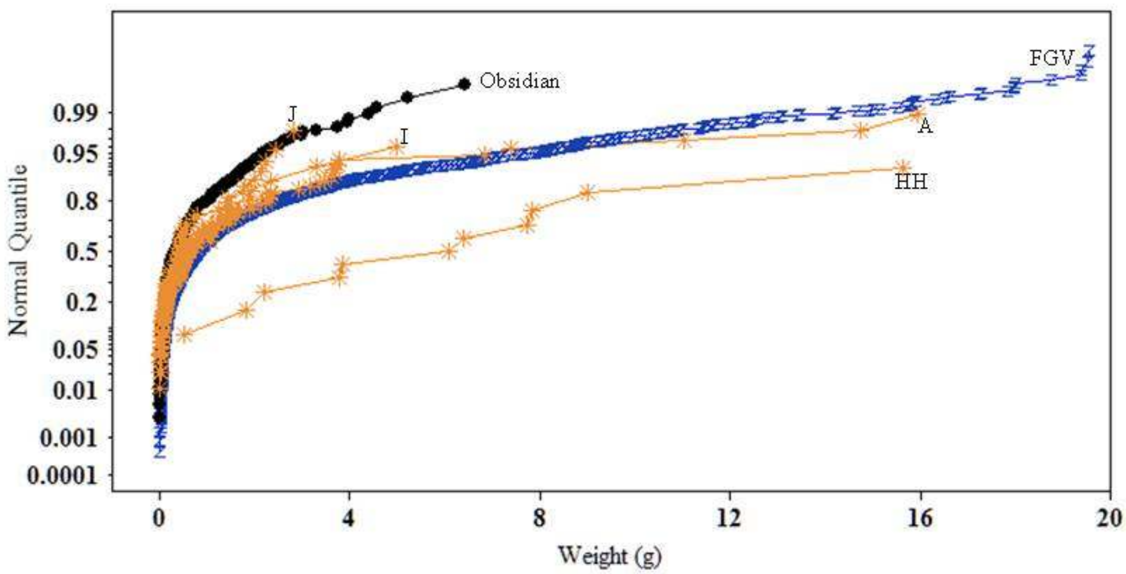


Figure 4.52: BRF size (weight) distributions of chert analytical nodules compared to FGVs and obsidian, excluding specimens weighing more than 20 g (which is why the curves do not all go to 1). To avoid cluttering the quantile plot, only a few analytical nodules that exemplify the variability within the chert sub-assemblages are depicted here. Also note that not all chert analytical nodules contain enough members for meaningful depiction in this way.

Several more analytical nodules (MAN A, AA, C, CC, D, DD, F, JJ, M, U, Z, red, and green) exhibit BRF size distributions similar to FGVs, which may suggest that some of these analytical nodules derive from sources that are a similar distance away from the study area as FGV sources (i.e., often 60-80 km, Figure 4.8). Analytical nodules I and L exhibit a BRF size distribution profile between FGVs and obsidian, which may point to a source located at a distance between FGV and obsidian sources. Finally, analytical nodules D, J, and O exhibit a size distribution comparable to obsidian, which may suggest a source at distances similar to those known for obsidian (i.e., as great as 200-250 km). Again, these suppositions are guided by the simple expectation that early-stage reduction will occur closer to a toolstone source than late-stage reduction, especially given concerns regarding transport. While suggestive, these inferences certainly require further evaluation using additional technological analyses, as well as source provenance analysis.

To this end, one last comparison between analytical nodules within Butte and Jakes valleys may suggest the direction from which some of these analytical nodules originate and, therefore, the direction in which to look in order to find the chert sources. As one example, the BRF size distribution depicted in Figure 4.53 indicates that the specimens that comprise analytical nodule Z in Butte Valley represent earlier stages of reduction than the specimens that comprise analytical nodule Z in Jakes Valley, consistent with the cortical flake comparison presented earlier. This pattern may point to a source for analytical nodule Z that is north of Jakes Valley and nearer to the Butte Valley assemblages, despite the numerical abundance of analytical nodule Z in Jakes Valley. Similarly, the BRF size distributions of analytical nodules AA and U suggest earlier stages of reduction occurred in Jakes Valley than in Butte Valley, which may point to a chert source nearer to LPL1 than to the Butte Valley assemblages.

In sum, MANA suggests the possibility of distinguishing chert procurement ranges which may fill-in and/or cross-cut zones defined by FGV and obsidian provenance. Because many of these analytical nodules exhibit BRF size distributions suggesting comparable or earlier stages of reduction to FGVs, it may be that these chert procurement ranges reflect small-scale processes (e.g., seasonally variable foraging radii) within a multi-tiered model of Paleoarchaic adaptation. Yet some analytical nodules exhibit BRF size distributions that suggest later stages of reduction than FGVs, with a few approximating the BRF size distribution of obsidian. These distributions may indicate the procurement and circulation of high-quality, nonlocal chert, much as seen in

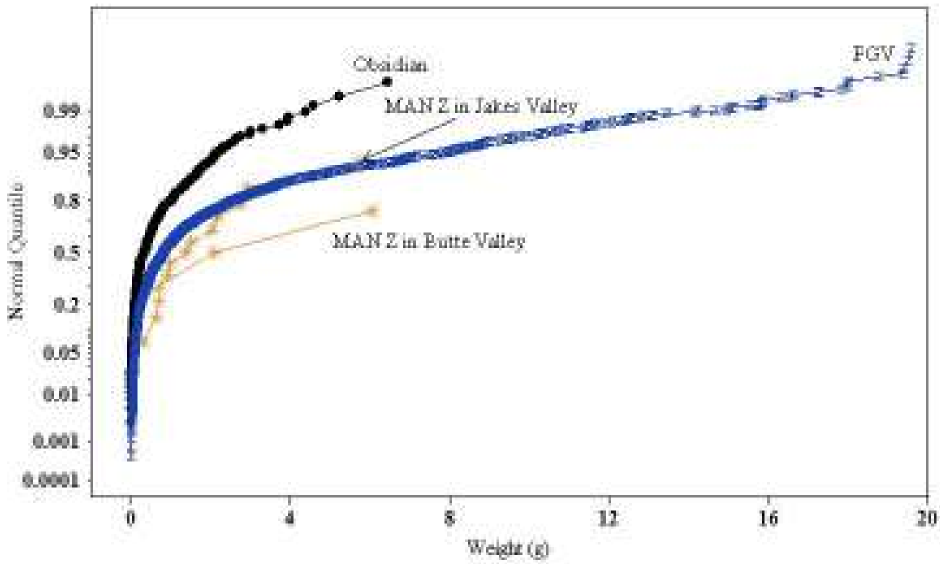


Figure 4.53: BRF size distribution comparing analytical nodule Z from Butte Valley to analytical nodule Z from Jakes Valley, with FGV and obsidian included for comparison. Specimens weighing more than 20 g have been excluded (which is why the curves do not all go to 1).

other Paleoindian sites. If high-quality chert was transported into and through these Paleoarchaic localities, then the preferential utilization of nonlocal obsidian for projectile points may reflect more than strictly functional and/or economic motives. Again, these observations suggest, albeit indirectly, that the processes responsible for introducing nonlocal obsidian (and, perhaps, high-quality chert) into east-central Nevada may include non-utilitarian mobility and/or exchange.

A Brief Word on Occupation Span and Mobility

In the preceding pages, I have presented a series of comparisons in support of a multi-tiered model of Paleoarchaic mobility and intergroup interaction in east-central Nevada; however, I have not weighed in on the question that prompted this research: at a general level, do these assemblages reflect residentially mobile hunter-gatherers (after Jones et al. 2003) or semi-sedentary hunter-gatherers (after Madsen 2007)? Given the preceding analyses and the model advanced here, this question may seem out of place. Yet I do not think that a general characterization of Paleoarchaic mobility need be opposed to a more specific treatment of the mobility of particular Paleoarchaic subgroups. Rather, my concern is not to collapse onto one dimension the variable processes that the preceding analyses, as well as hunter-gatherer ethnography, suggest contributed to the Paleoarchaic record in east-central Nevada. With that in mind, I briefly consider a number of measures that lithic analysts suggest may differentiate short- and long-term occupations and, in turn, reflect varying degrees of mobility (e.g., Duke and Young 2007:Table 7.2; Kelly 2001:Table 4-2; Kuhn 1995; Surovell 2008). Many of the expectations considered here result from the distinction between the provisioning of individuals (e.g., the development and maintenance of a mobile toolkit that is replenished as needed during movement from one place to another) and the provisioning of places (e.g., the stockpiling of tools and toolstone at residential bases; Kuhn 1995:Figures 2.1, 2.2), but these differences are not immutable (e.g., Birmingham 1985; Chatters 1987:346, 368; Fletcher 1990; Hayden 1978; Kelly 1992; Kuhn 1990, 1995; O'Connell et al. 1991; Price 1978).

David Hurst Thomas (1988:381; also see Chatters 1987; Cowan 1999; Estes 2009; Kuhn 1995; Surovell 2008; Thacker 2006; Veth 2005, 2006) suggests that a comparison of the statistical relationship between assemblage size (total artifact count per site) and assemblage richness (the number of artifact categories represented within an assemblage) may be used to distinguish different site types. Within a given system, long-term occupations (e.g., residential base camps) will be used for a wider range of activities, producing debris related to various activities. As a result, assemblage diversity will increase rapidly in relation to assemblage size, generating a steep slope. At the other end of the spectrum, short-term occupations (e.g., the locus of diurnal activities) may be used fairly redundantly, producing the same types of debris. As a result, assemblage diversity increases slowly with increasing assemblage size, generating a flat slope. Logistical camps will describe an intermediate profile, as assemblage diversity increases moderately with increasing assemblage size (Thomas 1988:Figure 144). Using these relationships I expect that if the Eastern Nevada Study Area was exploited through short-term occupations within a system of high residential or logistical mobility, the sizes and diversities of these assemblages should be characterized by a regression line of low slope. If the Eastern Nevada Study Area was exploited through long-term occupations within a system of low residential mobility or sedentism, the sizes and diversities of these assemblages should be characterized by a regression line of steep slope.

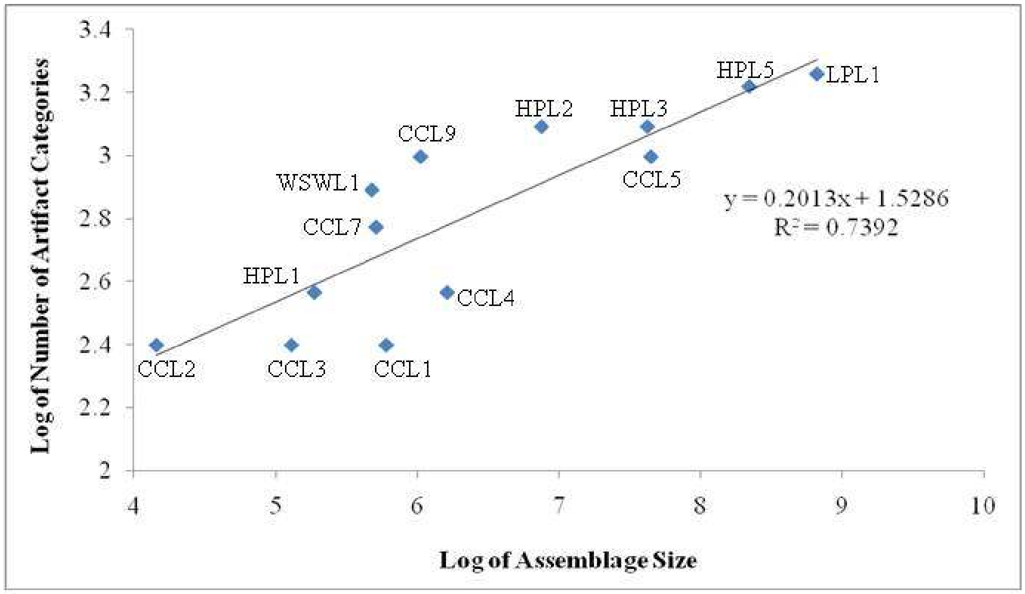


Figure 4.54: Size/diversity regression for the Eastern Nevada Study Area localities.

The relationship between assemblage size and diversity (Figure 4.54) is found to be log-linear (after Jones et al. 1983; Thomas 1983a:Figure 218), with a correlation coefficient of r = 0.86 (comparable to Thomas 1983a:Figure 220). Interpretation of this regression in terms of occupation duration is rendered difficult, however (Kelly 2001:76; also see Estes 2009:189; Sullivan and Tolonen 1998). First, any comparison of these localities on the basis of the size/diversity relationship rests on the premise that "all other factors" (e.g., deflation, collection by avocational archaeologists) have been equal, which may seem unlikely for surface lithic assemblages. Yet if avocational collecting, for example, compromised these assemblages, we might expect projectile points and bifaces to be under-represented (e.g., Kelly 1983b); in fact, we find that obsidian and FGV projectile points and bifaces are over-represented in the Eastern Nevada Study Area assemblages, in at least partial answer to the "all other factors have been equal" qualifier. Second and more significant, the predictions generated to differentiate occupation duration, though seemingly sound in theory, lack a standard for their evaluation (Kelly 2001); for example, how "steep" is a steep slope? In other words, the differences between occupation durations in relation to assemblage size/diversity (as is also the case for the other measures considered below) is relative, rendering comparisons between assemblages meaningful for differentiating sites only *within a given system* (Thomas 1988:381, emphasis in original). Previous analyses of the Eastern Nevada Study Area have suggested that larger sites may be habitation or long-term extraction sites (e.g., Beck and Jones 1990b:238; Kessler et al. 2009:157), but there is no independent indicator of site type within the study area that may guide this distinction. Moreover, some "obvious" indicators of occupation duration contradict each other. For example, if we suppose that assemblages containing the most artifacts represent longer-term occupations, then LPL1, HPL3, HPL5, and CCL5 may indeed represent long-term occupations. Yet if we suppose that clear spatial patterning indicates short-term occupation, given the tendency for the boundaries of activity areas and/or features to blur over time (Chatters 1987:346), then these same sites may represent short-term occupations (see Figure 4.2).

Table 4.15: Regression of various artifact categories by assemblage size for the entire Eastern Nevada Study Area and for just the Butte Valley localities.

	All assemblages		**Butte Valley assemblages only**	
Linear Regression	r^2	**r**	r^2	**r**
Size/Total Tools	0.9205	0.96	0.8706	0.93
Size/Formal Tools	0.9159	0.96	0.9114	0.95
Size/Informal Tools	0.9092	0.95	0.7325	0.86
Size/Debitage	0.9994	1.0	0.9996	1.0
Size/Bifaces	0.8783	0.94	0.8288	0.91
Size/Projectile Points	0.9263	0.96	0.8057	0.9
Size/Unifaces	0.9225	0.96	0.829	0.91
Size/Interior Flakes	0.9981	1	0.9947	1
Size/Cortical Flakes	0.7263	0.85	0.7086	0.84
Size/Biface Reduction Flakes	0.9738	0.99	0.9496	0.97
Size/Core Reduction Flakes	0.7342	0.86	0.2363	0.49
Size/Total Obsidian	0.576	0.76	0.8049	0.9
Size/Total FGV	0.9077	0.95	0.7024	0.84
Size/Chert	0.8917	0.94	0.7819	0.88

As it turns out, many artifact categories are highly correlated with assemblage size within the study area (Table 4.15). These correlations remain intact even when I exclude LPL1, which outnumbers the next largest assemblage (HPL5) by almost 2500 artifacts (see Table 4.1). While these correlations indicate that much of the inter-assemblage variability in the absolute abundance of particular artifact types is attributable to assemblage size (often > 80%), the consistently strong relationship between these artifact categories and assemblage size suggests that inter-assemblage variability in the relative abundance of particular artifact types (and the ratios calculated from them) may reflect real differences. Yet these differences may best be understood as variability *within the same site type*, rather than indicative of different site types. Thus, the low slope (0.2013) exhibited by the size/diversity regression may indicate that all of the localities within the Eastern Nevada Study Area represent the same part of a subsistence-settlement system characterized by high mobility. In fact, the localities within the Eastern Nevada Study Area exhibit low richness in comparison to many other early Great Basin sites (Beck and Jones 1990b:255), as expected for short-term occupations associated with high residential mobility.

To add to this characterization, several lithic analysts have also suggested that expedient artifacts are usually associated with longer-term occupations (Kelly and Parry 1987) and the provisioning of places rather than individuals (Kuhn 1995). As stated above, short-term occupations tend to yield relatively large numbers of tools carried by individuals, while places occupied for longer periods of time tend to permit a more expeditious use of tools because those sites are more likely to be provisioned with toolstone. Following from this distinction, I expect short-term occupations to include: (a) a higher ratio of tools to debitage; (b) a higher ratio of formal to informal tools; (c) a higher ratio of bifaces to total tools; (d) a higher ratio of bifaces to (non-biface reduction) flake tools; more evidence of bifaces used as cores, such as (e) a higher ratio of biface reduction flakes (BRF) to total flakes (excluding flakes without platforms) and (f) a higher ratio of utilized BRF to total utilized flakes; and (g) a lower ratio of utilized flakes to total debitage than long-term occupations (e.g., Elston 1990; Estes 2009; Kelly 1988, 2001:Table 4-2; though see Henry 1989).

While it bears repeating that caveats abound and there are few (no?) hard and fast rules governing where to draw these distinctions (e.g., Kelly 2001:76), the data presented in Table 4.16 suggest short-term occupations in accordance with high residential or logistical mobility. For example, BRFs constitute a large proportion of total flakes in most of these assemblages, consistent with the inclusion of bifaces in the mobile toolkit for use as tools and cores (Kelly 1988). Additionally, the ratio of utilized BRFs to total utilized flakes for most of these assemblages falls within a range that Kelly (1988:Table 7) associates with short-term occupation of the Carson Sink within a system of high residential or logistical mobility. Indeed, many of the measures traditionally utilized to

Table 4.16: Measures indicative of occupation duration.

Locality	Tool/ Debitage	Formal/ Informal Tools	Bifaces/ Total Tools	Bifaces/ Flake Tools	BRF/ Total Flakes	Utilized BRF/Total Utilized Flakes	Utilized Flakes/ Total Debitage
CCL1	0.31	0.23	0.12	0.20	0.79	0.23	0.25
CCL2	0.42	4.00	0.45	2.25	0.63	0.00	0.08
CCL3	0.52	0.44	0.19	0.37	0.79	0.23	0.36
CCL4	0.09	0.45	0.09	0.18	0.78	0.29	0.06
CCL5	0.12	0.56	0.15	0.34	0.81	0.32	0.08
CCL7	0.32	0.31	0.09	0.12	0.32	0.03	0.24
CCL9	0.31	1.12	0.12	0.28	0.47	0.10	0.14
WSWL1	0.18	0.69	0.20	0.45	0.55	0.24	0.11
HPL1	0.25	1.63	0.43	1.36	0.64	0.19	0.10
HPL2	0.23	0.74	0.28	0.48	0.47	0.14	0.13
HPL3	0.11	1.10	0.22	0.64	0.88	0.30	0.05
HPL5	0.12	0.96	0.23	0.68	0.87	0.25	0.06
Butte Valley Total	*0.15*	*0.76*	*0.20*	*0.46*	*0.77*	*0.23*	*0.09*
LPL1	0.20	0.97	0.27	0.68	0.81	0.22	0.10
Total	*0.17*	*0.84*	*0.23*	*0.55*	*0.79*	*0.23*	*0.09*

assess the degree of mobility emphasize the use of formal tools, especially bifaces, by highly mobile peoples (e.g., Cowan 1999; Kelly 1988; Parry and Kelly 1987). Finally, the proportion of bifaces and formal tools within these assemblages falls within a range that, in other contexts, is attributed to “relatively mobile residential camps” (e.g., Cowan 1999:598). It is worth noting, however, that the measures presented in Table 4.16 do not fully capture the pervasiveness of bifacial technology within these assemblages. For example, recall that many of the informal tools (e.g., flake tools) also derive from bifaces (i.e., they were made on biface reduction flakes). Here, then, is another reason to be careful in the uncritical application of these indices to questions of occupation span and mobility. Even so, and despite the variability exhibited by some of these measures, as a whole these data may be consistent with short-term occupations associated with highly mobile hunter-gatherers.

Two other indicators of occupation span warrant attention. First, if bipolar reduction serves as a solution to a shortage of toolstone, then evidence of bipolar reduction should be rare in assemblages associated with high residential or logistical mobility, and more common in assemblages associated with low residential mobility or sedentism, although there is some room for equivocation here (Elston 1990; Eren 2010; Kelly 2001). Highly mobile hunter-gatherers would presumably encounter sufficient toolstone sources in their travels to have enough toolstone with them in order to meet their needs without recourse to bipolar reduction. Bipolar reduction may be more common at camps where people have stayed longer than intended and/or used more toolstone than anticipated. Bipolar reduction may become less common at sites occupied for an extended period of time, as it becomes increasingly worthwhile to provision that place (Kuhn 1995) with toolstone procured from a quarry or other sources. The Eastern Nevada Study Area assemblages include a total of 46 split pebbles (i.e., a core or core fragment produced by bipolar reduction; Crabtree 1972), constituting 6.6% of total cores (counting bifaces as cores, n = 701) and 0.25% of the total assemblage. Although the paucity of bipolar reduction could be read to support high or low residential mobility, Beck and Jones (1990b:240) suggest that the pertinent variable is actually package size; that is, the small nodules (< 5 cm diameter) available at the local Butte Mountain source encouraged manipulation by bipolar reduction. The use of bipolar reduction only when demanded by the material at-hand suggests that the general lack of bipolar reduction in the Eastern Nevada Study Area indicates high residential mobility.

Second, Kelly (1985:234-236, 2001) suggests that fire-cracked rock, representative of the time-consuming, low-return-rate pit baking of various roots gathered around Stillwater Marsh, would indicate low residential mobility and/or sedentism. The Eastern Nevada Study Area localities contain no fire-cracked rock. Indeed, there is no evidence of features or permanent structures associated with these assemblages (also see Estes 2009:259).

Although some of these measures are less easily interpreted than others, together they may support a view of Paleoarchaic groups practicing high residential mobility geared toward wetland and other shallow-water resources (after Jones et al. 2003). Yet this does not imply that the annual or territorial range utilized by the Paleoarchaic inhabitants of east-central Nevada included the entirety of the eastern OCZ. Additionally, I would repeat that characterizing these assemblages using the size/diversity regression and the other measures presented in Table 4.16 collapses onto one dimension the variability the other analyses presented here amply document. For example, what does the proportion of bifaces to total tools really reflect when many of the unifacial and flake tools are manufactured from biface reduction flakes? Especially in assemblages similar to those considered here, where toolstone types are utilized for different tools, it may be more informative to consider the variability manifested within these assemblages. Consideration of this variability leads to a view of Paleoarchaic adaptation that includes different levels of mobility and modes of resource acquisition, perhaps in association with different subgroups performing different tasks using different tools.

Conclusion

The analyses presented here suggest that we move beyond a general characterization of Paleoarchaic technological organization and mobility to consider the variability present within Paleoarchaic lithic assemblages. The Eastern Nevada Study Area assemblages clearly demonstrate the utilization of different toolstone for different tools, perhaps in association with Paleoarchaic subgroups performing different tasks and utilizing different spheres of mobility, though determining what behavioral processes the zones defined by the provenance of these toolstone types reflect requires further evaluation. Nevertheless, the MANA indicates the operation of distinct chert procurement ranges that may operate within and/or cross-cut the zones defined on the basis of FGV and obsidian provenance. If we suppose that many of these cherts derive from local sources, as suggested by the BRF size distributions, then the ranges defined by these local cherts may represent small-scale landscape units (e.g., foraging radii, logistical radii, and/or annual ranges). Yet many cherts exhibit BRF size distributions comparable to FGVs, which may suggest that these cherts derive from 60-80 km away. The zones defined by the provenance of these toolstone types may represent intermediate-scale landscape units (e.g., longer logistical forays, annual ranges, territorial ranges). Finally, a few cherts exhibit BRF size distributions comparable to obsidian, which may suggest that these cherts derive from sources that are upwards of 200 km away. The zones defined by the provenance of these toolstone types may reflect large-scale landscape units (e.g., social and informational networks). I have also suggested that obsidian may not be the best toolstone available to Paleoarchaic peoples for the manufacture of stemmed projectile points. As such, we might entertain a "non-utilitarian" motive for the preferential utilization of (often) nonlocal obsidian for Paleoarchaic projectile points. Again, I do not wish to promote a new dichotomy here. None of these social and ideological processes negate the use of obsidian for functional purposes and these social forays, by necessity, include subsistence pursuits. What changes is the primary motivation for these long-distance forays and, in the Paleoarchaic context, what the scale of OCZs actually reflects in terms of human behavior.

Ultimately, the partitioning of lithic assemblages in this way should allow archaeologists to go beyond a unitary treatment of subsistence-settlement strategy. By focusing on subsets of lithic assemblages related to different technologies, activities, modes of resource acquisition, spheres of mobility, and perhaps subgroups, we may uncover the combination of tactics that together constitute a group's overall adaptive strategy (e.g., Chatters 1987). While we will surely continue to quibble over the appropriate partitioning of these assemblages and what social groups and behavioral processes they reflect, such an approach to lithic analysis at least has the potential to capture the inter- and intra-group variability manifest amongst ethnographically-known hunter-gatherers. As such, we may yet be able to squeeze some more of the dynamism of daily life out of the stone tools and detritus we so often find scattered across the landscape. For present purposes, our ability to test propositions relating chert sub-assemblages to distinct spheres of mobility and/or intergroup interaction will be significantly enhanced if we can distinguish, and therefore source, macroscopically-similar cherts in the Great Basin; I turn to this question in Chapter 5.

Chapter 5: The Lithic Landscape of the Eastern Nevada Study Area

Studies of toolstone procurement, mobility, and exchange in the Great Basin have generated an extensive database of obsidian geochemistry and provenance over the last 25 years or so, and, more recently, provenance analyses have been successfully extended to other toolstone types (e.g., Jones et al. 1997) and, using isotope and trace-metal analyses, even textiles (Benson et al. 2006). Nevertheless, our current knowledge of chert provenance, with a few notable exceptions (e.g., Lyons 2001; Lyons et al. 2003), remains poor, especially in comparison to our knowledge of obsidian and fine-grained volcanics (FGVs, e.g. andesite and dacite) (Amick 1999). Given the predominance of chert in many Paleoarchaic lithic assemblages, as well as the importance of toolstone availability and accessibility in understanding lithic technological organization (see Chapter 4), this deficit is significant. Furthermore, the pronounced toolstone selection patterns documented for many Paleoarchaic lithic assemblages suggests the study of chert provenance holds the potential to elucidate different scales of mobility and modes of toolstone acquisition than those documented by obsidian or FGVs.

As I discussed in Chapter 3, obsidian provenance defines Paleoarchaic ranges that are far larger than the ranges used by modern hunter-gatherers in pursuit of subsistence, regardless of habitat. Accordingly, I explored the possibility that obsidian conveyance zones (OCZs) may reflect procurement through non-utilitarian mobility and/or exchange. In order to sort out these alternatives, obsidian procurement and distribution must be contextualized within a fuller understanding of the lithic landscape (i.e., the natural distribution of accessible and potentially knappable lithic raw materials; Blanton 1985). Contextualization begins by evaluating toolstone exploitation practices within the geographical distribution of available lithic resources, including local and nonlocal materials (Thacker 2006). In other words, robust modeling of Paleoarchaic toolstone procurement, mobility, and exchange requires a comprehensive understanding of the lithic landscape, which, in east-central Nevada at least, must include FGVs and chert in addition to obsidian. Establishing the nature of the lithic landscape provides a baseline against which patterns of realized procurement and distribution can be evaluated (e.g., Blanton 1985; Hoard et al. 1993). For example, if abundant, tool-quality chert and FGV sources are available close at hand, then a *utilitarian* explanation for the procurement and transport of nonlocal obsidian may prove unnecessary (for a similar argument see Bamforth 2006:523; Shackley 2002:70), especially within paleoenvironmental contexts (i.e., rich wetland and adjacent steppe) that may have promoted residential and/or logistical mobility over smaller areas than those defined by the distribution of obsidian. Alternatively, a lack of tool-quality chert and FGV sources close at hand may suggest that Paleoarchaic groups were either required to travel long distances and/or engage in exchange to procure high-quality toolstone (for a similar argument regarding obsidian transport in southeastern Utah, see Nelson 1984). While other alternatives are possible, the point is simple: since the Paleoarchaic record consists primarily of surface lithic assemblages, our understanding of Paleoarchaic mobility and toolstone procurement is intimately connected to our understanding of the complete Paleoarchaic lithic landscape.

With that in mind, this chapter presents the geological context, data, and analyses pertinent to building a database of chert sources in east-central Nevada, as a complement to the provenance analyses of obsidian and FGVs that George T. Jones and colleagues (1997, 2003) have previously conducted in the Eastern Nevada Study Area. My goal here is modest: while I cannot solve the riddle of Paleoarchaic mobility and toolstone procurement for the entire Great Basin with the limited sample considered here, I hope to demonstrate the feasibility of chert sourcing and its potential contribution to Great Basin archaeology. In combination with the analyses presented in Chapter 4, and bolstered by future work, this approach may allow the evaluation of current models of Paleoarchaic subsistence-settlement strategies, lithic technological organization, and intergroup interaction, ultimately building toward a multi-tiered model of Paleoarchaic adaptation.

Geological Setting

As discussed briefly in Chapter 2, the physiographic Great Basin is defined by a distinctive basin-and-range topography attributable to extensional forces which began at least as early as the Oligocene (e.g., Coney and Harms 1984; Effimofff and Pinezich

1981; Morrison 1965; Price 2004; Stewart 1980a; Zoback et al. 1981). Volcanism associated with Quaternary block faulting extruded basaltic and andesitic flows over wide areas, especially in the northwestern Great Basin. Volcanic deposits containing obsidian are generally younger than 15 million years old and tend to occur along the perimeter of the Great Basin, especially to the north and west (Stewart 1980b). In the central Great Basin, including the Eastern Nevada Study Area, volcanism tends to be greater than 30 million years old and obsidian, if present at all, typically occurs as small nodules or pebbles (Jones et al. 2003; Stewart 1980b). For the Eastern Nevada Study Area, the anthropological significance of the geological occurrence of obsidian is simple: except for a pebble source found as lag on alluvial fans emanating from Butte Mountain into Butte Valley (Beck and Jones 1990a; Jones et al. 2003), obsidian is not readily available in the study area. Instead, FGVs and chert (i.e., "fine-grained siliceous sedimentary rock of biogenic, biochemical or chemogenic origin;" Stow 2003:184) are the toolstone types that occur within the study area. As depicted in Figure 4.8, several FGV sources have been identified in the Eastern Nevada Study Area. These FGV sources occur in extrusive lavas that range between andesite and rhyolite, and are related primarily to middle Tertiary volcanism associated with crustal extension (Jones et al. 1997).

Despite the abundance of FGV artifacts within the lithic assemblages in the Eastern Nevada Study Area, the region is dominated by sedimentary rocks of Cambrian to Carboniferous age. From late Precambrian at least until Early Triassic time, east-central Nevada was part of the Cordilleran miogeosyncline, during which 30,000-40,000 feet of strata were deposited (Hose and Blake 1976; Kleinhampl and Ziony 1985). At most places within White Pine and northern Nye counties, within which sample localities from around Butte, Jakes, Long, and Railroad valleys are located (Figure 5.1), Paleozoic limestone, shale, and dolomite units either maintain fairly uniform character or exhibit gradual changes in lithology and thickness. In Lincoln County, within which sample localities from in and around Coal Valley are located (Figure 5.1), Paleozoic units decrease in thickness from the western to the southeast corner of the county due in large part to a seven-fold decrease in the Cambrian section (Tschanz and Pampeyan 1970). Seven Paleozoic units (including all of the Silurian units) mapped west of a northeast-striking hinge line near Meadow Valley Wash are absent in eastern Lincoln County.

Paleozoic limestone, shale, and dolomite units are still abundant in the ranges bounding Coal Valley, although the formations are sometimes different or, at least, named differently than the units in White Pine and northern Nye counties. Cherts, quartzites, silty limestones, siltstones, and silicified dolomites occur as beds within most of these Paleozoic units; thus, survey and sampling of chert-bearing geological formations focused on these units.

Figure 5.1: Relief map showing the relationship between the valleys within which occur the Paleoarchaic localities I discuss in this chapter.

Charlotte Beck and George T. Jones (1990a, 1990b) previously recorded four chert quarries within the Eastern Nevada Study Area, referred to here as Sample Localities 1, 20, 21, and 24. On the basis of macroscopic properties, they suggested that chert from these sources is rare in the Butte Valley Paleoarchaic localities, despite the fact that the majority of the chert artifacts from late Archaic sites in the area derives from Sample Locality 20. According to Beck and Jones (1990b:239), the most common chert in the Butte Valley lithic assemblages is a highly-uniform, orange-red material (possibly heat-treated) that they suggested may derive from an as yet unknown source area in the Butte Mountains just south of Pony Springs.

Sample Design and Methodology

Although this sentiment is rarely made explicit, it seems to me that the default expectation amongst many Great Basinists is that most chert was procured locally for expedient use. As I have suggested in earlier chapters, Great Basinists often conduct extensive technological and provenance analyses of obsidian and FGVs, while chert is treated much more casually. Many a Great Basin site report suggests that the chert artifacts must have been procured from a local source, only to state a few pages later that the chert source could not be located. Such a treatment gives the impression that tool-quality chert occurs abundantly across the landscape and, as such, has little bearing on lithic technological organization. An inability to find these local chert sources, however, may be leading us to inappropriate conclusions about the role of chert in Paleoarchaic mobility and technological strategies.

Obviously, surveying and sampling the chert-bearing geological formations throughout east-central Nevada would require more resources than are at my disposal. Yet by focusing my survey and sampling strategy on a local scale, I am able to (1) assess the validity of this default expectation—does a ubiquity of chert-bearing geological formations equate to a ubiquity of tool-quality chert?—while (2) demonstrating the feasibility of distinguishing chert sources, as (3) a first step toward building a chert source database for east-central Nevada. Informed by modern hunter-gatherer data (e.g., Binford 1983b; see Chapter 3), I defined circles with a 10 km radius around the Paleoarchaic localities in Butte and Jakes valleys that I analyzed in Chapter 4 (Figure 5.2). I then surveyed and sampled many chert-bearing geological formations from the ranges bounding Butte and Jakes valleys, as well as Long, Railroad, and Coal valleys, all of which are located within the Eastern OCZ.

This effort was guided by the Nevada Bureau of Mines and Geology county bulletins, which include detailed descriptions of the distribution, lithology, thickness, age, and correlation of geological formations represented within a county. As survey continued, it became apparent that tool-quality chert often occurred at places where chert-

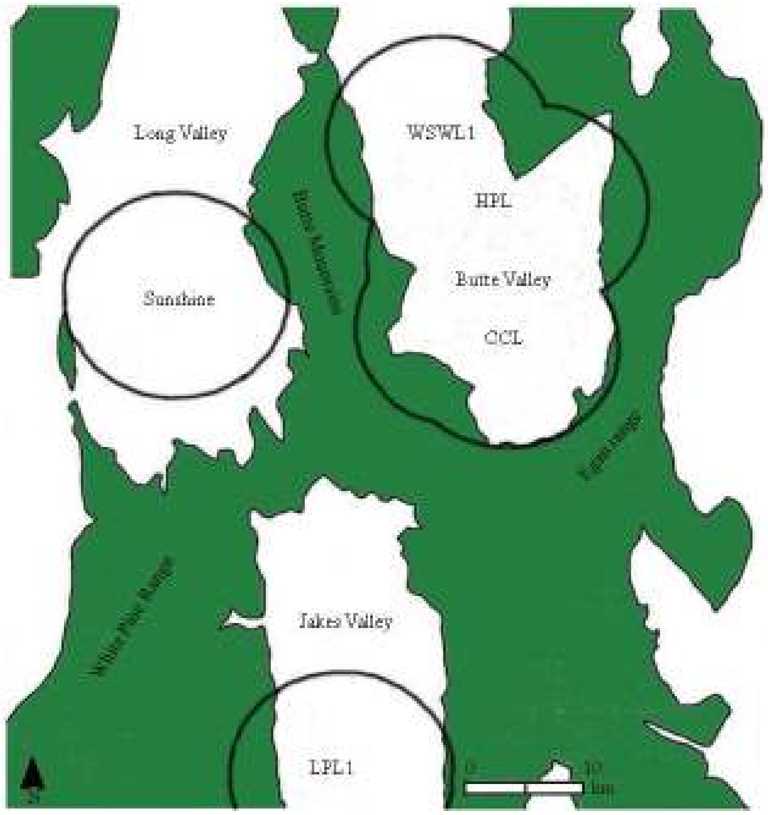


Figure 5.2: Design for surveying and sampling chert-bearing geological formations around Butte, Jakes, and Long valleys. The circles are centered on specific Paleoarchaic localities and have a radius of 10 km.

bearing sedimentary units come into contact with younger volcanic units, which may have induced the formation of chert as a replacement mineral in the parent material. Similarly, Lyons et al. (2003) demonstrate differences in southeastern Oregon chert sources, many of which may owe their diagnostic geochemical signatures to unique and relatively rapid formation in association with late Miocene fissure eruptions (Orr and Orr 1999). Accordingly, I expanded my survey and sampling design to include many of these locations, regardless of whether or not they fall within the foraging radii (i.e., within 10 km of a Paleoarchaic locality). Finally, the Nevada Bureau of Mines and Geology county bulletins also occasionally mention particular chert outcrops, many of which I sampled as well. In all, I surveyed 59 localities within the ranges bounding Butte, Jakes, Long, and

Railroad valleys (Figures 5.4, 5.21, 5.35, 5.44). Given funding limits, I determined the geochemical composition of 27 of these chert sample localities, selecting what I deemed to be tool-quality cherts (i.e., cherts that are not filled with impurities, riddled with microfractures, or otherwise difficult to flake).

Recently, George T. Jones and Charlotte Beck have conducted fieldwork in Coal Valley, located to the south of Butte and Jakes valleys (Figure 5.1). This fieldwork has confirmed a Paleoarchaic record in Coal Valley associated with the now dry Coal Valley Pleistocene lake (Busby 1979). Obsidian artifacts obtained from these localities have

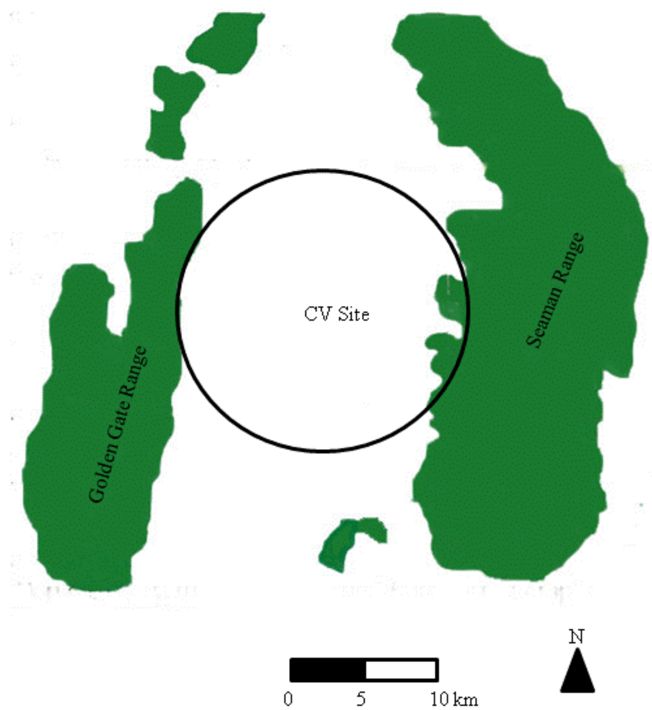


Figure 5.3: Design for surveying and sampling chert-bearing geological formations around Coal Valley. The circles are centered on specific Paleoarchaic localities and have a radius of 10 km.

allowed Jones and Beck (2010; Jones et al. 2012) to test whether or not the Paleoarchaic localities located in Coal Valley were, in fact, part of the Eastern OCZ as they initially defined it (Jones et al. 2003). As discussed briefly in earlier chapters, this more recent fieldwork indicates that obsidian from Coal Valley is derived only from southern source, not the northern sources that were included in the original OCZ; therefore, Jones and colleagues (2012) have divided the original Eastern OCZ into two. While the collections from Coal Valley are less numerous and have been less intensively analyzed than the collections from Butte, Jakes, and Long valleys, further research in this area will continue to clarify the nature of Paleoarchaic mobility and toolstone procurement in eastern Nevada. In line with these ongoing efforts, I also surveyed and sampled chert-bearing geological formations in the vicinity of Coal Valley (Figure 5.3). In all, I surveyed 20 localities within or near Coal Valley (Figure 5.50) and determined the geochemical composition of 8 of these localities, selecting, as above, those cherts I deemed of tool-quality. Finally, I analyzed two samples from a chert source in the southern Las Vegas Range (Figure 5.65), that were provided to me by a student at the University of Nevada, Las Vegas, and two samples from Tosawihi in Elko County (Elston and Raven 1992a, 1992b; Lyons et al.2003). I included these samples simply because they are from known sources and they were given to me, not because of any preconception that the Paleoarchaic inhabitants of east-central Nevada used them.

The number of localities and the number of samples collected within a single locality were dictated by the macroscopic variability represented across the geologic formations, both vertically and horizontally. As a comparable example, Michael Collins and Pam Headrick examined 257 specimens of Edwards chert from 47 localities across the Edwards outcrop in central Texas (~5 samples per locality) in order to obtain a representative sample of this chert source (Frederick et al. 1994). For this study, I collected at least 10 samples from each locality. I then analyzed many of these samples further, as described below.

Robert Tykot (2002, 2003; also see Ives 1985; Shackley 2002; Ward 1974a) suggests that in order for a provenance study of lithic artifacts to be successful, several prerequisites should be met. First of all, all relevant geological sources must be known. Frankly, it is unlikely that all relevant geological sources are known in this case, especially given the exploratory nature of this research. Nevertheless, the sample design employed here should allow me to sort out, at least preliminarily, those cherts that occur within the foraging radii of a Paleoarchaic locality (i.e., within 10 km) from those that do not. Secondly, sources must be characterized for the physical properties or parameters which will be measured for the artifacts. To this end, I analyzed the chert samples I collected using a hierarchy of characterization methods, as described below. These exploratory analyses aim to discern those properties that are homogeneous within an individual source (prerequisite #3) and those properties that demonstrate measurable, statistically valid differences between sources (prerequisite #4; Tykot 2003; also see Earle and Ericson 1977). Ideally, the number of properties for characterization, whether macroscopic, microscopic, or geochemical, should be the minimum capable of differentiating all sources within a study area (Zietlin and Heimbuch 1978). While certain archaeologically-relevant materials may approach this ideal (e.g., obsidian), chert usually is not one of them. Chert typically undergoes multiple phases of genesis and mineral reconfiguration during its formation, often over great expanses at the bottom of oceans or inland lakes. These processes may result in geographically distinct chert outcrops that are difficult to distinguish geochemically. Fortunately, not all elements are similarly affected by the processes of chert genesis and deposition. Sieveking et al. (1972), for example, suggest that those elements associated with clay minerals, phosphates and organic matter, and heavy minerals in the environment of chert deposition may result in variation of the trace element content of chert. In fact, recent studies utilizing more-advanced instrumentation and a combination of properties derived from various analyses has demonstrated that chert artifacts, as well as artifacts made from other "less-well behaved" raw materials, may be sourced (e.g., Baxter et al. 2008; Faradas 2003; Roll et al. 2005; Speakman et al. 2002; Zedeno et al. 2005).

With this in mind, I begin by describing the macroscopic properties for the chert localities sampled, using the minimum analytical nodule analysis (MANA) protocol described in Chapter 4. Additionally, previous studies throughout the United States (e.g., Hillsman 1992; Hofman et al. 1991; Lyons 2001; Lyons et al. 2003; Newlander and Speth 2009) have suggested that ultraviolet fluorescence (UVF) at times can be another useful technique for distinguishing visually similar cherts; therefore, I report the fluorescent response of chert samples under shortwave (265 nm) and longwave (365 nm) ultraviolet light, elicited using a Raytech R5-FLS-2 Lamp at an arbitrary distance of 5 cm between lamp and sample (after Hillsman 1992; Newlander and Speth 2009). These macroscopic properties are presented with sample locality descriptions. Thin sections were also prepared by Burnham Petrographics; however, available time and funding preclude their analysis at the present time. Finally, previous studies have successfully utilized compositional analyses to discriminate chert sources, often using neutron activation analysis (e.g., Aspinall and Feather 1972; de Bruin et al. 1972; Huckell et al. 2011; Julig et al. 1987, 1989, 1991a, 1991b; Luedtke 1976, 1978, 1979b; Lyons 2001; Lyons et al. 2003; McGinley and Schweikert 1979; Sieveking et al. 1972), though laser-ablation inductively-coupled plasma mass spectrometry (LA-ICP-MS; Gratuze et al. 2001; Roll et al. 2005; Speakman et al. 2002) has recently proven up to the task. Thus, I analyze lithic samples using LA-ICP-MS and portable x-ray fluorescence spectrometry (PXRF) to obtain compositional data. I also present compositional data obtained using laboratory x-ray fluorescence spectrometry (XRF) on three sample localities. Because chert often demonstrates considerable visual and chemical variability, even within a single source (Luedtke 1978, 1979b), as well as low elemental concentrations in general (Speakman et al. 2002), it has often proven difficult to identify physical, mineralogical, and/or geochemical characteristics that reliably distinguish chert sources. Yet with adequate sampling and the use of a number of analytical methods, particularly given the technical improvements over the last several decades, it is increasingly possible to distinguish chert sources and to "source" chert artifacts. The analyses presented below demonstrate the feasibility of distinguishing chert sources in east-central Nevada, as a step toward building a comprehensive understanding of the lithic landscape in east-central Nevada and some day perhaps for the Great Basin as a whole.

Description of Geological Sample Localities

M. Steven Shackley (2008) describes an extensive field program and source sampling strategy designed for building a database of toolstone sources. My research in east-central Nevada will ultimately build toward such an understanding of the chert and other toolstone sources available to the prehistoric inhabitants of this region. As stated above, however, my current focus is on two issues: (1) does the ubiquity of chert-bearing geological formations equate to a ubiquity of tool-quality chert; and (2) can chert-bearing geological formations, whether regularly utilized by people or not, be distinguished from each other. In order to address these issues, I surveyed many, and sampled some, chert-bearing geological formations that show little evidence of prehistoric utilization.

It bears noting that lack of evidence for extraction does not mean a chert source was not utilized, however. While the most intensively utilized toolstone sources in east-central Nevada show evidence of prehistoric use in the form of quarry pits and/or reduction loci, chert procurement more often may have been less impactful, perhaps occurring at what Philip Wilke and Adella Schroth (1989) term prospecting sites. Prospecting sites are defined as ephemeral, inconsistent toolstone sources, where potentially flakeable stone was tested for quality. In fact Wilke and Schroth (1989) suggest that the highly structured and intensive toolstone procurement documented at sites such as Tosawihi and Alibates may be the exception rather than the rule, as these sites are inconsistent with Lewis Binford's (1979:259) suggestion that one rarely goes out "into the environment for the express and exclusive purpose of obtaining raw material for tools" (though see Bamforth 2006). Given the aforementioned default expectation that chert was procured locally for expedient use and the widespread availability of chert-bearing geological formations within east-central Nevada, perhaps we should expect that a fair amount of chert procurement will leave faint archaeological evidence. To take this a step further, Anne Ross and colleagues (2003) suggest that culturally significant toolstone sources may not necessarily show evidence of stone extraction and removal at all. Most of the chert samples I collected for this study, for example, I simply picked up off the ground at these sample localities, leaving no archaeological evidence for extraction. Significantly, evidence for the utilization of toolstone derived from such a location still will be manifested in the artifacts that can be sourced to that locality. In fact, the analyses presented below suggest that Paleoarchaic hunter-gatherers utilized chert from Sample Locality 18, yet no flaking debris was evident there.

Obviously, a comprehensive treatment of toolstone procurement and distribution should combine provenance analysis with an extensive investigation of the toolstone source as a potentially significant archaeological site in itself (e.g., Shackley 2008). For the present, however, I emphasize the former, working what I suppose may be viewed as backwards (i.e., from sample and/or artifact to source) in order to meet my goals for this study. As such, the descriptions that follow emphasize the geological context and characteristics of these sample localities; future research will be aimed at the investigation of utilized chert sources as significant archaeological sites in their own right.

BUTTE VALLEY

Butte Valley lies north of Ely in White Pine County, Nevada, between the Egan and Cherry Creek ranges and Steptoe Valley to the east and the Butte Mountains and Long Valley to the west. Elevations range from 1900 m on the valley floor to over 3100 m in the Egan and Cherry Creek ranges. Several of the Paleoarchaic localities considered in this study are located in southern Butte Valley, just south of Hunter's Point (Figure 5.4).

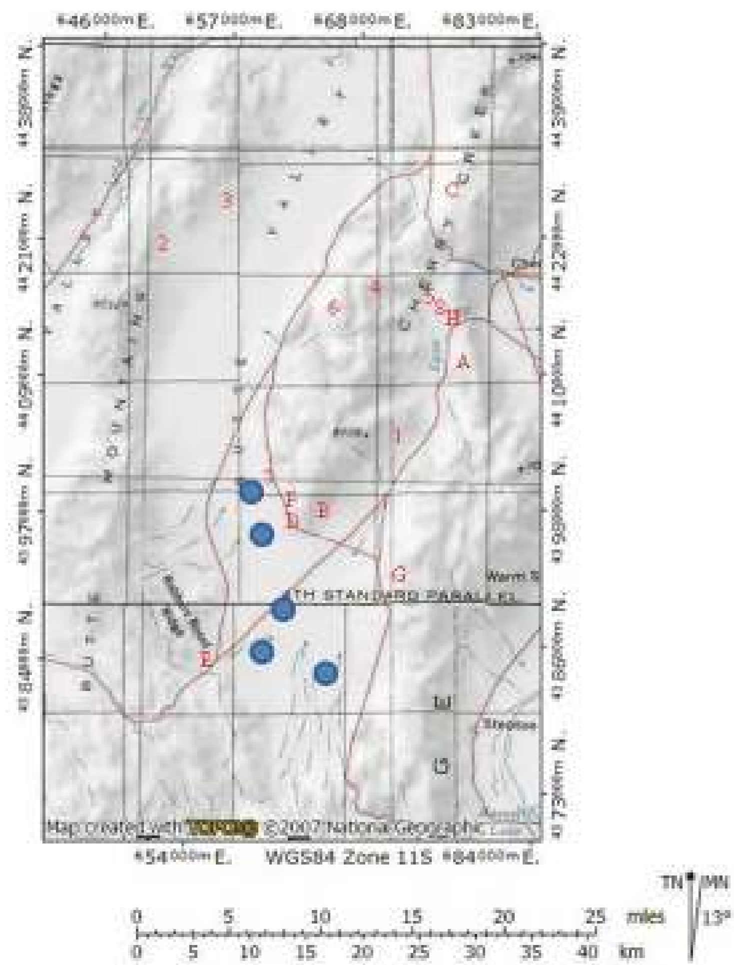


Figure 5.4: Map of chert-bearing geological formations surveyed and sampled around Butte Valley. Numbers designate localities from which geological samples were procured and analyzed geochemically. Letters designate localities surveyed but not analyzed geochemically. The blue circles mark the locations of WSWL1, the Hunter's Point localities, and the Combs Creek localities.

Sample Locality 1: (Locus A: 11S, E0672289, N4404049; Locus B: 11S, E0672165, N4404176; Locus C: 11S, E0672337, N4403890): Sample Locality 1 is located on the southeast side of the Cherry Creek Range, just northwest of Ninemile Summit. A northeast-southwest trending slope of alluvium is covered by interior and cortex flakes (maximum density of 200+ flakes/sq. m) apparently struck from cobbles for assay, though no cobbles or cores are present (Figure 5.5). In fact, no chert outcrop is evident at

Figure 5.5: Sample Locality 1, Locus C. Scale in cm

this location, although a seam of chert and quartzite seems to run along the contour of the slope. Both the Pogonip Group and overlying Eureka Quartzite (Ordovician and Silurian units) occur here, although the contact between these units is typically covered (Hose and Blake 1976:9), which may account for the absence of an obvious chert outcrop at this locality and the evidence for quarry pits. In western Utah, the Pogonip Group includes medium- to thin-bedded limestone with abundant chert nodules. The Eureka Quartzite varies in color from white to grayish brown, and exhibits a coarser texture than that exhibited by the chert specimens.

These characteristics are consistent with the geological samples collected from this locality, the variability perhaps indicative of the contact between the Eureka Quartzite and Pogonip Group at this locality. Specimens are primarily very pale orange (10YR 8/2), although a few pieces are light olive gray (5Y 6/1). Specimens from Locus C are often white (N9), very pale orange (10YR 8/2), or medium gray (N5). Often the orange is interbedded between white (N9) and light brown (5YR 5/6). Specimens exhibit well-sorted megascopic quartz, medium to coarse texture (although finer specimens occur at Locus C), dull luster, and variable translucency (2 mm for dark-colored specimens; 15 mm for light-colored specimens). Cortex is a coarse, yellowish gray (5Y 8/1).Specimens do not exhibit a discernible ultraviolet fluorescent response.

Sample Locality 2 (Locus A: 11S, E0651241, N4419554; Locus B: 11S, E0651196, N4419524): Sample Locality 2 occurs on the east side of the Butte Mountains. A knob consisting of lobate formations of chert is covered by a large amount of flaking debris (maximum density of 200 flakes/sq. m), which seems to extend well beyond the knob. The Park City Group (a Permian unit), which consists of the Kaibab Limestone, the Plympton Formation, and the Gerster Limestone, occurs at this locality. Each unit contains nodular chert, with light gray to yellowish gray specimens typical of the Kaibab Limestone and yellowish and reddish specimens typical of the Plympton Formation and Gerster Limestone (Hose and Blake 1976:15-16). These samples do not exhibit the brachiopods indicative of the Gerster Limestone, however. Thus, it would seem that these samples derive from the Kaibab Limestone (in particular, Locus B) and the Plympton Formation (in particular, Locus A), which accounts for some of the macroscopic variability documented here.

Specimens from Locus A are typically light brown (5YR 5/6), with some moderate yellowish brown (10YR 5/4) spots and dark yellowish orange (10YR 6/6) spots or banding (Figure 5.6). Some specimens are dark reddish brown (10R 3/4). Others are medium light gray (N6) with streaks of pale yellowish orange (10YR 8/6). Specimens exhibit fine texture and dull luster. Translucency varies from low (1 mm) for red and orange specimens to high (11 mm) for gray specimens. Cortex is coarse, but the same or slightly darker color as fresh surfaces. Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 5.6: Sample Locality 2, Locus A. Scale in cm.

Specimens from Locus B (Figure 5.7) are typically light gray (N7) with medium dark gray (N4) streaks, though some are moderate yellowish brown (10YR 5/4), and one specimen is pinkish gray (5YR 8/1) mottled with moderate orange pink (10R 7/4). Specimens exhibit fine texture, dull luster, and low translucency (2 mm). Cortex is a coarse, very pale orange (10YR 8/2). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 5.7: Sample Locality 2, Locus B. Scale in cm.

Sample Locality 3 (11S, E0658748, N4423620): Sample Locality 3 occurs on the east side of the Butte Mountains, southeast of Pony Springs. A southeast facing alluvial fan is covered by flaking debris (maximum density 50 flakes/sq. m.) and small chert nodules. Dacite cobbles, flakes, and bifaces are also apparent at this locality. The Arcturus

Formation (a Permian unit) abuts undifferentiated, Tertiary volcanic rocks at this locality. Specimens are dark reddish brown (10R 3/4) with dusky brown (5YR 2/2) or dark yellowish orange (10YR 6/6) streaks, or olive gray (5Y 3/2) with light brown (5YR 6/4) mottling (Figure 5.8). Some specimens exhibit megascopic quartz and iron staining. Specimens exhibit fine to medium texture, dull luster, and low translucency (1-2 mm). Cortex is a coarse light brown (5YR 5/6) or moderate reddish brown (10R 4/6). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 5.8: Sample Locality 3. Scale in cm.

Sample Locality 4 (11S, E0669951, N4418400): Sample Locality 4 is an outcrop of opalized material, previously recorded as Pony Express Area LB 20, site 8670 (Figure 5.9, top). Abundant chert flakes (maximum density 200 flakes/sq. m) and nodules (some baseball-sized) occur along a northeast-trending slope. Sevy Dolomite (Devonian system), which is typically very fine-textured (Hose and Blake 1976:10), occurs at this locality. Chert may occur as a replacement mineral within dolomite formations, where it is formed as a result of metamorphism, likely attributable, in this case, to hydrothermal activity associated with Tertiary volcanism.

Specimens are typically white (N9) and homogeneous, though some specimens are pinkish gray (5YR 8/1) toward the edges, and some pieces are very pale orange (10YR 8/2) with moderately-sorted quartz, schist, and volcanic clasts (Figure 5.9, bottom). Specimens exhibit fine to medium texture, dull to medium luster, and low to medium translucency (3-10 mm). Cortex is a coarse, grayish orange pink (5YR 7/2). Specimens do not exhibit a discernible ultraviolet fluorescent response.

A coarse medium gray (N5) quartzite with medium light gray (N6) streaks and moderately-sorted megascopic quartz also occurs at this locality, although its origin is unclear. Translucency is minimal (~0 mm), luster is dull, and cortex is brownish gray (5YR 4/1).

Figure 5.9: Sample Locality 4. Scale in cm.

Sample Locality 5 (11S, E0672981, N4417025): Sample Locality 5 occurs on the southeast side of the Cherry Creek Mountains, just northwest of the Egan Basin Well. A chert outcrop (technically, agate) occurs amongst a host of Ordovician, Silurian, and Devonian dolomites. In particular, most of the Fish Haven and equivalent Hanson Creek or Ely Springs Dolomite (Ordovician and Silurian units) occur in beds of finely crystalline to cryptocrystalline material, including some small chert nodules (Hose and Blake 1976:9). While the chert appears to be of tool-quality, there is little other evidence of human activity at this sample locality.

Specimens are often a medium gray (N5), medium light gray (N6), or yellowish gray (5Y 8/1), with bands and streaks of dusky red (5R 3/4), moderate orange pink (10R 7/4), and pale yellowish orange (10YR 8/6) (Figure 5.10). Specimens exhibit fine texture, dull to medium luster, and variable translucency – from minimal (1 mm) on darker specimens to high (10 mm) on lighter specimens. Cortex is coarse pale brown (5YR 5/2) and light brown (5YR 5/6). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 5.10: Sample Locality 5. Scale in cm.

Sample Locality 6 (11S, E0666849, N4417238): Sample Locality 6 is located on the west side of the Cherry Creek Range, northeast of Black Mountain. Sevy Dolomite (Devonian system), which is typically very fine-textured (Hose and Blake 1976:10), occurs at this locality, much as at Sample Locality 4 though with less evidence of human use. Specimens are typically light brown (5YR 5/6) with streaks of moderate brown (5YR 4/4). Also, some specimens are very pale orange (10YR 8/2) with streaks of moderate red (5R 5/4) and light brown (5YR 5/6), though a few specimens are grayish brown (5YR 3/2) or light olive gray (5Y 6/1) with pale red purple (5RP 6/2) streaks (Figure 5.11). Specimens exhibit medium to coarse texture, dull luster, and minimal translucency (~0 mm). Cortex is a coarse moderate orange pink (5YR 8/4) to brownish gray (5YR 4/1). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 5.11: Sample Locality 6. Scale in cm.

Sample Locality 7 (11S, E0661091, N4398926): Sample Locality 7 is located on an isolated knob northwest of Hunter's Point (Figure 5.12, top). Reported in the BLM literature as a "cherty limestone," Riepe Spring and Ely Limestone (Pennsylvanian and Permian units) occur at this locality. While this limestone contains abundant nodules, concretions, lenses, and bands of chert (Hose and Blake 1976:14), this knob seems to lack any significant chert outcrop, despite the BLM report to the contrary. Specimens are fairly homogeneous medium gray (N5) with few well-sorted megascopic quartz clasts (Figure 5.12, bottom). Specimens exhibit fine texture, dull luster, and low translucency (1 mm). Cortex is a coarse, moderate yellowish brown (10 YR 5/4). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 5.12: Sample Locality 7. Scale in cm.

Sample Locality 8 (11S, E0673394, N4416722): Sample Locality 8 occurs on the southeast side of the Cherry Creek Mountains, just northwest of the Egan Basin Well and near Sample Locality 5. The chert samples collected from this locality presumably occur as a replacement mineral within a host of Ordovician, Silurian, and Devonian dolomites. There is little evidence of human use of this locality, however. Specimens are typically medium dark gray (N4) with iron staining to medium light gray (N6) with very pale orange (10YR 8/2) to moderate brown (5YR 3/4) streaks (Figure 5.13). Specimens exhibit fine texture, dull luster, and medium translucency (4-7 mm). Cortex is a coarse light brown (5YR 5/6) to dark yellowish brown (10YR 4/2). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 5.13: Sample Locality 8. Scale in cm.

Sample Locality A (11S, E0676350, N4410089): Sample Locality A occurs on the west side of the Cocomongo Mountains at the north end of the Egan Range, where McCoy Creek Quartzite (Precambrian unit), Prospect Mt. Quartzite, and Pioche Shale (Cambrian units) occur. These quartzitic beds include fine-grained quartzose siltstone, from which some large (softball-sized) quartzite cobbles are derived. Flaking debris is not evident, however. Specimens are typically yellowish gray (5Y 8/1) or very light gray (N8) to light gray (N7), with macroscopic quartz evident (Figure 5.14). Specimens exhibit coarse texture, dull luster, and medium translucency (3.5 mm). Cortex is coarse, dark reddish brown (10R 3/4). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 5.14: Sample Locality A. Scale in cm.

Sample Locality B (11S, E0664840, N4395628): Sample Locality B occurs at the south end of the Cherry Creek Range, just northeast of Hunter's Point. Chainman Shale, Pilot Shale, and Joana Limestone (Devonian and Mississippian units) occur at this locality. The Chainman Shale and Pilot Shale both include bedded siltstone and silty shales, and the Joana Limestone includes some beds producing chert nodules (Hose and Blake

1976:12-13); however, this material appears unlikely to be used for tools. No flaking debris is evident at this locality. Specimens are typically a homogeneous medium gray (N5) (Figure 5.15). Specimens exhibit coarse texture, dull luster, and minimal translucency (~0 mm). Cortex is a coarse medium light gray (N6) to medium gray (N5). The cortex of specimens exhibits an orange fluorescent response to shortwave ultraviolet light.

Figure 5.15: Sample Locality B. Scale in cm.

Sample Locality C (11S, E0674813, N4424345): Sample Locality C occurs on the west side of the Cherry Creek Range, just northeast of the Johnson Spring Basin. Recorded as Flint Creek area FS-8, several Ordovician and Silurian dolomite units occur here. Chert nodules, presumably occurring as replacement minerals within these dolomite units, occur as float on an alluvial fan at this locality. Specimens are typically a white (N9), poorly-sorted quartz conglomerate, although some specimens are more homogeneous with pinkish gray (5YR 8/1) streaks (Figure 5.16). Specimens exhibit medium to coarse texture, medium to shiny luster, and high translucency (16 mm). Cortex is pale brown (5YR 5/2) to yellowish gray (5Y 8/1). Quartz specimens exhibit an orange fluorescent response to shortwave and longwave ultraviolet light. Additionally, a coarse light brownish gray (5YR 6/1) quartzite with moderately-sorted feldspar and quartz clasts occurs. These specimens exhibit medium luster and minimal translucency (0 mm). The cortex for these specimens is the same as the quartz conglomerate. Quartzite specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 5.16: Sample Locality C. Scale in cm.

Sample Locality D (11S, E0663472, N4396011): Sample Locality D occurs just west of Hunter's Point. A vein of chert occurs within Joana Limestone (a Devonian, Mississippian unit) at this locality; however, this chert appears to be unsuited for tool use (Figure 5.17). Specimens are typically dark gray (N3), with moderately-sorted megascopic quartz. Specimens exhibit medium to coarse texture, dull to medium luster, and minimal translucency (0.5-1 mm). Cortex is moderate yellowish brown (10YR 5/4). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 5.17: Sample Locality D. At top, orange fieldbook is 18 cm long. At bottom, scale in cm.

Sample Locality E (11S, E0656518, N4384298): Sample Locality E occurs on the east side of the Butte Mountains. Ely Limestone and Riepe Spring Limestone (Pennsylvanian and Permian units) occur at this locality. A thin vein of chert is evident at this locality; however, it is difficult to extract in nodules of sufficient size for tool manufacture. Flaking debris is not evident at this locality. Specimens are typically pale brown (5YR 5/2), and fairly homogeneous, with some well-sorted feldspar and quartzitic clasts (Figure 5.18). Specimens exhibit medium to coarse texture, dull luster, and low translucency (2.5 mm). Cortex is a pale yellowish orange (10YR 8/6) to light brown (5YR 5/6). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 5.18: Sample Locality E. At top, orange fieldbook is 18 cm long. At bottom, scale in cm.

Sample Locality F (11S, E0663377, N4396513): Sample Locality F occurs just west of Hunter's Point, north of Sample Locality D. The Guilmette Formation (a Devonian unit) occurs here. The Guilmette Formation is predominantly an even-bedded, dark-gray to grayish-black sublithographic limestone, which includes as much as 30% dolomite in many sections (Hose and Blake 1976:11). A chert vein occurs within this unit; however, the chert seems to be of poor quality. Flaking debris is not evident at this locality. Specimens typically occur as medium dark gray (N4) quartzite with moderately-sorted feldspar and quartz clasts (Figure 5.19). Specimens exhibit coarse texture, dull luster, and minimal translucency (~0 mm). Cortex is light brown (5YR 5/6) to dusky yellowish brown (10YR 2/2). The cortex of some specimens exhibits an orange fluorescent response under shortwave and longwave ultraviolet light.

Figure 5.19: Sample Locality F. At top, orange fieldbook is 18 cm long. At bottom, scale in cm.

Sample Locality G (11S, E0671860, N4393185): Sample Locality G occurs on the east side of the Egan Ridge, near an abandoned mine shaft north of Hunter. Simonson

Dolomite, Sevy Dolomite, Guilmette Formation (Devonian units), Joana Limestone (Devonian and Mississippian unit), and Ely Limestone (Pennsylvanian and Permian unit) all occur here, although only a few nodules of quartzite are evident. Flaking debris is not evident at this locality. Specimens are typically medium gray (N5) with well-sorted megascopic quartz (Figure 5.20). Specimens exhibit coarse texture, dull luster, and minimal translucency Cortex is a coarse, very pale orange (10YR 8/2). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 5.20: Sample Locality G. Scale in cm.

Sample Locality H (11S, E0673666, N4416379): Sample Locality H occurs on the southeast side of the Cherry Creek Mountains, just northwest of the Egan Basin Well and near Sample Localities 5 and 8. Notch Peak Limestone (a Cambrian unit) occurs at this locality. The lower 750 feet of this formation within the Cherry Creek Mountains contains some black chert (Hose and Blake 1976:8); however, this chert was not evident. Accordingly, no sample was taken at this locality.

JAKES VALLEY

Jakes Valley is a relatively small extensional basin located southwest of Ely. Jakes Valley is bounded by the Egan Range to the east and the Butte Mountains and White Pine Range to the west (Figure 5.21). Limestone Peak Locality 1 (LPL1) occurs at the southeast margin of Pleistocene Jakes Lake within this valley.

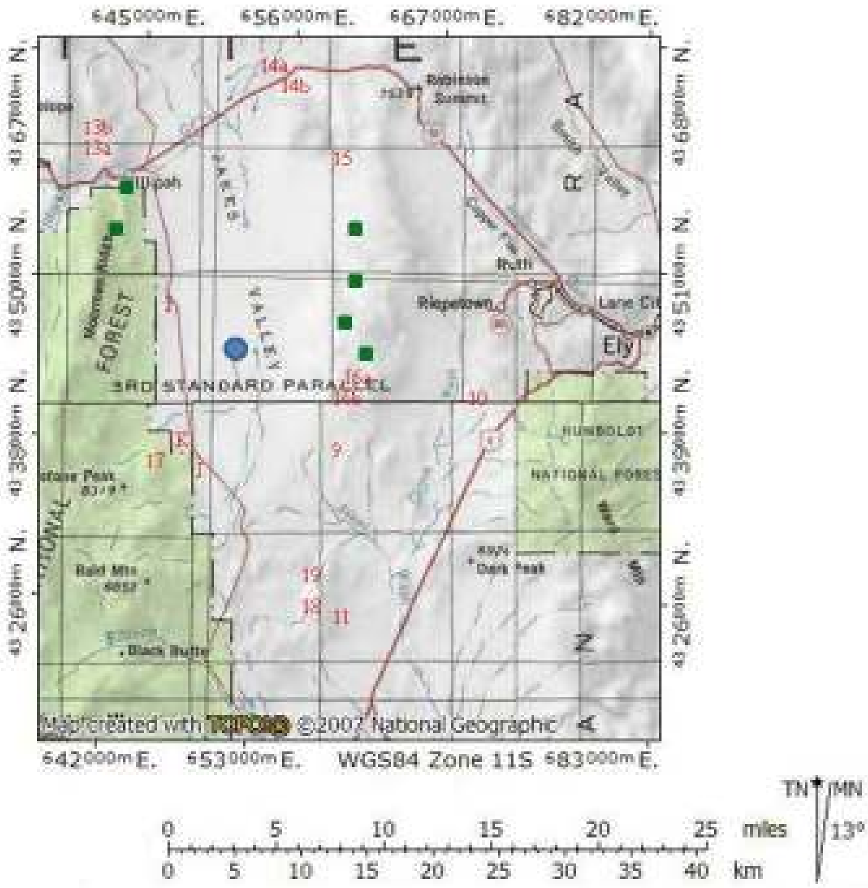


Figure 5.21: Map of chert-bearing geological formations surveyed and sampled around Jakes Valley. Numbers designate localities from which geological samples were procured and analyzed geochemically. Letters designate localities surveyed but not analyzed geochemically. Green squares represent chert-bearing geological formations that were surveyed, but at which chert was not evident. The blue circle marks the location of LPL1.

Sample Locality 9 (11S, E0659912, N4334301): Sample Locality 9 occurs on a north-south trending ridge on the west side of the Egan Range, northeast of Jakes Wash. Abundant white chert nodules and flaking debris (maximum density 200+ flakes/sq. m) are dispersed across a ridge of younger, undifferentiated ash flow, especially on the west slope (Figure 5.22, top). The chert likely derives from Joana Limestone (a Devonian and Mississippian unit), and was probably opalized by hydrothermal activity associated with Tertiary volcanic activity. Shallow quarry pits do occur at this locality, although many of these may be historic. The Civilian Conservation Corps Camp located in southern Long Valley, for example, utilized nodules that probably derive from this locality to line the camp pathways.

Specimens are typically brownish gray (5YR 4/1) or grayish orange pink (5YR 7/2) with some well-sorted quartz, feldspar, and schist clasts (Figure 5.22, bottom). Specimens exhibit fine texture, dull luster, and low to medium translucency (2-11 mm). Specimens are wrapped in a soft, yellowish gray (5Y 8/1) cortex shell, although some specimens are this color and consistency throughout. Some lighter-colored specimens exhibit an orange fluorescent response to shortwave and longwave ultraviolet light.

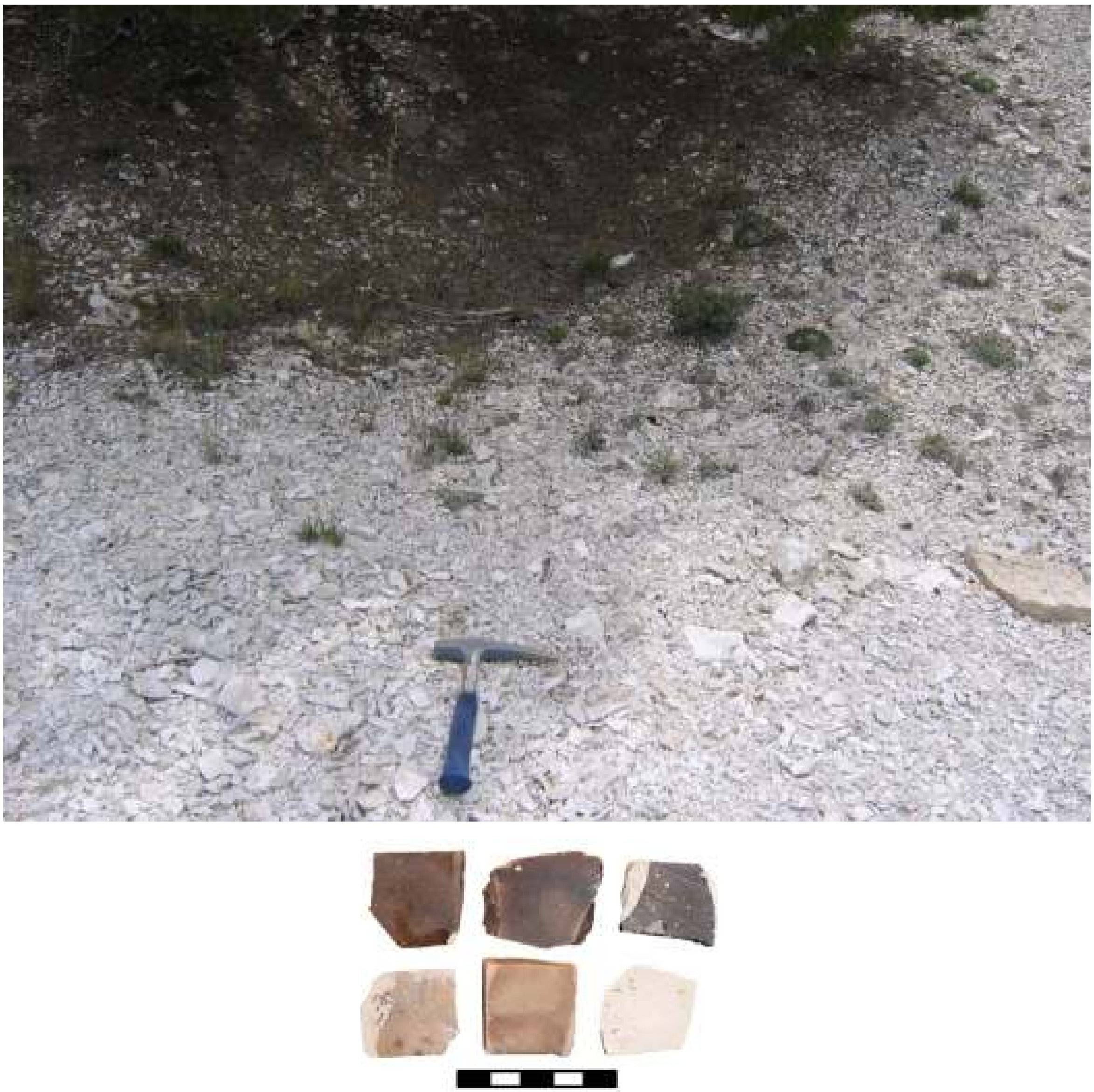


Figure 5.22: Sample Locality 9. Quarry pit at top (hammer is 33 cm long) and polished specimens at bottom (scale in cm).

Sample Locality 10 (11S, E0670342, N4343059): Sample Locality 10 is located on the east side of the Egan Range, east of Giroux Wash and southwest of Ruth. Gray chert nodules are eroding out of a north-south trending slope at the fence to the mine at Ruth (Figure 5.23, top). The geological literature does not specify a geological unit at this location; however, the Park City Group (a Permian unit) is recorded near this locality.

Figure 5.23: Sample Locality 10. At top, rock hammer is 33 cm long, At bottom, scale in cm.

The Park City Group includes Kaibab Limestone, the Plympton Formation, and Gerster Limestone, all of which include chert nodules (Hose and Blake 1976:15-16). The Gerster Limestone, however, does not occur south of Highway 50 in White Pine County, so it cannot account for these chert nodules. The Kaibab Limestone and Plympton Formation have approximately the same distribution, including an occurrence 6-9 miles west-southwest of Ely (Hose and Blake 1976:15), which would include this locality. Because the Plympton Formation includes more abundant chert nodules, I suspect the chert at this locality derives from this unit, perhaps dispersed by later geomorphic processes. Some flaking debris (maximum density of 50 flakes/sq. m) is apparent at this locality.

Specimens are often very light gray (N8) with light gray (N7) streaking, and moderately-sorted feldspars and quartz clasts (Figure 5.23, bottom). Some specimens are medium gray (N5) and light brown (5YR 6/4) with very dark red (5R 2/6) bands. Specimens exhibit fine texture, dull to medium luster, and high translucency (11-24 mm). Cortex is a medium coarse, very pale orange (10YR 8/2). Specimens exhibit no discernible fluorescent response.

Sample Locality 11 (11S, E0657489, N4324512): Sample Locality 11 occurs as a knob in the southern Egan Range, just southeast of Midway Well and southwest of Jakes Wash Well (Figure 5.24, top). The Guilmette Formation (a Devonian unit) is overlain by a younger (Tertiary) volcanic unit at this locality, which may have encouraged the silification of dolomite derived from this unit, a process attested to by the occurrence of a similarly formed jasperiod located nearby (Hose and Blake 1976). Abundant cobbles and cores, as well as andesite hammerstones and flakes, evidence toolstone assay at this locality.

Specimens are primarily dark yellowish orange (10YR 6/6) to moderate yellowish brown (10YR 5/4) with some megascopic quartz inclusions and grayish orange pink (5YR 7/2) banding (Figure 5.24, middle). Other colors include pale yellowish orange (10YR 8/6), moderate brown (5YR 4/4), and grayish brown (5YR 3/2). Additionally, dark reddish brown (10R 3/4) to blackish red (5R 2/2) specimens with medium gray (N5) banding and few, well-sorted feldspar and schist clasts occur. Specimens exhibit fine to medium texture, dull to medium luster, and low translucency (1 mm for red and brown specimens, 2-3 mm for orange specimens). Cortex varies from moderate orange pink (10R 7/4) to very pale orange (10YR 8/2).

On the west side of the road (11S, E0657111, N4324191) nodules of mottled moderate red jasper (5R 4/6) and light gray (N7) cherts occur on a second rhyolitic knob (Figure 5.24, bottom). Specimens exhibit fine texture, medium luster, and low (2 mm) translucency. A dark gray (N3) chert becomes more prominent beyond Knob 2. These specimens exhibit fine texture, medium luster, and minimal (0.5 mm) translucency. Specimens typically do not exhibit a discernible ultraviolet fluorescent response, though a few exhibit a light green fluorescent response to shortwave ultraviolet light (on quartz speckling).

Figure 5.24: Sample Locality 11. At top, orange knob (rock hammer is 33 cm long). At middle, orange specimens (scale in cm). At bottom, jasper specimens (scale in cm).

Sample Locality 13: (Locus A: 11S, E0641284, N4359309; Locus B: 11S, 0641178, N4359628): Sample Locality 13 occurs at the south end of the Butte Mountains, a little northwest of Moorman Ranch. Abundant, large chert nodules occur primarily on the east and southeast flank of a volcanic unit located west of the road, although flaking debris was not particularly dense (maximum density < 20 flakes/sq. m). The Rib Hill Sandstone and Arcturus Formation (Permian units) underlie a younger (Tertiary) volcanic unit at this locality, evident especially in a seam of chert that crops out at Locus A. The Arcturus Formation is particularly well exposed near Moorman Ranch, the upper part of which includes fine-grained siltstone.

Specimens are typically pale brown (5YR 5/2), some with brownish black (5YR 2/1) banding and large, poorly-sorted feldspar clasts (Figure 5.25). Specimens exhibit fine texture, medium luster, and high (15-24 mm) translucency. Cortex is white (N9) with iron staining. The more translucent specimens exhibit a light green fluorescent response to shortwave ultraviolet light and an orange fluorescent response to longwave ultraviolet light.

Figure 5.25: Sample Locality 13. Scale in cm.

Sample Locality 14a (11S, E0655534, N4365970): Sample Locality 14a occurs as an isolated knob on the southwest side of the Butte Mountains, just south of Townsend Reservoir. Some baseball-sized chert cobbles occur at a north-south trending contact of the Park City Group (a Permian unit) and a Tertiary unit of volcanic rocks, although there is little flaking debris evident at this locality. Isolated outcrops of Kaibab Limestone and the Plympton Formation, constituents of the Park City Group, occur west-southwest of Ely. Both units contain nodules of chert (Hose and Blake 1976:15-16), which likely accounts for this sample locality.

Specimens are typically light brown (5YR 6/4) mottled with pale brown (5YR 5/2) and very pale orange (10YR 8/2), with moderately-sorted opaques and feldspar clasts (Figure 5.26). Specimens exhibit fine texture, dull to medium luster, and medium to high translucency (5-12 mm). Cortex is dark yellowish orange ((10YR 6/6) to grayish orange (10YR 7/4). Some lighter-colored specimens exhibit a light green fluorescent response to shortwave ultraviolet light.

Figure 5.26: Sample Locality 14a. Scale in cm.

Sample Locality 14b (11S, E0656104, N4365411): Sample Locality 14b occurs on the northeast side of Egan Range, as an isolated outcrop located just across Route 50 from Sample Locality 14a. No unambiguous flaking debris or chert outcrop is apparent at this locality; however, large white/gray chert nodules occur around a tree-trunk (Figure 5.27, top). Perhaps brought to the surface by a tree-throw, these nodules may testify to a chert deposit buried under more recent alluvium, as the only unit recorded here in the geological literature is undifferentiated Lower Triassic sedimentary rocks. Significantly, "the base of the Triassic is marked by a thin bed of conglomerate made up of rounded fragments of quartzite, chert, and limestone in a matrix of yellowish-gray limestone" (Hose and Blake 1976:16), consistent with the samples recovered from this locality.

Specimens are primarily yellowish gray (5Y 8/1), though some are very pale orange (10YR 8/2) and moderate yellowish brown (10YR 5/4). The most homogeneous specimens are highly (15 mm) translucent light brown (5YR 6/4) to moderate brown (5YR 4/4) specimens. Otherwise, specimens tend to exhibit moderately-sorted feldspar and carbonaceous clasts, fine texture, dull luster, and medium translucency (8 mm). Cortex is yellowish gray (5Y 8/1). Some specimens exhibit a light green fluorescent response to shortwave ultraviolet light.

Figure 5.27: Sample Locality 14b. At top, rock hammer is 33 cm long. At bottom, scale in cm.

Sample Locality 15 (11S, E0659407, N4359620): Sample Locality 15 occurs on a north-south trending slope on the northwest side of the Egan Range. Some large (softball-sized) cobbles occur amongst a large amount of shatter (200 flakes/sq. m), although many of these flakes are likely not cultural. As with Sample Locality 14a and 14b, the Kaibab Limestone and Plympton Formation, members of the Park City Group (a Permian unit), occur at this locality. Both units contain chert nodules, although chert is more abundant in the Plympton Formation (Hose and Blake 1976:16).

Specimens are typically very light gray (N8) with moderate red (5R 5/4) streaks, though some are medium gray (N5) with banding and some are grayish orange pink (10R 8/2) to moderate orange pink (10R 7/4) with moderate red (5R 5/4) streaks (Figure 5.28). Specimens exhibit fine texture, dull luster, and low translucency (2.5 mm). Cortex is very pale orange (10YR 8/2) to moderate brown (5YR 3/4) and quite translucent (11 mm). Few light gray specimens exhibit a light green fluorescent response to shortwave ultraviolet light.

Figure 5.28: Sample Locality 15. Scale in cm.

Sample Locality 16 (Locus A: 11S, E0659072, N4339998, Locus B: 11S, E0659173, N4339992): Sample Locality 16 occurs on the west side of the Egan Range, east of Railroad Crossing Dam. The Arcturus Formation (a Permian unit) occurs at this locality. The upper part of the Arcturus Formation consists mainly of very fine-grained, yellowish gray calcareous sandstone and siltstone, consistent with Locus A. The lower part of the Arcturus Formation consists mainly of massive light-olive gray to cream-colored

Figure 5.29: Sample Locality 16, Locus A. Scale in cm.

limestone, with interbeds of platy limy siltstone, consistent with Locus B (Hose and Blake 1976:15). Angular cobbles are apparent, although not abundant. Flaking debris is not evident at this locality.

Specimens from Locus A are primarily dark yellowish orange (10YR 6/6) to medium light gray (N6), with moderately-sorted quartz and feldspar clasts (Figure 5.29). Specimens exhibit fine to medium texture, dull luster, and low translucency (2-3 mm).Cortex is pale yellowish brown (10YR 6/2) with iron staining. Specimens exhibit a reddish orange fluorescent response to shortwave and longwave ultraviolet light.

Specimens from Locus B are primarily medium light gray (N6) mottled with light olive gray (5Y 6/1), and include well-sorted feldspar clasts (Figure 5.30). Specimens exhibit fine texture, low luster, and low translucency (3-5 mm). Cortex is a more translucent, coarse medium light gray (N6) to light brown (5YR 6/4). Some specimens exhibit an orange fluorescent response to shortwave ultraviolet light.

Figure 5.30: Sample Locality 16, Locus B. Scale in cm.

Sample Locality 17 (11S, E0645861, N4337837): Sample Locality 17 occurs on a northeast-southwest trending slope on the east side of the White Pine Range, just northeast of Limestone Peak. Riepe Spring Limestone and Ely Limestone (Pennsylvanian and Permian units) occur at this locality. The slope-forming beds of these units typically consist of platy medium-gray to yellowish-gray silty limestone that is yellowish gray on fresh fractures (Hose and Blake 1976:14). The limestone contains abundant chert nodules, concretions, lenses, and bands (Hose and Blake 1976:14). Flaking debris is not evident at this locality.

Specimens from this locality are typically grayish orange (5Y 8/4) with light olive gray (5Y 5/2) to medium light gray (N6) banding and few, moderately-sorted schist clasts (Figure 5.31). For some specimens, the light gray and orange is more mottled than banded. Specimens exhibit fine texture, dull luster, and low to medium (3-6 mm) translucency. Cortex is moderate yellowish brown (10YR 5/4) to dark yellowish orange (10YR 6/6) to pale yellowish brown (10YR 6/2). Some specimens exhibit an orange fluorescent response to shortwave ultraviolet light.

Figure 5.31: Sample Locality 17. Scale in cm.

Sample Locality 18 (11S, E0656869, N4327564): Sample Locality 18 is located in the southern Egan Range, just southeast of Midway Well and west of Jakes Wash Well. Riepe Spring Limestone and Ely Limestone (Pennsylvanian and Permian units) underlie a Tertiary jasperoid breccia at this locality. Large nodules of jasper, found eroding out of the banks of a dry stream bed (Figure 5.32, top), occur within this brecciated unit. Silicification was likely caused by hydrothermal solutions moving through the breccias while they were still permeable (Hose and Blake 1976:22). Flaking debris is not evident at this locality; however, this may reflect the location of these chert nodules in the stream bed.

Figure 5.32: Sample Locality 18. At top, orange fieldbook is 18 cm long. At bottom, scale in cm.

Specimens are typically light gray (N7) to pinkish gray (5YR 8/1), with moderate red (5R 4/6) to very dark red (5R 2/6) banding (Figure 5.32, bottom). Specimens exhibit fine texture, dull to medium luster, and minimal (0.5-1 mm) translucency. Cortex is a coarse, dusky red (5R 3/4). Specimens exhibit no discernible fluorescent response to ultraviolet light.

Sample Locality 19 (11S, E0656892, N4327661): Sample Locality 19 is located in the southern Egan Range, just southeast of Midway Well and west of Jakes Wash Well. Riepe Spring Limestone and Ely Limestone (Pennsylvanian and Permian units) occur at this locality. The slope-forming beds typically consist of platy medium-gray to yellowish-gray silty limestone that is yellowish gray on fresh fractures (Hose and Blake 1976:14). The limestone contains abundant chert nodules, concretions, lenses, and bands (Hose and Blake 1976:14). Small chert nodules occur at this locality (Figure 5.33, top), although flaking debris is not evident.

Figure 5.33: Sample Locality 19. At top, orange fieldbook is 18 cm long. At bottom, scale in cm.

Specimens are typically pale yellowish brown (10YR 6/2) with megascopic quartz and light brown (5YR 5/6) streaks (Figure 5.33, bottom). Specimens exhibit fine texture, dull luster, and low translucency (0.5-2 mm). Cortex is dark yellowish orange (10YR 4/2). Some specimens exhibit an orange fluorescent response to shortwave ultraviolet light.

Sample Locality I (11S, E0646245, N4348218): Sample Locality I is located on the east side of White Pine Range, just west of Cottonwood Pond. Riepe Spring Limestone and Ely Limestone (Pennsylvanian and Permian units) occur at this locality, both of which contain abundant nodules, concretions, lenses, and bands of chert (Hose and Blake 1976:14). Small nodules occur at this locality, although there is no evidence of flaking debris.

Specimens are typically medium light gray (N6) but also occur as pale yellowish brown (10YR 6/2) and dark yellowish orange (10YR 6/6), with minimal carbonaceous and siltstone clasts (Figure 5.34). Specimens exhibit fine to medium texture, dull to medium luster, and medium to high (4-12 mm) translucency. Cortex is a yellowish gray (5Y 8/1) with moderately-sorted opaques, carbonaceous, and siltstone clasts. Some specimens exhibit an orange fluorescent response to ultraviolet light.

Figure 5.34: Sample Locality I. Scale in cm.

Sample Locality J (11S, E0648085, N5337347); *Sample Locality K* (11S, E0649071, N4336774): Sample Localities J and K are located on the east side of the White Pine Range, a little northeast of Limestone Peak. Ely Limestone and Riepe Spring Limestone (Pennsylvanian and Permian units) occur at these localities. These units contain abundant nodules, concretions, lenses, and bands of chert (Hose and Blake 1976:14); however, no chert is apparent at these localities. Thus, no sample was taken.

Other chert-bearing geological formations were surveyed around southern Long Valley in particular, although chert was not apparent at these localities either. Just south of Illipah, at the north end of the White Pine Range, Riepe Spring Limestone and Ely Limestone (Pennsylvanian and Permian units) occur. These units contain abundant nodules, concretions, lenses, and bands of chert (Hose and Blake 1976:14); however, no chert was apparent here. Farther south, though still toward the north end of the White Pine Range, the Arcturus Formation and Ribhill Sandstone occur, which contain siltstone and silty limestone (Hose and Blake 1976:15); however, no chert was apparent here. Between Sample Localities 15 and 16 along the west side of the Egan Range, the Arcturus Formation, Ribhill Sandstone, Ely Limestone, and Riepe Spring Limestone (Pennsylvanian and Permian units) crop out. While these formations include silty limestone, siltstone, and, in the case of the limestone units, abundant nodules, concretions, lenses, and bands of chert, no chert was apparent at these locations.

LONG VALLEY

Bounded on its eastern and southern sides by the Butte Mountains and on its western side by the southern extension of the Ruby Mountains, Long Valley lies near the geographic center of the Great Basin (Figure 5.35). The Sunshine Locality, a TP/EH site that has yielded thousands of Paleoarchaic artifacts, occurs at the south end of Long Valley (Beck and Jones 2009c).

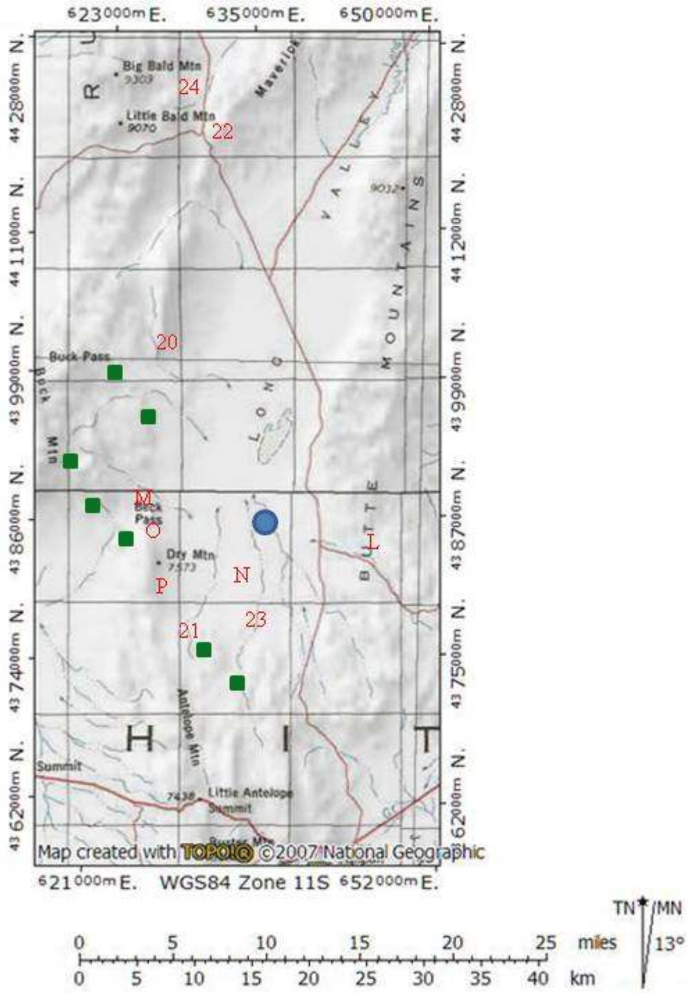


Figure 5.35: Map of chert-bearing geological formations surveyed and sampled around Long Valley. Numbers designate localities from which geological samples were procured and analyzed geochemically. Letters designate localities surveyed but not analyzed geochemically. Green squares represent chert-bearing geological formations that were surveyed, but at which chert was not evident. The blue circle marks the location of the Sunshine Locality.

Sample Locality 20 (11S, E0627165, N4394087): Sample Locality 20 occurs on an isolated knob just south of Alligator Ridge, on the east side of the Ruby Mountains. Devils Gate Limestone and Pilot Shale (Devonian units) occur at this locality, and may have been silicified in relation to recent hydrothermal activity. A creamy/gray chert breccia is underlain by a reddish cherty breccia, which includes many large cobbles (Figure 5.36, top). Flaking debris (maximum density of 200+ flakes/sq. m) is abundant around the knob and within slopewash derived from the knob. The banding and swirls apparent on these specimens are suggestive of agate (“eye agate,” in particular), on the basis of which this source has been affectionately dubbed “Wonderstone.”

Figure 5.36: Sample Locality 20. Scale in cm.

Specimens (Figure 5.36, bottom) are typically very light gray (N8) to yellowish gray (5Y 8/1) with moderate pink (5R 7/4) and moderate orange pink (5YR 8/4) banding, though some pieces are completely moderate red (5R 4/6). Specimens exhibit fine texture, dull luster, and minimal to medium translucency (~0 mm for red specimens, 4-9 mm for lighter-colored specimens). Cortex is an iron-stained pale yellowish orange (10YR 8/6). Gray sections of some specimens exhibit a yellow fluorescent response to shortwave and longwave ultraviolet light, while darker sections of some specimens exhibit an orange fluorescent response to shortwave and longwave ultraviolet light.

Sample Locality 21 (11S, E0631325, N4373987): Sample Locality 21 is located just east of the north end of the White Pine Range. Nodules, some bowling ball-sized and many more softball-sized, occur as float in a northwest-southeast trending ashflow unit. Ely Limestone and Riepe Spring Limestone (Pennsylvanian and Permian units) are the closest units containing chert nodules, although no outcrop is apparent at this locality. Flaking debris (maximum density 50 flakes/sq. m) does occur at this locality.

Affectionately dubbed "Long Valley Jade," specimens are primarily dark greenish gray (5G 4/1) with grayish yellow green (5GY 7/2) banding, though some pieces are predominantly grayish yellow green (5GY 7/2) with dark greenish gray (5G 4/1) banding (Figure 5.37). Specimens exhibit fine to medium texture, medium to shiny luster, and minimal translucency (1.5 mm). Cortex is medium bluish gray (5B 5/1) to greenish gray (5G 6/1). The coloring of these specimens is suggestive of chrysoprase, although the specimens do not exhibit the translucency often associated with chrysoprase (Frondel 1962:218). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 5.37: Sample Locality 21. Scale in cm.

Sample Locality 22 (11S, E0631076, N4418217): Sample Locality 22 is located at the south end of the Maverick Springs Range in Hibson Pass, just east of the Mooney Basin. Chert nodules (some bowling ball-sized) are eroding from a seam in a Tertiary ashflow unit. The seam of chert apparent here is likely attributable to the Diamond Peak Formation (a Mississippian unit), which includes conglomerate containing quartzite and chert pebbles and cobbles (Hose and Blake 1976:13). The entire slope is covered by white chert nodules and flaking debris (maximum density of 50 flakes/sq. m), including some reduction loci. Additionally, many gray chert flakes, macroscopically-similar to the chert derived from Sample Locality 24, occur at this locality, although the only temporally diagnostic artifact is an obsidian corner-notched point.

Specimens are primarily a fairly homogeneous white (N9), though with some yellowish gray (5Y 8/1) and pinkish gray (5YR 8/1) streaks (Figure 5.38). Some pieces are primarily yellowish gray (5Y 8/1). Specimens have few minor, well-sorted opaques. Specimens exhibit fine texture. Luster is dull for white pieces and shiny for yellowish gray pieces. Translucency is high (~22 mm) for yellowish gray pieces and medium (8-18 mm) for white specimens. Cortex is white (N9) to yellowish gray (5Y 8/1). Specimens exhibit a light green fluorescent response to shortwave ultraviolet light.

Figure 5.38: Sample Locality 22. Scale in cm.

Sample Locality 23 (11S, E0635193, N4375946): Sample Locality 23 is located at the north end of the Butte Mountains, on a Tertiary ashflow unit redistributed as alluvium along a slope oriented northeast-southwest. Chert occurs as large nodules eroding out of the slope (Figure 5.39, top). These nodules are likely derived from the Diamond Peak Formation (a Mississippian unit), which occurs to the south and includes conglomerate containing pebbles and cobbles of quartzite and chert (Hose and Blake 1976:13). Flaking debris is not apparent.

Specimens are primarily medium light gray (N6) with dark yellowish orange (10YR 6/6) to moderate yellowish brown (10YR 5/4) banding, suggestive of agate (Figure 5.39, bottom). Chert also occurs as brownish gray (5YR 4/1) to dark gray (N3), and some specimens are predominately dark yellowish orange (10YR 6/6). Specimens exhibit fine texture, medium to shiny luster, and low translucency (~2.5 mm). Cortex is light brown (5YR 5/6) to very dark red (5R 2/6). Specimens do not exhibit a discernible ultraviolet fluorescent response.

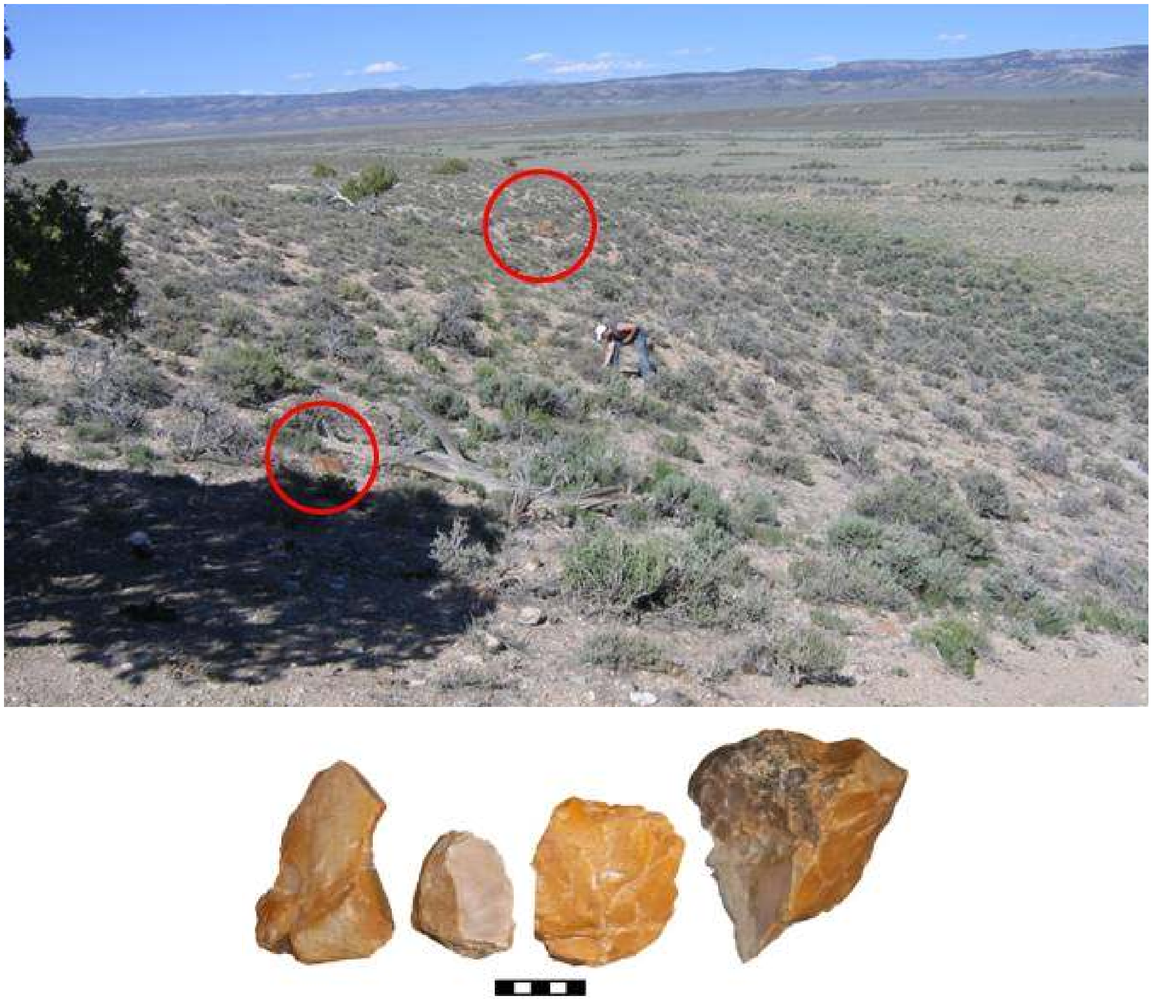


Figure 5.39: Sample Locality 23. At top, large boulders are strewn across a slope of alluvium (Will Swearson is included for scale). At bottom, specimens from Sample Locality 23 (scale in cm).

Sample Locality 24 (11S, E0629587, N4425006): Sample Locality 24 occurs on a knob on the south side of Mahoney Canyon, on the east side of the Ruby Mountains. Devils Gate Limestone (a Devonian unit) occurs at this locality. The Devils Gate Limestone is roughly equivalent in lithology and age to the Guilmette Formation (Hose and Blake 1976:11). These units contain dolomite that may be subject to silicification by later hydrothermal activity. Large nodules of brecciated cherts (Figure 5.40, top), dense flaking debris (maximum density 200+ flakes/sq. m), and FGV hammerstone spalls occur across this outcrop.

Chert occurs as four main varieties at this locality (Figure 5.40, bottom): (a) Specimens are light gray (N7) with medium gray (N5) streaks. These specimens exhibit fine texture, dull luster, and minimal translucency (~1 mm). Cortex is pale yellowish brown (10YR 6/2). Specimens do not exhibit a discernible ultraviolet fluorescent response. (b) Specimens are moderate reddish brown (10R 4/6) mottled with light browns (5YR 6/4 and 5YR 5/6). Specimens exhibit fine texture, dull luster, and minimal

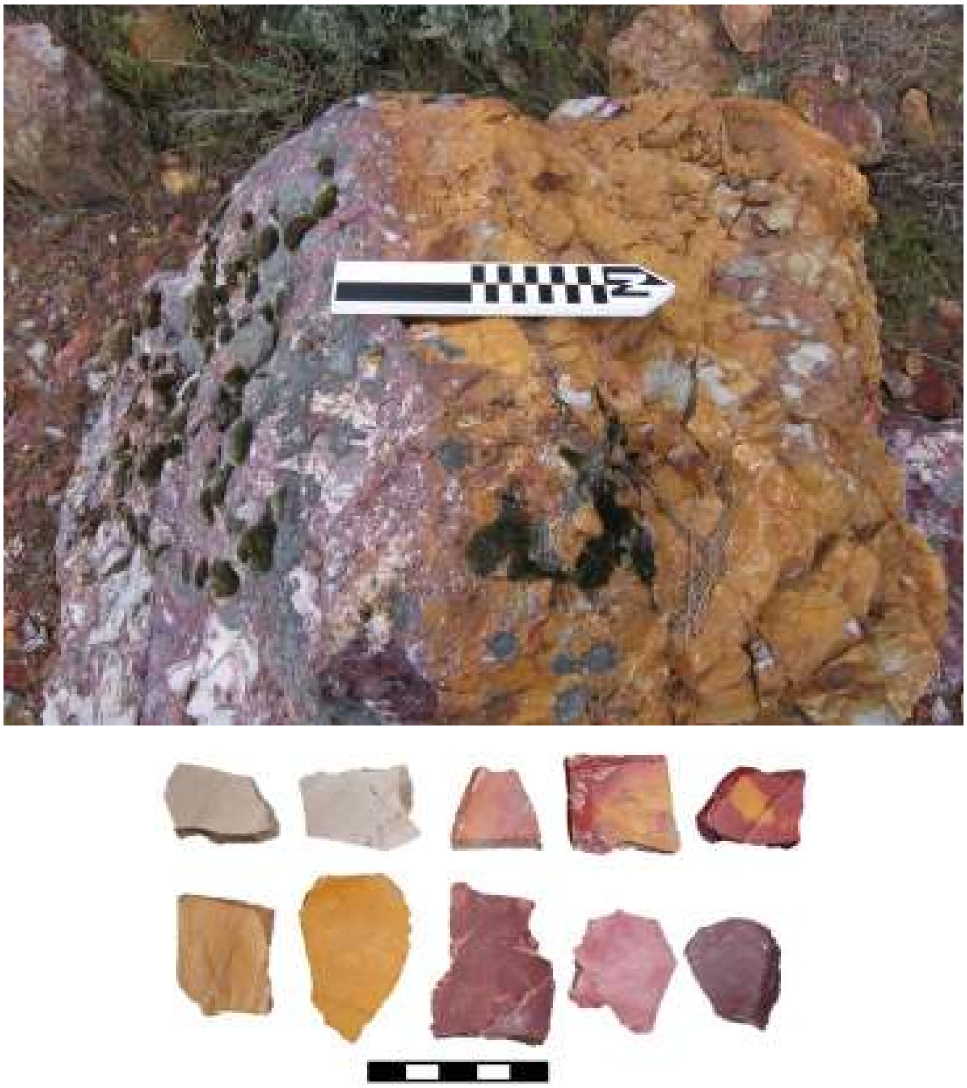


Figure 5.40: Sample Locality 24. Scale in cm.

translucency (~0 mm). Cortex is brownish gray (5YR 4/1). Specimens do not exhibit a discernible ultraviolet fluorescent response. (c) Specimens are dark yellowish orange (10YR 6/6) banded with grayish orange (10YR 7/4); darker or lighter oranges may alternately dominate the specimen and some light gray (N7) spots peek through. Specimens exhibit fine texture, dull to medium luster, and minimal translucency (~0 mm). Cortex is a coarse, dark yellowish orange (10YR 6/6). Specimens do not exhibit a discernible ultraviolet fluorescent response. (d) Specimens are very dusky purple (5RP 2/2) to grayish red purple (5RP 4/2) to pale red purple (5RP 6/2) mottled with grayish red purple (5RP 4/2). Specimens exhibit fine texture, medium to shiny luster, and minimal translucency (0.5-1 mm). Cortex is a coarse, very dusky purple (5RP 2/2). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Sample Locality L (11S, E0646868, N4383516): Sample Locality L is located on the west side of the Butte Mountains. The Park City Group (a Permian unit) occurs at this locality. In particular, the rounded cliff of medium-coarse- to very coarse-grained, massive organic-detrital limestone, containing some nodules of chert, is consistent with the Kaibab Limestone (Hose and Blake 1976:15). While chert does occur at this locality, it is not available in a form that seems suited to human use nor is there evidence for toolstone assay at this locality (Figure 5.41).

Figure 5.41: Sample Locality L (orange fieldbook is 18 cm long).

Specimens are typically light olive gray (5Y 6/1) to moderate yellowish brown (10YR 5/4) to dark yellowish orange (10YR 6/6). Specimens are a conglomerate of poorly-sorted megascopic quartz, schist, feldspar, and carbonaceous clasts. Specimens exhibit medium to coarse texture, medium luster, and medium translucency (~6 mm). Cortex is a very pale orange (10YR 8/2). Moderate yellowish brown sections of specimens exhibit an orange fluorescent response to shortwave and longwave ultraviolet light.

Sample Locality N (11S, E0635589, N4377339): Sample Locality N is located at the north end of the Butte Mountains, just north of Sample Locality 23. As with Sample Locality 23, these nodules are likely derived from the Diamond Peak Formation (a Mississippian unit), which occurs to the south and includes conglomerate containing pebbles and cobbles of quartzite and chert (Hose and Blake 1976:13). Indeed, these samples are macroscopically similar to samples collected from Sample Locality 23, although a significant chert outcrop and flaking debris is not apparent at this locality. Chert cobbles are typically baseball-size or smaller, although one cobble is bowling ball-size.

Specimens are typically light brownish gray (5YR 6/1), pale yellowish brown (10YR 6/2), or moderate yellowish brown (10YR 5/4), with dark yellowish orange streaks (10YR 6/6) and moderately sorted opaques and feldspar clasts (Figure 5.42). The more-orange specimens exhibit fine to medium texture, medium luster, and low translucency (2.5 mm). Grayer specimens exhibit fine to medium texture, dull luster, and medium translucency (4 mm). Cortex is a dark yellowish orange (10YR 6/1) or light brownish gray (5YR 6/1). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 5.42: Sample Locality N. Scale in cm.

Sample Locality M (11S, E0627637, N4387623); *Sample Locality O* (11S, E0627892, N4385679); *Sample Locality P* (11S, E0628476, N4380089): Sample Localities M, O, and P are located on the north and east side of Dry Mountain, a northern arm of the White Pine range on the southwest side of Long Valley. The Arcturus Formation and Rib Hill Sandstone (Permian units) occur at Sample Localities M, O, and P, overlying Riepe Spring Limestone and Ely Limestone (Pennsylvanian and Permian units) at Sample Locality P. The Rib Hill Sandstone and Arcturus Formation both include some interbeds of platy limy siltstone (Hose and Blake 1976:15), which likely accounts for the tabular samples obtained from Sample Localities M and O. The Riepe Spring Limestone and Ely Limestone contain abundant nodules, concretions, lenses, and bands of chert, which likely accounts for the specimens obtained from Sample Locality P.

Specimens from Sample Locality M are typically medium light gray (N6) to pale red (5R 6/2) with grayish red purple (5RP 4/2) banding (Figure 5.43, at top). Specimens are a conglomerate of poorly-sorted megascopic quartz/quartzite, feldspar, and lithic clasts. Specimens exhibit fine to medium texture, dull to medium luster, and low to medium translucency (2-6 mm). Banding on these specimens exhibits a light green fluorescent response to shortwave ultraviolet light.

Specimens from Sample Locality O (Figure 5.43, at bottom) are typically moderate yellowish brown (10YR 5/4) to dark yellowish orange (10YR 6/6). Specimens exhibit moderately-sorted organic and lithic clasts, dull luster, medium texture, and high translucency (10-21 mm), especially on more orange specimens. Cortex is very pale orange (10YR 8/6). Lighter specimens exhibit an orange fluorescent response to shortwave and longwave ultraviolet light.

Specimens from Sample Locality P are typically a tabular medium light gray chert (N6) mottled with brownish gray (5YR 4/1), with poorly sorted megascopic quartz and lithic clasts. Specimens exhibit coarse texture, dull luster, and low translucency (1.5 mm). Cortex is a yellowish gray (5Y 8/1). Brownish gray sections exhibit a light green fluorescent response to shortwave ultraviolet light.

Figure 5.43: Sample Locality M (at top) and Sample Locality O (at bottom). Scale in cm. (Sample Locality P is not pictured.)

Other chert-bearing geological formations were surveyed around southern Long Valley in particular, although chert was not apparent at these localities. For example, I attempted to trace the chert evident at Sample Localities 21 and 23 south to the Diamond Peak Formation from which I suppose it derives in the northern Butte Mountains, but to no avail. Additionally, the Arcturus Formation and Rib Hill Sandstone (Permian units), which contain siltstone, occur on the west side of Dry Mountain, opposite of Sample Locality O; however, no chert was evident here. Finally, Arcturus Formation, Rib Hill Sandstone, Riepe Spring Limestone, and Ely Limestone (Pennsylvanian and Permian units) occur throughout the southeastern Ruby Mountains, west and southwest of Sample Locality 20. The Riepe Spring Limestone and Ely Limestone, in particular, contain abundant nodules, concretions, lenses, and bands of chert; however, no chert was evident at these locations.

RAILROAD VALLEY

Railroad Valley occurs mostly in northern Nye County, although the northern end of the valley reaches into White Pine County. Railroad Valley is bounded on the west primarily by the Pancake Range and on the east by the northern extension of the Quinn Canyon Range, Grant Range, Horse Range, and southern extension of the White Pine

Range. Zancanella (1988) records several Paleoarchaic surface lithic scatters located along the course of Bull Creek in northern Railroad Valley. As discussed in Chapter 4, the Paleoarchaic inhabitants of Butte and Jakes valleys appear to have been familiar with the toolstone available in Railroad Valley, as FGV artifacts derive from the Little Smoky Quarry and Duckwater sources at the north end of the valley (Figure 4.8).

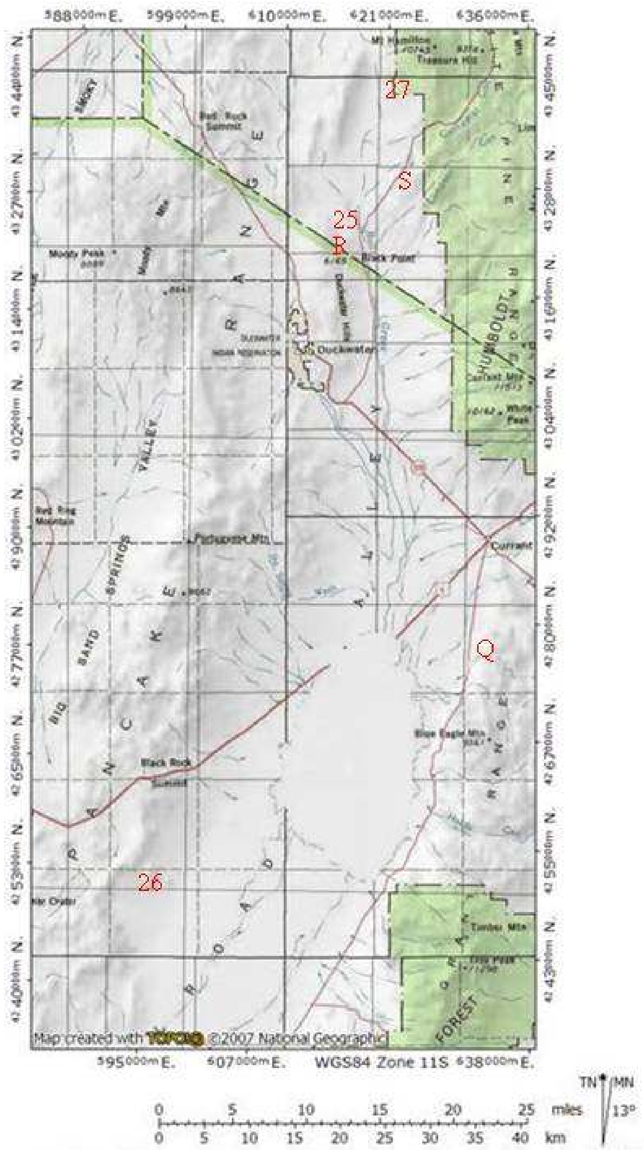


Figure 5.44: Map of chert-bearing geological formations surveyed and sampled around Railroad Valley. Numbers designate localities from which geological samples were procured and analyzed geochemically. Letters designate localities surveyed but not analyzed geochemically.

Sample Locality 25 (11S, E0620904, N4324536): Sample Locality 25 is located on the east side of the north end of the Duckwater Hills. Riepe Spring Limestone and Ely Limestone (Pennsylvanian and Permian units) occur at this locality. These limestone units contain abundant nodules, concretions, lenses, and bands of chert (Hose and Blake 1976:14). Nodules that occur at this locality are small (i.e., less than the size of a baseball); however, flaking debris is not evident.

Specimens are typically brownish gray (5YR 4/1), although some are moderate yellowish brown (10YR 5/4) and dark reddish brown (10R 3/4); many exhibit moderately-sorted schist and quartz clasts (Figure 5.45). Specimens exhibit fine to coarse texture, dull to medium luster, and low translucency (2-3 mm). Cortex is a coarse, dark reddish brown (10R 3/4). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 5.45: Sample Locality 25. Scale in cm.

Sample Locality 26 (11S, E0599816, N4251387): Sample Locality 26 is located at a knob just east of The Wall, on the east side of the Pancake Range. The Nevada Formation (a Devonian unit) occurs at this locality. The Nevada Formation in northern Nye County is typified by both limestone and dolomite (Kleinhampl and Ziony 1985:73). Chert is rare in the Nevada Formation, although it occurs in the form of dark gray to black lenses and stringers in the Pancake Range about 19 km (12 miles) southwest of Lockes (Kleinhampl and Ziony 1985:74), which is where Sample Locality 26 is located. Many artifacts of grey chert occur at this locality, although these artifacts do not seem to be derived from this locality (Figure 5.46, top).

Specimens are typically a homogeneous reddish brown (10R 3/4) or yellowish gray (5Y 8/1), with a few specimens reflecting a combination of these, resulting in a pale reddish purple (5RP 6/2) (Figure 5.46, bottom). Specimens exhibit fine to medium texture, dull luster, and low translucency (1.5-2 mm). Cortex is a coarse dark reddish brown (10R 3/4) or grayish orange pink (5YR 7/2). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 5.46: Sample Locality 26. At top, orange fieldbook is 18 cm long. At bottom, scale in cm.

Sample Locality 27 (11S, E0619319, N4343780): Sample Locality 27 is located on the west side of the White Pine Range, just west of the Shermantown and Eberhardt sites. Riepe Spring Limestone and Ely Limestone (Pennsylvanian and Permian units), which contain abundant nodules, concretions, lenses, and bands of chert, occur at this locality. Abundant nodules of softball-sized gray chert was evident here (Figure 5.47, top), although flaking debris was not evident.

Specimens are typically yellowish gray (5Y 8/1), though some pieces are mottled with medium light gray (N6) and iron-stained (Figure 5.47, bottom). Specimens exhibit fine texture, medium luster, and high translucency (11-18 mm). Cortex is a coarse yellowish gray (5Y 8/1). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 5.47: Sample Locality 27. At top, orange fieldbook is 18 cm long. At bottom, scale in cm.

Sample Locality Q (11S, E0628673, N4271125): Sample Locality Q is located on the west side of the Grant Range, just east of the Blue Creek Ranch. Simonson Dolomite (a Devonian unit), which includes a finely crystalline dark- to medium-gray dolomite (Hose and Blake 1976:11) occurs at this locality. So described, I thought this dolomite might be knappable; however, this seems unlikely without further silicification.

Specimens are typically medium gray (N5) to medium dark gray (N4), with some megascopic quartz. Specimens exhibit coarse texture, dull luster, and minimal translucency (~0 mm). Cortex is a coarse, yellowish gray (5Y 8/1). The cortex of some specimens exhibits a light green fluorescent response to shortwave ultraviolet light.

Figure 5.48: Sample Locality Q. Scale in cm.

Sample Locality R (11S, E0618392, N4319530): Sample Locality R is located on the east side of the north end of the Duckwater Hills, just south of Sample Locality 26. Devils Gate Limestone, a Devonian unit equivalent in lithology and age to the Guilmette Formation, occurs at this locality. Small pebbles of chalcedony with botryoidal crust are evident here; however, they are not tool-quality. Flaking debris is not evident.

Specimens are typically very light gray (N8) to light bluish gray (5B 7/1). Specimens exhibit medium to coarse texture, dull luster, and high translucency (9-12 mm). Specimens exhibit a light green fluorescent response to shortwave ultraviolet light.

Figure 5.49: Sample Locality R. Scale in cm.

Sample Locality S (11S, E0622646, N4329173): Sample Locality S is located on the west side of the White Pine Range, just south of Green Springs. The Guilmette Formation, a Devonian unit equivalent in lithology and age to the Devils Gate Limestone as described for Sample Locality R, occurs at this locality; however, no chert or silicified dolomite is evident. Thus, no sample was taken at this locality.

COAL VALLEY

Coal Valley straddles the boundary between northwestern Lincoln County and northeastern Nye County (Figure 5.50). Coal Valley is bounded on the east by the Seaman Range, on the west by the Golden Gate Range, on the south by the northern slope of the North Pahrangat Range, and on the north by the alluvial divide between the north ends of the Seaman and Golden Gate Ranges (Busby 1979:9). A series of discrete, surface lithic scatters are present in the central southern portions of Coal Valley, occurring in severely deflated zones along old shorelines and beach terraces associated with the now dry Coal Valley Pleistocene lake (Busby 1979:101).

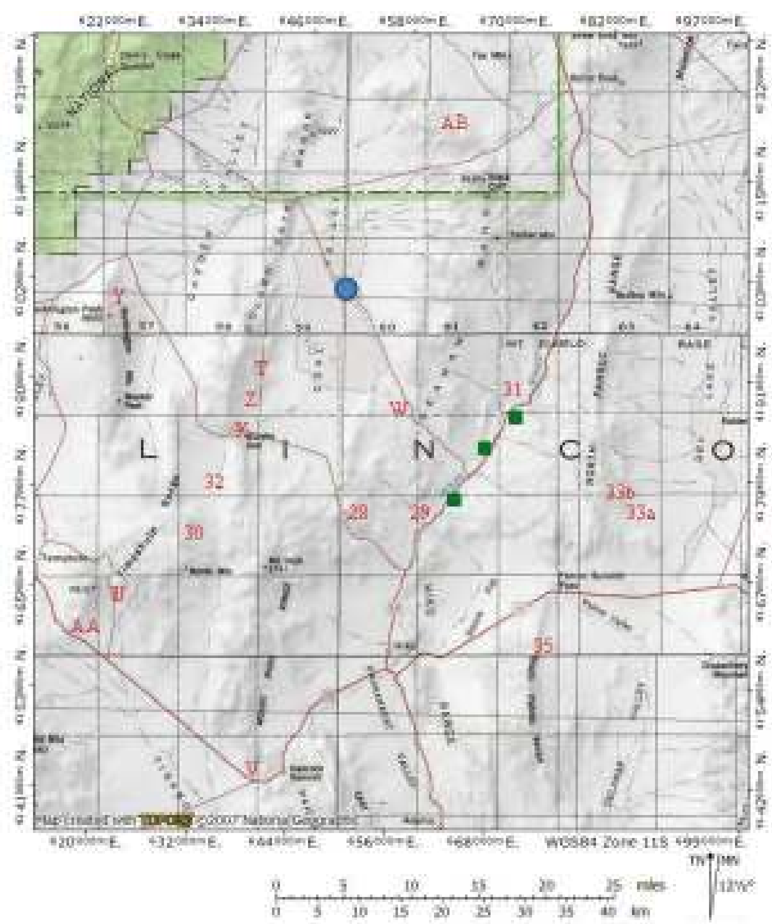


Figure 5.50: Map of chert-bearing geological formations surveyed and sampled around Coal Valley. Numbers designate localities from which geological samples were procured and analyzed geochemically. Letters designate localities surveyed but not analyzed geochemically. Green squares represent chert-bearing geological formations that were surveyed, but at which chert was not evident. The blue circle marks the location of a Paleoarchaic site.

Sample Locality 28 (11S, E0651118, N4174519): Sample Locality 28 is located in the northeastern Mount Irish Range at Mail Summit. The Guilmette Formation (a Devonian unit) underlies undifferentiated, Tertiary volcanic rocks at this location. The basal unit of the Guilmette Formation includes a thick bed of silty dolomite (Tschanz and Pampeyan 1970:36) that may have been subject to further silicification at this locality. Previously recorded as a quarry in the BLM literature, this sample locality includes abundant chert and quartzite nodules, as well as flaking debris (Figure 5.51, top and middle).

Figure 5.51: Sample Locality 28. At top and middle, orange fieldbook is 18 cm long. At bottom, scale in cm.

Specimens from this sample locality occur in two basic forms: (a) Specimens are typically moderate reddish brown (10R 4/6) mottled with moderate reddish orange (10R 6/6) to dark reddish brown (10R 3/4). Some specimens exhibit carbonaceous inclusions. Specimens exhibit fine texture, dull luster, and high translucency (11-16 mm), at least on lighter red sections. Cortex is a platy, very pale orange (10YR 8/2). Some specimens exhibit a light green fluorescent response to shortwave ultraviolet light. (b) Specimens are typically moderate yellowish brown (10YR 5/4), mottled with dark yellowish brown (10YR 4/2), dark yellowish orange (10YR 6/6), and dusky yellowish brown (10YR 2/2), some with few carbonaceous inclusions. Specimens exhibit fine texture, dull to medium luster, and low to medium translucency (2-11 mm). Cortex is a very pale orange (10YR 8/2). Light sections of some specimens exhibit a light green fluorescent response to shortwave ultraviolet light.

Sample Locality 29 (11S, E0661418, N4173992): Sample Locality 29 is located near the contact of the northeast Mount Irish Range and southeast Seaman Range, just southeast of Fossil Peak. Although the southern portion of the Seaman Range is composed primarily of Tertiary volcanic rocks and tuff, large nodules of chert are readily apparent in lobate formations (Figure 5.52, top) tucked in amongst these volcanic units. In fact, several Devonian and Mississippian units crop out beneath the volcanic rocks at both ends of the range (Tschanz and Pampeyan 1970:95) and the Silurian and Devonian rocks south of Fossil Peak are thrust over Ordovician rocks. More specifically, the Guilmette Formation (a Devonian unit) occurs at this locality, where it overlies Laketown Dolomite (a Silurian unit), Ely Springs Dolomite, and Eureka Quartzite (both Ordovician units). The Guilmette Formation includes silty dolomite from which the chert nodules may be derived; however, the Laketown Dolomite, Ely Springs Dolomite, and Eureka Quartzite all include cherty beds (Tschanz and Pampeyan 1970:27, 28, 30). While this sample locality does not seem to exhibit the lithology characteristic of the Eureka Quartzite (Tschanz and Pampeyan 1970:27), the complex structure exhibited by these units south of Fossil Peak is difficult to decipher (Tschanz and Pampeyan 1970:99). This sample locality is recorded in the Nevada BLM literature as chert acquisition site 26LN4605.

Specimens are typically light brown (5YR 5/6), with moderately-sorted feldspar and opaques (Figure 5.52, bottom). Specimens exhibit fine to medium texture, medium to shiny luster, and medium translucency (7 mm). Cortex is very pale orange (10YR 8/2). Some specimens exhibit a light green fluorescent response to shortwave ultraviolet light.

Figure 5.52: Sample Locality 29. Scale in cm.

Sample Locality 30 (11S, E0632029, N 4173915): Sample Locality 30 is located in the middle of the Timpahute Range, north of Monte Mountain and southwest of Sample Locality 32 in Wildhorse Valley. Outcrops attributable to the Eureka Quartzite (an Ordovician unit) occur at this locality. In the western parts of Lincoln County, the lower 50 to 150 feet of this unit “are composed of varicolored quartzite that commonly weathers brownish, yellowish, or yellowish-brown” (Tschanz and Pampeyan 1970:27), much as depicted in Figure 5.53 (top). Evidence of assay, as well as a large amount of quartzite, chert, and obsidian flakes, is evident at this sample locality.

Specimens vary in color from medium gray (B5) with poorly-sorted quartz clasts to light olive gray to mottled grayish orange (10YR 7/4), and dark yellowish orange (10YR 6/6) with moderately sorted feldspar and opaque clasts to moderate orange pink (5YR 8/4) to moderate reddish brown (10R 4/6) with macroscopic quartz clasts (Figure 5.53, bottom). Gray specimens exhibit fine to coarse texture, dull to shiny luster (quartzite is more lustrous), and medium translucency (6-8 mm). Orange specimens exhibit fine to medium texture, medium luster, and medium translucency (5-11 mm). Pink specimens are more translucent (13-16 mm), with medium to coarse texture, and medium to shiny luster. Cortex is a pale yellowish brown (10YR 6/2). Some orange specimens exhibit a light green fluorescent response to shortwave ultraviolet light.

Figure 5.53: Sample Locality 30. Scale in cm.

Sample Locality 31 (11S, E0671929, N4189836): This sample locality is located on the east side of the Seaman Range near the White River Narrows. The BLM literature documents white chert locally available in alluvial deposits at this locality (recorded as site 26LN4610); however, the locality does not appear to include many chert nodules. The chert nodules that do occur here may be derived from Pilot Shale, Chainman Shale, or Scotty Wash Quartzite (Devonian and Mississippian units), all of which include bedded cherts, cherty limestone, siltstone, and/or quartzite (Tschanz and Pampeyan 1970:42, 48, 52), though the Pilot Shale seems the most likely candidate.

Presumably due to the secondary, alluvial context in which they occur, specimens from this locality are quite variable (Figure 5.54): (a) Some specimens are moderate brown (5YR 3/4) with light brown (5YR 6/4) streaks and moderately-sorted carbonaceous and quartz clasts. These specimens exhibit fine texture, dull luster, and medium translucency (4 mm). (b) Some specimens are moderate yellowish brown (10YR 5/4) with carbonaceous streaks. These specimens exhibit fine texture, medium luster, and high translucency (14 mm). (c) Some specimens are dark yellowish brown (10YR 4/2) mottled with very pale orange (10YR 8/2). These specimens exhibit fine texture, dull luster, and medium translucency (4 mm). (d) Some specimens are mottled very light gray (N8), very pale orange (10YR 8/2) and light brown (5YR 5/6). These specimens exhibit fine texture, medium luster, and medium translucency (7 mm). (e) Some specimens are dark yellowish brown (10YR 4/2) mottled with dark yellowish orange (10YR 6/6) and very dark red (5R 2/6) with moderately-sorted schist clasts. These specimens exhibit fine texture, dull luster, and medium translucency (7 mm). Cortex is very pale orange (10YR 8/2) to pale yellowish orange (10YR 8/6) to light brown (5YR 5/6). Specimens with light brown streaks exhibit a light green fluorescent response to shortwave ultraviolet light.

Figure 5.54: Sample Locality 31. Scale in cm.

Sample Locality T (11S, E0642046, N4190545): Sample Locality T is located on the east side of the Golden Gate Range, west of Murphy Gap Reservoir. Previously recorded as a chert source (CRNV-04-3783) by Colin Busby, red, yellow, and white cherts occur on an east facing alluvial fan emanating from the Golden Gate Range. The bedrock of the Golden Gate Range consists primarily of Paleozoic units, including the Guilmette Formation, Pilot Shale, Chainman Shale, Scotty Wash Quartzite, Mississippian limestone, and Pennsylvanian limestone; however, chert is not particularly abundant at this locality. In fact, my field crew and I walked a 3 km transect along the east front of the Golden Gate Range ending at Sample Locality T, crossing a series of alluvial fans, yet few cobbles of chert and/or quartzite, or artifacts (maximum density of <1 flake/sq. m) were noted.

The few specimens that were collected are moderate brown (5YR 4/4) and yellowish gray (5Y 8/1) to dark yellowish brown (10YR 6/6), though some grayish red (5R 4/2) occurs (Figure 5.55). Yellowish gray specimens are more quartzitic; otherwise these specimens include moderately-sorted megascopic quartz. Specimens exhibit medium to coarse texture, dull to medium luster, and low translucency (2-2.5 mm). Cortex is moderately yellowish brown (10YR 5/4) to light brown (5YR 5/6). Some moderate brown specimens exhibit a light green fluorescent response to shortwave ultraviolet light.

Figure 5.55: Sample Locality T. Scale in cm.

Sample Locality U (11S, E0622816, N4164458): Sample Locality U occurs in the southwest Timpahute Range, just south of the Tempiute site. The Guilmette Formation (a Devonian unit) occurs at this locality, where it includes "conspicuously more quartzite than in the surrounding region" (Tschanz and Pampeyan 1970:96). Few nodules of quartzite occur at this locality, although no flaking debris is apparent.

Specimens are typically very light gray (N8) to pale brown (5YR 5/2) quartzite with moderately-sorted megascopic quartz clasts (Figure 5.56). Specimens exhibit coarse texture, dull luster, and low translucency (< 2 mm). Cortex is a moderate brown (5YR 4/4 and 5YR 3/4). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 5.56: Sample Locality U. Scale in cm.

Sample Locality V (11S, E0641845, N4142058): Sample Locality V occurs southwest of Hancock Summit, at the south end of the Mount Irish Range. The Guilmette Formation (a Devonian unit) occurs at this locality, and includes silty dolomite and quartzite. Small chert and quartzite nodules were evident, although only one red flake was found at this locality.

Specimens are primarily yellowish gray (5Y 7/2) to grayish orange (10YR 7/4) with moderately-sorted quartz clasts (Figure 5.57). Some specimens are moderate pink (5R 7/4) quartzite with moderately-sorted macroscopic quartz and siltstone clasts. Specimens exhibit coarse texture, dull to shiny luster, and medium to high translucency (9-17 mm), with lighter colors more translucent. Cortex is a coarse grayish orange (10YR 7/4). Some grayish orange specimens exhibit a light green response to shortwave ultraviolet light.

Figure 5.57: Sample Locality V. Scale in cm.

Sample Locality W (11S, E0658104, N4187212): Sample Locality W is located at the south end of the Seaman Range, on the south side of Seaman Wash. Devonian and Mississippian units ranging from the Sevy Dolomite to the Scotty Wash Quartzite crop out at the south end of the Seaman Range. Thin lenses including some poor-quality chert conglomerate occur at this locality. Only a few red chert flakes were evident here.

Specimens are primarily moderate reddish brown (10R 4/6) and moderate yellowish brown (10YR 5/4), though more quartzitic specimens are medium gray (N5) (Figure 5.58). Specimens exhibit medium texture, dull luster, and low to medium translucency (3-6 mm). Cortex is a coarse brownish gray (5YR 4/1) to light brown (5YR 5/6). Reddish brown specimens exhibit a light green fluorescent response to shortwave ultraviolet light.

Figure 5.58: Sample Locality W. Scale in cm.

Sample Locality X (11S, E0639103, N4183591): Sample Locality X is located on the east side of the south end of the Golden Gate Range, at Murphy Gap. Chert nodules occur as float in alluvium. The middle and upper part of the Laketown Dolomite (a Silurian unit) includes chert nodules that may account for the chert present at this locality (Tschanz and Pampeyan 1970:30). A variety of obsidian and chert artifacts, including a Rosegate point, occur at this locality.

Specimens are typically very light gray (N8) with well-sorted feldspar and quartz clasts and iron staining (Figure 5.59). Specimens exhibit coarse texture, medium luster, and high translucency (30-35 mm). Cortex is pale yellowish brown (10YR 6/2). A few specimens are olive gray (5Y 4/1), with moderately-sorted megascopic quartz and schist clasts. These specimens exhibit coarse texture, medium luster, and low translucency (3 mm). The very light gray specimens exhibit a light green fluorescent response to shortwave ultraviolet light.

Figure 5.59: Sample Locality X. Scale in cm.

Sample Locality Y (11S, E0624389, N4200586): Sample Locality Y occurs on the east side of the northern Worthington Mountains, just southeast of Feiberg Mine. The rocks at the north end of the Worthington Mountains are highly faulted dolomite and quartzite, mostly of Devonian Age (Tschanz and Pampeyan 1970:96). The Eureka Quartzite (an Ordovician unit) also occurs at this locality, and may account for the quartzites noted here. No flaking debris was observed at this locality, however.

Quartzite specimens are typically medium light gray (N6) and medium gray (N5), interspersed with grayish red purple (5RP 2/2) to very dusky purple (5RP 2/2) to pinkish gray (5YR 8/1), and exhibit poorly-sorted megascopic quartz, feldspar and schist clasts (Figure 5.60). Specimens exhibit coarse texture, dull luster, and minimal translucency (~0 mm). Cortex is often purplish to pinkish gray (5RP 4/2 to 5YR 8/1). Specimens do not exhibit a discernible ultraviolet fluorescent response.

Figure 5.60: Sample Locality Y. Scale in cm.

Sample Locality Z (11S, E0641075, N4188359): Sample Locality Z is located at the southeast end of the Golden Gate Range, south of Sample Locality T. Eureka Quartzite (an Ordovician units) occurs at this locality, and includes varicolored quartzite that commonly weathers brownish, yellowish, or yellowish brown (Tschanz and Pampeyan 1970:27).The nodules recovered from this locality, some softball-sized, likely derive from this unit. No flaking debris was evident at this locality, however.

Specimens are typically brownish gray (5YR 4/1) and pale yellowish brown (10YR 6/2), mottled with moderate orange pink (10R 7/4) and poorly-sorted megascopic quartz, feldspar clasts, and opaques (Figure 5.61). Specimens exhibit coarse texture, dull luster, and low translucency (4 mm). Cortex is dark yellowish orange (10YR 6/6). Some specimens exhibit orange speckling in response to ultraviolet light due to the megascopic quartz.

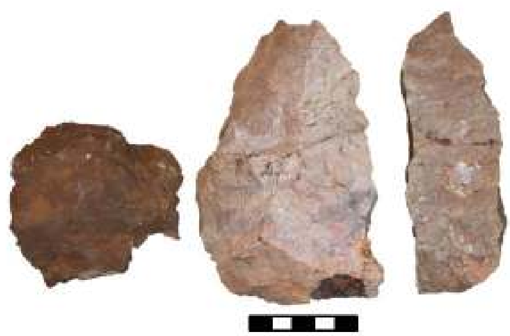


Figure 5.61: Sample Locality Z. Scale in cm.

Sample Locality AA (11S, E0619590, N4158807): Sample Locality AA is located at the southwest end of the Timpahute Range, at Coyote Summit. The Pogonip Group (a Devonian unit) occurs at this locality. The Pogonip Group consists chiefly of limestone, with some beds containing abundant chert lenses and nodules (Tschanz and Pampeyan 1970:24). A few orange and red chert cobbles are evident at this locality, although flaking debris is absent.

Sample Locality AB (11S, E0664385, N4221149): Sample Locality AB is located on the east side of the northern Seaman Range, north of Timber Mountain Pass. Sevy Dolomite (a Devonian unit) occurs at this locality. The Sevy Dolomite is a homogeneous, microcrystalline dolomite that exhibits conchoidal fracture and includes cherty, argillaceous dolomite in western Lincoln County (Tschanz and Pampeyan 1970:33). No chert was evident at this locality; thus, no sample was taken.

Finally, a series of archaeological sites located along the east side of the Seaman Range have been noted in the survey of a fiberoptic line running along Route 318 from Sunnyside to Alamo. Some of these have been dubbed chert acquisition sites and include numerous chert nodules (e.g., Sample Localities 29 and 31); however, many are less productive.

SUPPLEMENTAL LOCALITIES

Some other chert-bearing geological formations were sampled in the vicinity of Coal Valley, informed by the geological bulletins published by the Nevada Bureau of Mines and Geology and local informants.

Sample Locality 32 (11S, E0635679, N4176326): Sample Locality 32 is located in the northwest Mount Irish Range, south of Murphy Gap. Here chert nodules (many softball-sized) occur in a southwest-northeast trending alluvial fan that juts into Wild Horse Valley. The chert is likely derived from the base of the Guilmette Formation (a Devonian unit) that outcrops upslope. Only a handful of flakes were evident at this locality.

Figure 5.62: Sample Locality 32. Scale in cm.

Specimens are primarily moderate yellowish brown (10YR 5/4) with moderately-sorted opaques, and grayish black (N2) with brownish gray (5YR 4/1) streaks and moderately-sorted schist and quartz clasts (Figure 5.62). Also some specimens are moderate orange pink (10R 7/4) with grayish red purple (5RP 4/2) and grayish black (N2) streaks. Specimens exhibit fine texture, dull to medium luster, and variable translucency (4 mm in grayer specimens to 6 mm in orange/red specimens). Cortex is very pale orange (10YR 8/2) to dark yellowish brown (10YR 4/2). Brownish gray sections on some specimens exhibit a dark green fluorescent response to ultraviolet light.

Sample Locality 33a (Locus A: 11S, E0686366 N4177142; Locus B: 11S, E0682359, N 4178844): Sample Locality 33 is located along the east side of the south end of the North Pahroc Range (Figure 5.63, top). The Guilmette Formation (a Devonian unit) occurs at these localities, in close association with younger (Tertiary), undifferentiated volcanic rocks. The silty dolomite characteristic of the base of the Guilmette Formation (Tschanz and Pampeyan 1970:36) has seemingly been further silicified by subsequent metamorphism. These cherty outcrops occur along an alluvial fan and include some very large cobbles (bowling-ball sized), especially at Locus B.

Figure 5.63: Sample Locality 33, Locus A. At top, orange fieldbook is 18 cm long. At bottom, scale in cm.

Specimens from Locus A (Figure 5.63, bottom) are typically dark gray (N3) with some specimens exhibiting very dusky purple (5RP 2/2) bands and quartz clasts, others exhibiting light brown (5YR 5/6) streaks, and still others mottled with dark yellowish orange (10 YR 6/6). Some specimens are more fully dark yellowish orange (10YR 6/6) with moderately-sorted carbonaceous clasts. Other chert specimens are mottled moderate reddish brown (10YR 4/6) and dark reddish brown (10R 3/4) with moderately-sorted carbonaceous clasts. Specimens exhibit fine texture, dull to medium luster (with gray specimens more lustrous), and low translucency (1-4 mm). Specimens with light brown streaks exhibit a light green fluorescent response to shortwave ultraviolet light.

Specimens from Locus B (Figure 5.64) are typically dark gray (N3), some with brownish gray (5YR 4/1) to yellowish gray (5Y 8/1) streaks and few moderately-sorted light gray (N7), translucent quartz clasts. Specimens exhibit fine texture, medium luster, and little translucency except for larger quartz inclusions. The cortex is dark yellowish brown (10YR 4/2), which is quite translucent (12-14 mm). Brownish gray and yellowish gray streaks exhibit a light green fluorescent response to shortwave ultraviolet light.

Figure 5.64: Sample Locality 33, Locus B. Scale in cm.

Sample Locality 34 (11S, E0684152, N4050293): Sample Locality 34 is located on an isolated knob at the south end of the Las Vegas Range (Figure 5.65). Large chert nodules and flaking debris is abundant (Figure 5.66). In fact, archaeology classes at the University of Nevada, Las Vegas procure cobbles from this source to practice flintknapping. These nodules presumably derive from Cambrians units that outcrop at the south end of the Las Vegas Range, "consist chiefly of bristly weathering siliceous, crystalline, chert limestone, often having a peculiar mottled structure" (Spurr 1903:155). Specimens are typically grayish black (N2) with a brownish gray (5YR 4/1) cortex, and develop a distinctive brown patina (Figure 5.66). Specimens exhibit fine texture, medium luster, and no translucency. Specimens do not exhibit a discernible ultraviolet fluorescent response.

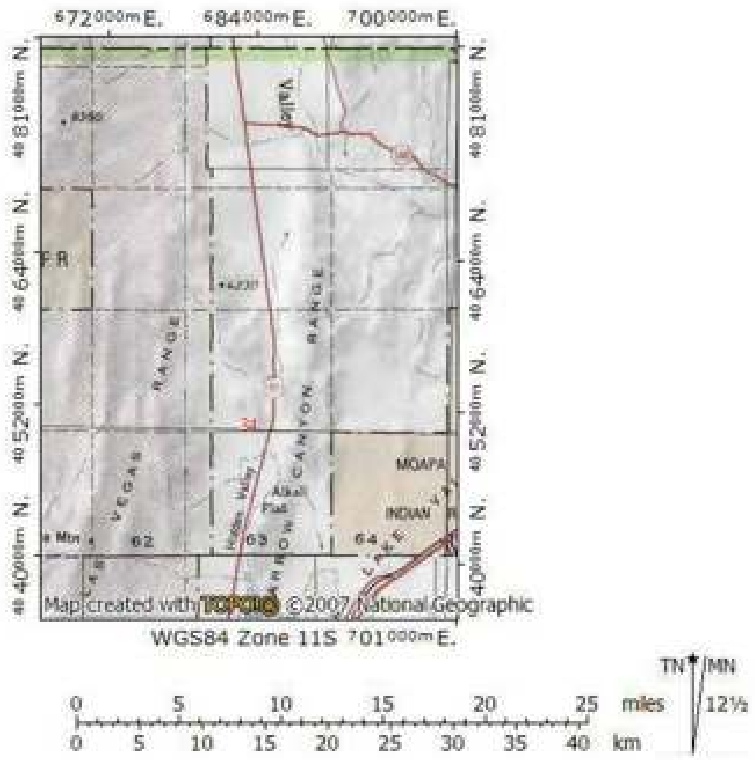


Figure 5.65: Map showing the location of Sample Locality 34, located south of Coal Valley.

Figure 5.66: Sample Locality 34. At top, orange fieldbook is 18 cm long. At bottom, scale in cm.

Sample Locality 35 (11S, E0675714, N4158476): Sample Locality 35 is located on the east side of the north end of the South Pahroc Range. Volcanic sections in this part of the South Pahroc Range, which are probably Oligocene or Miocene in age, include black chert, silicified limestone, and quartzite in sequence with obsidian and perlite (Tschanz and Pampeyan 1970:101). Some small brown and purple chert and quartzitic nodules were recovered near perlite mines, though no flaking debris was evident.

Specimens are typically grayish red (5R 4/2) to brownish gray (5YR 4/1) with medium light gray (N6), moderately-sorted quartz inclusions. Specimens exhibit fine texture, medium luster, and minimal translucency (0.5 mm). Cortex is brownish gray (5YR 4/1). Specimens do not exhibit a discernible ultraviolet fluorescent response. This chert may prove too brittle for tool manufacture.

Figure 5.67: Sample Locality 35. Scale in cm.

Sample Locality 36: These samples are from Tosawihi, a large prehistoric quarry complex in Elko County (Lyons et al. 2003:Figure 1) that was used intensively during the late prehistoric period (Elston and Raven 1992a, 1992b). Comprising an upper part of the vertically zoned Hollister Gold Deposit, Tosawihi opalite is silica formed in volcanic units by hydrothermal replacement (Lyons et al. 2003).

Specimens are typically light gray (N7) to yellowish gray (5Y 8/1), with well-sorted feldspar and quartz clasts (Figure 5.68). Specimens exhibit fine, soft texture, dull luster, and medium translucency is (8-11 mm). Cortex is very pale orange (10YR 8/2).

Figure 5.68: Sample Locality 36. Scale in cm.

INITIAL IMPRESSIONS OF THE CHERT OUTCROPS IN EAST-CENTRAL NEVADA

In Butte Valley, survey and sampling focused especially around Hunter's Point and in the southern Cherry Creek Range, as chert-bearing geological formations in these areas would be close to the Paleoarchaic localities recorded in southern Butte Valley. Additionally, previous fieldwork had identified chert outcrops in this area, as at Sample Locality 4. Interestingly, tool-quality chert does occur across the valley on the east side of the Butte Mountains; future research will expand survey and sampling of chert-bearing geological formations farther south in the Butte Mountains.

In Jakes Valley, survey and sampling focused toward the south end of the valley given the proximity to Limestone Peak Locality 1. Several sample localities in Jakes Valley yielded tool-quality chert, although not all of these localities evidenced prehistoric utilization. Future research will expand survey and sampling of chert bearing geological formations farther south in the White Pine Range.

In Long Valley, survey and sampling focused on the southern end of the valley given the proximity to the Sunshine Locality. Future research will include the survey and sampling of chert-bearing geological formations farther north. In particular, samples will be obtained from Mooney Basin Quarry (recorded in BLM reports as site 46-7249), which is located on the east side of the Ruby Mountains, northwest of Sample Locality 22 and south of Sample Locality 24. Unfortunately, geological samples could not be obtained for the present research because of heavy mining activity in this area, despite attempts to coordinate sample procurement with mine administrators. Four primary extraction locations have been identified at the Mooney Basin Quarry, including: (a) finely banded grey chert, (b) brecciated chert, and (c) red and yellow "jasperoids." The brecciated chert and red and yellow jasperoids show evidence of extraction, although they seem to have been utilized less than the finely banded grey chert.

My efforts in Railroad Valley were less intensive than in Butte, Jakes, and Long valleys. Here, survey and sampling of chert-bearing geological formations focused in northern end of the valley, where FGV sources utilized by Paleoarchaic hunter-gatherers from Butte and Jakes valleys are located. Future research will expand this survey within the Pancake and Grant ranges, in particular.

In Coal Valley and vicinity, tool-quality cherts and quartzites are particularly abundant at sample localities in the south end of the valley. Future research will expand survey and sampling of chert-bearing geological formations northward in the Seaman Range; Paleozoic units in the Golden Gate Range do not appear to yield much tool-quality chert.

Based on this survey, I offer a few observations regarding how the geological-geographic distribution of chert outcrops may have influenced Paleoarchaic mobility and toolstone procurement. First of all, chert-bearing geological formations are widespread in the Eastern Nevada Study Area, but tool-quality chert is not. In many cases, some of the "best looking" chert occurs in locations where the parent unit may have been altered due to hydrothermal or other metamorphic activity that induced silicification, increasing the flakeability and homogeneity of these cherts. Many of the lesser quality cherts, by comparison, are heavily weathered, small, and/or riddled with microfractures, making them difficult to flake. Second, chert does not seem to have been widely distributed as secondary sources. After walking several stream beds and relict landforms within the foraging radii defined above, it does not seem that chert is often redistributed beyond the margins of alluvial fans emanating from the mountain ranges that bound Butte, Jakes, Long, Railroad, and Coal valleys (for a similar conclusion in western Nevada, see Kelly 2001:73). These two observations suggest that cherts are not as readily available over the eastern Nevada landscape as many archaeologists have assumed and therefore the procurement and use of chert should be incorporated into our models of Paleoarchaic mobility and technological organization at the same level of sophistication with which we treat obsidian and FGVs.

In Chapter 4 I use macroscopic properties to define chert subgroups (MANs) from the artifacts present in the Paleoarchaic localities in the Eastern Nevada Study Area. Because of the macroscopic similarities exhibited by cherts from different sample localities, however, linking these chert artifacts to their sources will require a combination of macroscopic, microscopic, and compositional data, at least in most cases. Additionally, fluorescent responses to shortwave and longwave ultraviolet light does not seem particularly useful for distinguishing chert from these sample localities either because many of the sample localities exhibit the same fluorescent responses (also see

Church 1994). Thus, I turn next to the compositional analysis of geological samples, using both LA-ICP-MS and PXRF, derived from several of these sample localities (Table 5.1).

Table 5.1: Number of geological samples and artifacts analyzed using LA-ICP-MS and/or PXRF. (continued on next page)

Sample Locality	**See Figure…**	**Number of Samples Analyzed using LA-ICP-MS**	**Number of Samples Analyzed using PXRF**
1c	5.4	4	5
2a	5.4	4	12
2b	5.4	4	8
3	5.4	4	7
4	5.4	5	9
5	5.4	4	7
6	5.4	4	8
7	5.4	0	2
8	5.4	4	6
9	5.21	10 (5 gray, 5 white)	16 (8 gray, 8 white)
10	5.21	4	8
11	5.21	5	8
13a	5.21	4	5
13b	5.21	4	6
14a	5.21	4	5
14b	5.21	4	8
15	5.21	4	9
16b	5.21	4	7
17	5.21	4	8
18	5.21	4	8
19	5.21	5	5
20	5.35	9	18
21	5.35	5	10
22	5.35	5	10
23	5.35	4	8
24	5.35	15 (4 orange, 4 red, 4 gray, 3 purple)	31 (8 orange, 9 red, 7 gray, 7 purple)
25	5.44	2	3
26	5.44	3	5
27	5.44	4	7
28	5.50	9 (6 red, 3 orange/brown)	10 (6 red, 4 orange/brown)

Table 5.1 (continued): Number of geological samples and artifacts analyzed using LA-ICP-MS and/or PXRF.

Sample Locality	See Figure…	Number of Samples Analyzed using LA-ICP-MS	Number of Samples Analyzed using PXRF
29	5.50	4	6
30	5.50	4	8
31	5.50	4	7
32	5.50	4	6
33a	5.50	3	10
33b	5.50	4	7
34	5.65	2	2
35	5.50	0	6
36	Lyons et al. (2003:Fig. 1)	2	4
CCL1	4.1, 5.4	0	1
CCL2	4.1, 5.4	0	3
CCL3	4.1, 5.4	0	5
CCL4	4.1, 5.4	0	4
CCL5	4.1, 5.4	0	30
CCL7	4.1, 5.4	0	1
CCL8	4.1, 5.4	0	9
CCL9	4.1, 5.4	0	33
WSWL1	4.1, 5.4	0	15
HPL1	4.1, 5.4	0	12
HPL2	4.1, 5.4	0	20
HPL3	4.1, 5.4	0	45
HPL5	4.1, 5.4	0	51
LPL1	4.1, 5.21	0	26

Compositional Analysis

Prior to analyzing the compositional data obtained using LA-ICP-MS and PXRF, I present the analysis of compositional data for Sample Localities 9, 11, and 20 obtained using laboratory XRF. I present the analysis of these XRF data in some detail in order to illustrate the analytical procedures followed in the analysis of LA-ICP-MS and PXRF data, without overwhelming the reader with those larger datasets. I perform the statistical analyses and generate the graphics presented here using JMP Version 7 (SAS Institute Inc.).

X-RAY FLUORESCENCE (XRF) SPECTROMETRY

Dr. David Bailey (Department of Geosciences, Hamilton College, Clinton, New York) used XRF to obtain compositional data on specimens from Sample Localities 9, 11, and 20. I present an analysis of these data here in order to demonstrate the feasibility of discriminating chert sources geochemically and illustrate the analytical procedures I will use in my analysis of compositional data obtained using LA-ICP-MS and PXRF, presented later in this chapter.

Examination of a series of scatterplots demonstrates that a plot of Fe vs. Al discriminates these localities quite well, though the 95% bivariate normal density ellipses of localities 9 and 11 overlap each other slightly (Figure 5.69). The shape and angle of these ellipses also tells us about the strength of any correlation between these variables. For example, the diagonal, positive-trending, elongated ellipse for Sample Locality 11 indicates that iron and aluminum concentrations are positively correlated (r = 0.785), whereas the rounder, negative trending ellipse for Sample Locality 20 indicates that iron and aluminum concentrations are, in this case, weakly, negatively correlated (r = -0.380).

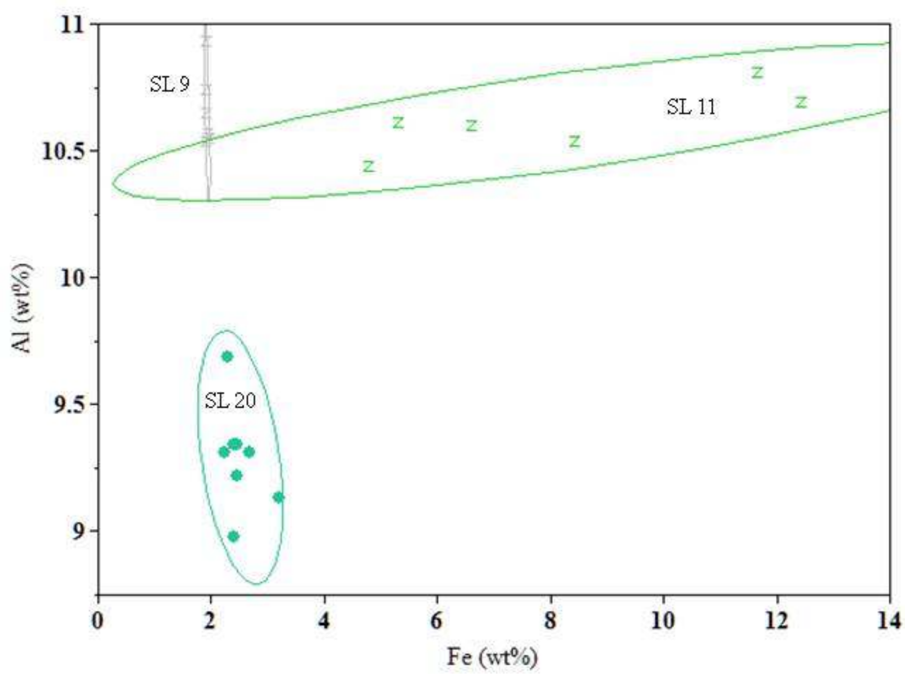


Figure 5.69: Scatterplot of Fe (wt%) vs. Al (wt%) for Sample Localities (SL) 9, 11, and 20, with a 95% bivariate normal density ellipse drawn around each SL.

Interestingly, Sample Localities 11 (an orange chert) and 20 (a red chert), which are more similar to each other macroscopically than either is to Sample Locality 9 (a white chert), are both very easily distinguished geochemically from each other. These data suggest that a combination of macroscopic properties (i.e., color, in this case) and basic scatterplots on raw geochemical data ("analytes") can effectively discriminate these localities. With this in mind, it is worth noting that visual sourcing, though often maligned, continues to be used, whether in combination with other properties or alone, to successfully distinguish various archaeologically-relevant raw materials (e.g., Bettinger et al. 1984; Braswell et al. 2000; Sieveking et al. 1972; Stewart and Adams 1999; Tabares et al. 2005; Zedeno et al. 2005). Ideally, archaeologists could proceed in their efforts to "source" artifacts by visual criteria alone—this would certainly be more time- and cost-effective, as well as conservation-friendly (Roll et al. 2005). Color, for example, is capable, at least theoretically, of meeting the "Provenance Postulate," which states that "sourcing is possible as long as there exists some qualitative or quantitative chemical or mineralogical difference between natural sources that exceeds the qualitative or quantitative variation within each source" (Neff 2000:107-108). The trick, of course, is determining that visual sourcing does not result in numerous false source designations, a possibility that is assessed nowadays by checking the results of visual sourcing against the results of geochemical sourcing using compositional analysis.

Ultimately, the point I wish to stress is that macroscopic properties, including color, though at times maddeningly variable within a source, hold as much potential to discriminate chert or other raw material sources as any other variable, at least a priori (also see Bishop and Neff 1989:70). While it may be tempting to dive directly into a multivariate statistical analysis armed with as many variables as possible, judicious selection of variables is desirable in any pattern-seeking statistical methodology (e.g., Baxter 2006). This leads to the fundamental challenge posed by provenance analysis: the analyst should exclude variables that are not structure-carrying, as these variables may hinder the detection of data structure, but the analyst often does not know what variables to exclude prior to analysis (Baxter and Freestone 2006). As such, analysis proceeds by a constant back and forth between method and results (Baxter et al. 2008; Beardah et al. 2003), looking for structure within the dataset, while trying not to invalidate the statistics or introduce superfluous structure as an artifact of the method (Baxter 1989, 2006; Bevins et al. 2011; Bishop and Neff 1989; Gordus et al. 1968:384; Shackley 2002).

Going back to Figure 5.69, it would seem that combining color with the concentration of iron and aluminum effectively discriminates these sources; however, in many cases provenance analysts transform raw compositional data to base-10 logarithms prior to analysis. Transforming these data provides a (closer to) normal distribution for many trace elements, while compensating for differences in magnitude between elements (e.g., Abbott and Watts 2010; Baxter and Freestone 2006; Bieber et al. 1976; Bishop and Neff 1989; de Bruin et al. 1972; Huckell et al. 2011; Neff et al. 1999; Roll et al. 2005; Ward 1974a). In this case, transformation of these data to base-10 logarithms accentuates the data structure apparent in Figure 5.69 (Figure 5.70).

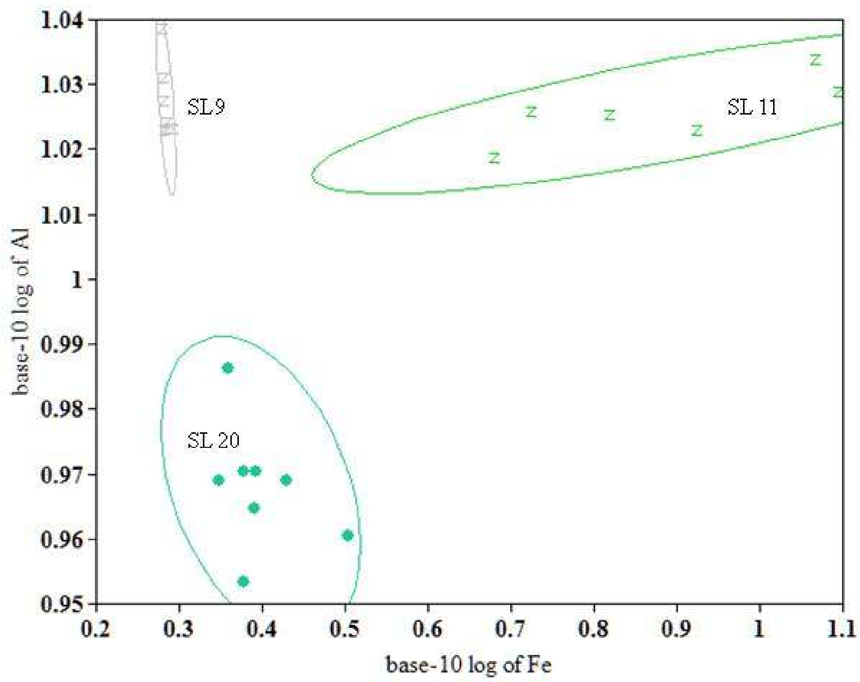


Figure 5.70: Scatterplot of base-10 log of Fe vs. base-10 log of Al for Sample Localities (SL) 9, 11, and 20, with a 95% bivariate normal density ellipse drawn around each SL.

Alternatively, some analysts have argued that compositions, because they provide information on relative rather than absolute values and often display marked curvature, should be analyzed using log-ratio analysis (alternatively referred to as the “loglinear contrast method;” e.g., Aitchison 1983, 1986; Aitchison et al. 2002). A popular log-ratio transformation suggested by Aitchison (1983, 1986) is the centered log-ratio transformation. Accordingly, the output after transformation (y_i) equals the natural logarithm of the input (x_i; an elemental concentration) divided by the geometric mean (g(X)) of the analytes (i.e., the geometric mean of the elemental concentrations for a sample); in short: $y_i = \ln(x_i/g(X))_{i=1,\ldots,D}$ (e.g., Baxter 1989:48; Tsagris et al. 2011).

This transformation accommodates the relative nature of compositional data resulting from the constant sum constraint (i.e., that the compositional data for a specimen should sum to 1 or 100%). Significantly, this transformation still applies to trace elements, even though they are counted in parts per million rather than oxide weight percents (Aitchinson et al. 2002:302). Principal components analysis (PCA) of these data then centers them by column; hence, the data are "double-centered" (Aitchinson and Greenacre 2002). Figure 5.71 presents a scatterplot of Fe vs. Al for Sample Localities 9, 11, and 20 after these data have been transformed according to the log-ratio transformation (prior to PCA).

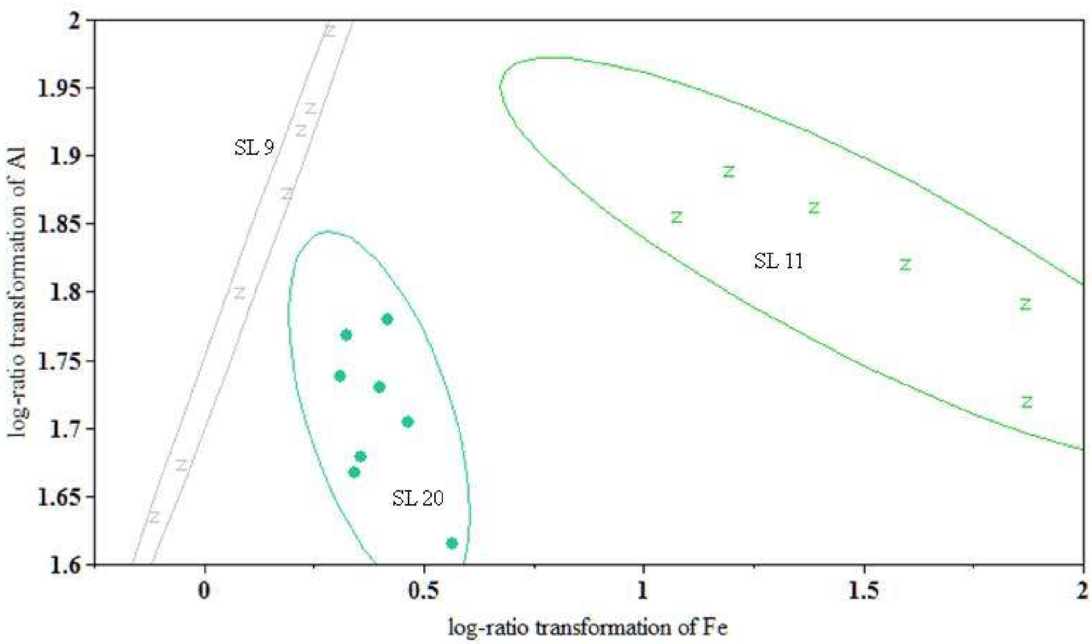


Figure 5.71: Scatterplot of Fe vs. Al (log-ratio transformation) for Sample Localities (SL) 9, 11, and 20, with a 95% bivariate normal density ellipse drawn around each SL.

Log-ratio analysis has met with some criticism, however, because of the potential for it to adversely affect data structure, either through the introduction of spurious structure (Tangri and Wright 1993) or the weakening of structure actually present within the data (Baxter 1993:114). For example, the results of log-ratio analysis can be overly influenced by elements (e.g., Mg, Mn; Baxter 1991) that, although they may be present at low absolute levels, can dominate the analysis due to their high relative variance (Baxter 1989, 1991, 1992a; Baxter and Freestone 2006; Beardah et al. 2003). In other words, because of the focus on ratios and relative variation rather than absolute differences, log-ratio analysis can miss more important structure in a data set (Baxter and Freestone 2006). For Sample Localities 9, 11, and 20, however, transformation to base-10 logarithms and log-ratio analysis (Figure 5.70, Figure 5.71) both effectively capture the same compositional subgroups. In fact, multivariate analysis on data transformed to base-10 logarithms and data transformed using log-ratio analysis often yield equivalent patterning (Aitchison et al. 2002; Baxter and Freestone 2006). Of greater practical concern for this analysis, Baxter (1991, 1992a) suggests that if a majority of elements within a composition have low absolute values, as is the case for chert, then the problems with correlation-based analysis of compositional data that led Aitchison (1983, 1986) to develop log-ratio analysis may not be significant.

Quite apart from Aitchison's (1983, 1986) log-ratio analysis, other analysts (e.g., Aspinall and Feather 1972:46; Gordus et al. 1968; Gratuze 1999; Parks and Tieh 1966; Pearce et al. 1997) have suggested the use of elemental ratios to achieve the same ends as transformation to base-10 logarithms; that is, to compensate for differences in magnitude between major, minor, and trace elements (Figure 5.72). Shackley (2010), however, warns that incorrect source assignments may stem from the possibility that two or more sources have the same ratio of the selected elements, but very different concentrations. In the present case, these elemental ratios do a poorer job of discriminating the compositional subgroups than the other methods of data transformation considered earlier.

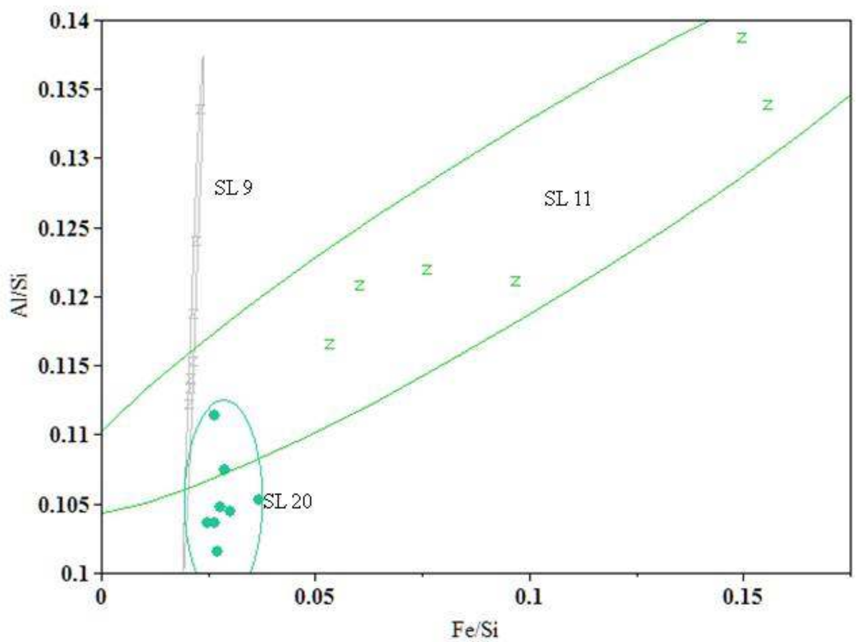


Figure 5.72: Scatterplot of Fe/Si vs. Al/Si elemental ratios for Sample Localities (SL) 9, 11, and 20, with a 95% bivariate normal density ellipse drawn around each SL.

This debate regarding data transformation in compositional analysis is noteworthy primarily because it illustrates, again, the constant struggle to balance practical and statistical concerns. For example, Tangri and Wright's (1993; also Baxter 1991, 1993; Beardah et al. 2003) criticisms regarding log-ratio analysis stem from their unsatisfactory results when applying this method of data transformation to their data. Ultimately, debate regarding these approaches reminds us that these methods are tools for exploring compositional data that have their own built-in strengths and weaknesses that we may best judge "by [their] archaeological interpretability and not by the mere fact of grouping" (Baxter 1993:113; also see Baxter 1989, 1991; Beardah et al. 2003; Bishop and Neff 1989; Tsagris et al. 2011; Tykot 2002:622). In the following analyses of the more complex LA-ICP-MS and PXRF datasets, these transformations are explored in order to tease out as much structure in the data as possible, while also providing a means to check each method (Baxter and Freestone 2006).

In the present case, considering compositional data for a few elements across only three sample localities, the scatterplots presented above readily identify the known compositional subgroups; however, the next step in provenance analysis—the assignment of an artifact to a source—may require more data than just the concentrations of iron and aluminum. In order to identify patterns when more than one or two variables are measured, provenance analysts frequently use multivariate statistical methods, especially PCA (Baxter and Freestone 2006; Bishop and Neff 1989). PCA facilitates the recognition and interpretation of subgrouping tendencies in compositional data by identifying the orientation of axes along which the data set is most elongated (Neff 1994). Dimensions of maximum elongation typically coincide with axes along which the separation between compositional subgroups is most easily visible (Baxter and Freestone 2006; Neff 1994). The inspection of scatterplots based on the scores of the first two or three principal components (PCs) is usually adequate for seeing any structure present in the data (Baxter and Freestone 2006).

Here, I conduct PCA on the correlation matrix of base-10 logarithms of Si, Ti, Al, Fe, Mn, Mg, and Ca, as these data are available for Sample Localities 9, 11, and 20. In Q-methodology, the eigenvalues of the correlation matrix determine the analyst's judgment of practical (not statistical) significance. PCs with eigenvalues greater than 1.00 are considered practically significant; that is, they explain an important amount of variability in the data. Table 5.2 and the associated scree plot (Figure 5.73) indicate that Sample Localities 9, 11, and 20 can be effectively segregated using three PCs, which account for greater than 90% of the cumulative variance in these samples.

Table 5.2: Eigenvalues for PCA of base-10 logarithms of Si, Ti, Al, Fe, Mn, Mg, and Ca for Sample Localities 9, 11, and 20.

Principal Component	Eigenvalue	Percent	Cumulative Percent
1	2.5044	35.778	35.778
2	2.0459	29.227	65.004
3	1.7985	25.693	90.697
4	0.5072	7.246	97.943
5	0.1159	1.656	99.599
6	0.0148	0.212	99.811
7	0.0132	0.189	100

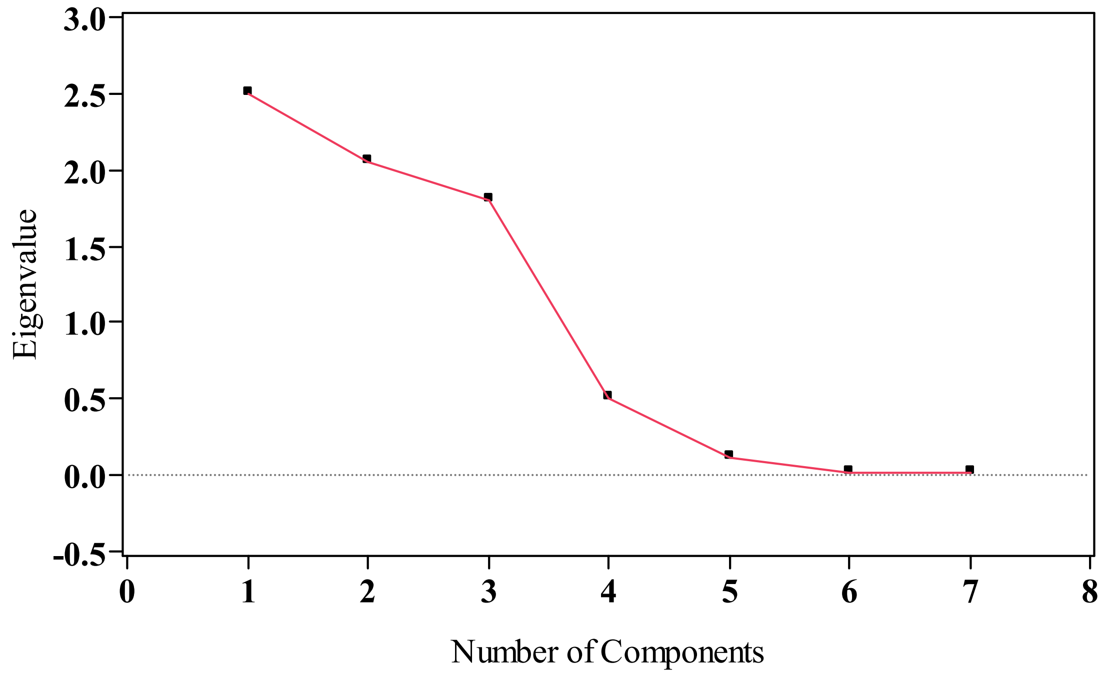


Figure 5.73: Scree plot of number of PCs for base-10 logarithms vs. eigenvalues.

A one-way analysis of variance (ANOVA) of the distribution of the first three PC scores reinforces the ability of PC 1 and PC 2 to clearly distinguish these sample localities; PC 3 does a much poorer job of segregating these samples even though it “explains” only slightly less of the variability in the data than PC 2 (Figure 5.74). The Tukey-Kramer HSD test for PCs 1 and 2, for example, demonstrates a significant difference between these subgroups at $\alpha = 0.05$, as indicated graphically by the smaller circle size and outside angle of circle intersection of less than 90°. Table 5.3 shows the Tukey-Kramer HSD statistic, calculated as the absolute difference of the means minus the least squares difference, comparing the PC means for each sample locality. In this table, positive values show pairs of means that are significantly different. As the table makes clear, these localities are significantly different according to PC 1 and PC 2, as expected. PC 3, again, does a worse job than PC 1 and PC 2 in segregating the compositional subgroups. The F-statistics associated with this one-way ANOVA (Table 5.4) reinforce this view (though for concerns regarding the use of the F-statistic, see Hughes 1984).

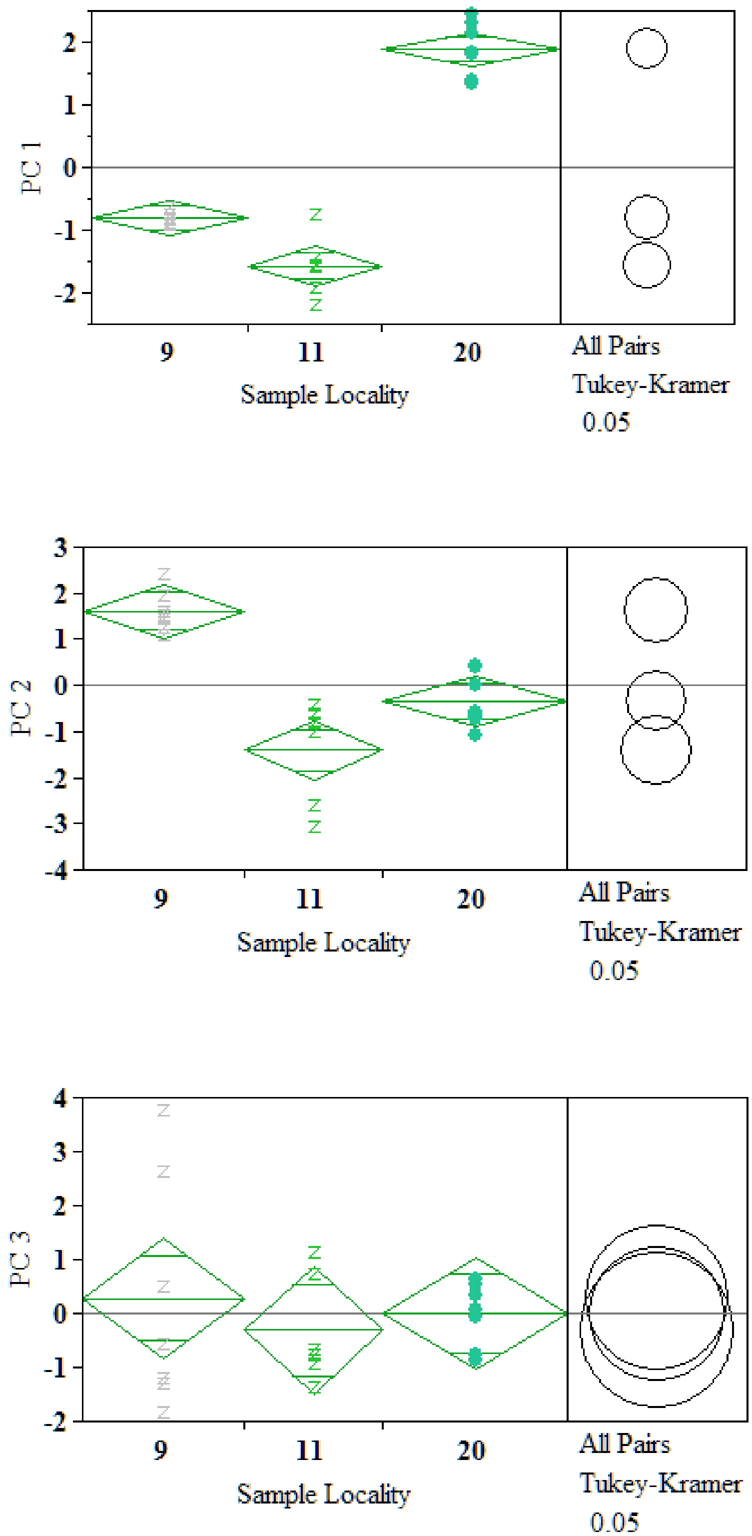


Figure 5.74: One-way ANOVA of the first three PCs for Sample Localities (SL) 9, 11, and 20. A graphical representation of the Tukey-Kramer HSD test is shown at right.

Table 5.3: Tukey-Kramer HSD test for comparison of PC means of Sample Localities 9, 11, and 20.

	Sample Locality	20	9	11
PC1	20	NA	2.2112	2.9536
	9	2.2112	NA	0.2484
	11	2.9536	0.2484	NA
PC2	20	NA	1.0075	0.0415
	9	1.0075	NA	1.9863
	11	0.0415	1.9863	NA
PC3	20	NA	-1.5482	-1.6163
	9	-1.5482	NA	-1.3847
	11	-1.6163	-1.3847	NA

Table 5.4: F-statistics associated with the one-way ANOVA depicted in Figure 5.74.

Principal Component	F Ratio	Prob > F
1	181.4902	<0.001
2	29.1072	<0.001
3	0.2916	0.7505

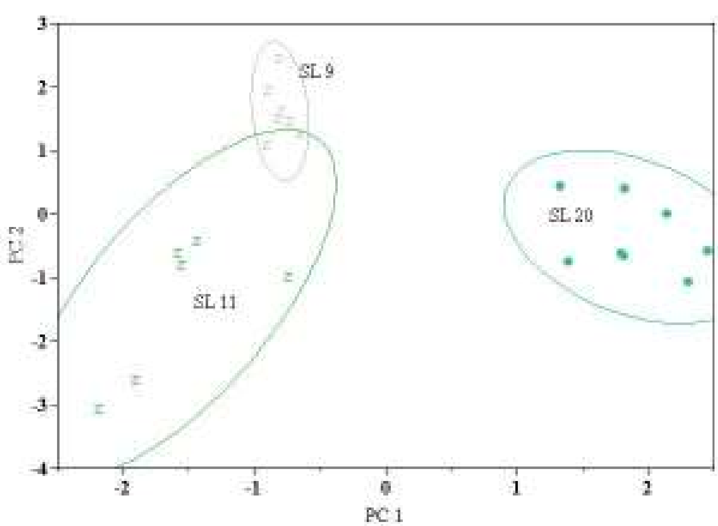


Figure 5.75: Scatterplot of PC 1 vs. PC 2 for Sample Localities (SL) 9, 11, and 20, with a 95% bivariate normal density ellipse drawn around each SL.

With this in mind, we can graph the distribution of PC 1 scores vs. PC 2 scores (Figure 5.75). As in the initial scatterplots, we see that these sample localities are easily distinguished, though the 95% bivariate normal density ellipses for white chert and orange chert slightly overlap. In this case, PCA actually does a little worse than a scatterplot of base-10 logarithms and the log-ratio transformation of Fe and Al in distinguishing these sample localities. Nevertheless, PCA does provide an effective method for reducing the dimensionality of the high dimension data typically generated by the analytical methods provenance analysts utilize.

Two methods may be used to check for subgroup outliers, which may manifest themselves as incorrect group assignments. Group-membership probabilities may be calculated using Mahalanobis distances in principal component space based on the first three principal components (Figure 5.76). Mahalanobis distance is analogous to expressing distance from a univariate mean (i.e., the centroid) in standard deviation units, which can then be converted into probabilities of group membership for each individual specimen (Bishop and Neff 1989; Hughes 1984; Neff et al. 1999; Ward 1974a, 1974b). For small sample sizes, as examined here, probabilities may be based on Hotelling's T^2, which is a multivariate extension of the univariate Student's t (Bieber et al. 1972). Tables may be generated to compare distances to various group centroids and the associated probability of group membership (e.g., Huckell et al. 2011:Table 5). In turn, these data, which are not displayed here, suggest the number of incorrect group assignments, thereby providing an assessment of the success of the PCA. In this case, the analysis indicates no incorrect assignments (Table 5.5).

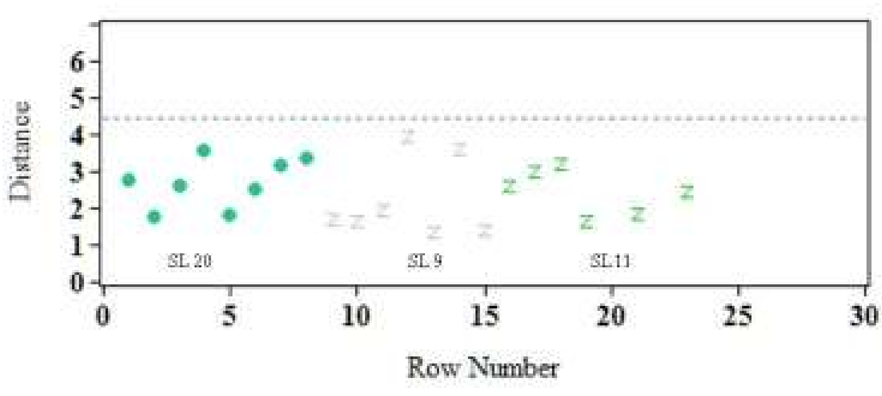


Figure 5.76: Mahalanobis distances calculated for PCA of base-10 logarithms for Sample Localities (SL) 9, 11, and 20. Outliers would be indicated by points above the line at the top of the graph.

Table 5.5: Actual vs. predicted group membership based on probabilities derived from Mahalanobis distances. Probabilities are calculated using the first three PCs of the dataset. Note that all samples are correctly attributed.

		Predicted		
	Sample Locality	**20**	**9**	**11**
Actual	**20**	8	0	0
	9	0	7	0
	11	0	0	6

Number Misclassified	0
Percent Misclassified	0
-2ln (likelihood ratio)	0.013

When specimen-to-variable ratios are small, as is common in provenance research, Mahalanobis distances may fluctuate dramatically depending upon whether or not the specimen is assumed to belong to the group with which it is being compared (Neff et al. 1999). To address this problem, each specimen may be removed from the group before calculating its probability of membership, a cross-validation method known as "jackknifing" (Jones 1974; Quenouille 1956). In other words, the Mahalanobis distance of each observation from the centroid of a group is calculated based on estimates of the mean, standard deviation, and correlation matrix that do not include the observation itself. As Figure 5.77 shows, there are a few samples that are slight outliers and, therefore, may most easily be assigned to the wrong group. Even so, other analyses (e.g., discriminant analysis, partition analysis) effectively generate the expected subgroups.

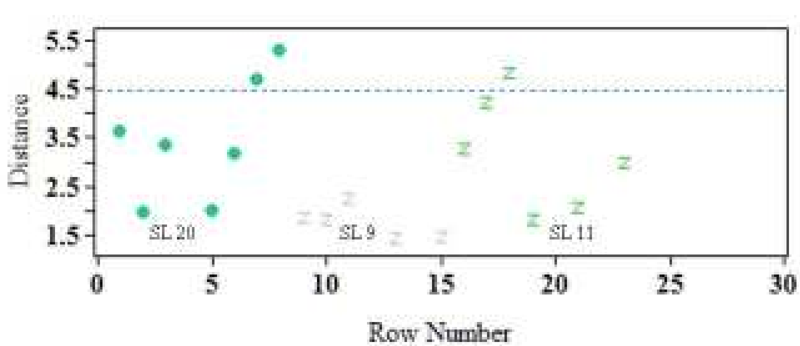


Figure 5.77: Jackknifed Mahalanobis distances calculated for PCA of base-10 logarithms for Sample Localities (SL) 9, 11, and 20. Outliers are indicated by points above the line at the top of the graph.

Finally, we are left to discern what variables contribute to the structure we see in Figure 5.75; that is, we are tasked with interpreting the PCs in terms of the original variables—a task that can be particularly complicated when dealing with many variables. A popular method for simultaneously displaying objects and variables, thereby presenting the data structure as well as the underling vectors, is the biplot. In essence, a biplot presents the results of an RQ-mode PCA: (1) it preserves the Euclidean relations between the objects in the sample as defined by the loadings of the original variables (i.e., the elemental concentrations) on each PC, as in R-mode PCA (Figure 5.75); while (2) providing the factor scores for the original variables, as in Q-mode PCA (Figure 5.78; Aitchison and Greenacre 2002; Baxter 1992b; Bishop and Neff 1989; Neff 1994).

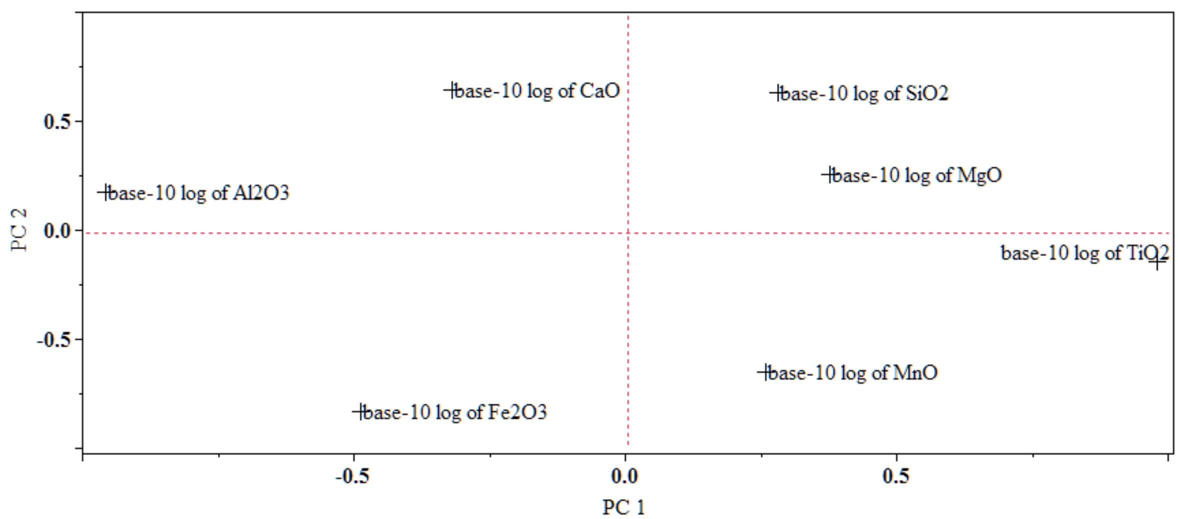


Figure 5.78: Loading plot of PC 1 vs. PC 2.

In a biplot, the length of the rays corresponds to the eigenvalue of the PCs. Thus, a biplot helps us to identify important variables (those variables that contribute to the elongation of subgroups in compositional space) and unimportant variables (those variables that plot close to the origin; Neff 1994). Additionally, correlations between variables are indicated by the angles between biplot rays; variables on biplot rays running perpendicular to each other are not correlated (Aitchison and Greenacre 2002; Aitchison et al. 2002). Unfortunately, JMP 7's version of the biplot in the PCA platform ("Scatterplot 3D") remains difficult to interpret given the projection of this 3-D representation into two-dimensional space (Figure 5.79). Fortunately, a centroid plot of canonical variates in JMP approximates the biplot generated in the PCA platform and, therefore, can be used to explore the relationships between these variables. Also, we can generate a two-dimensional biplot by manually plotting the factor scores on the scatterplot of PC 1 vs. PC 2 scores for the samples (Figure 5.80).

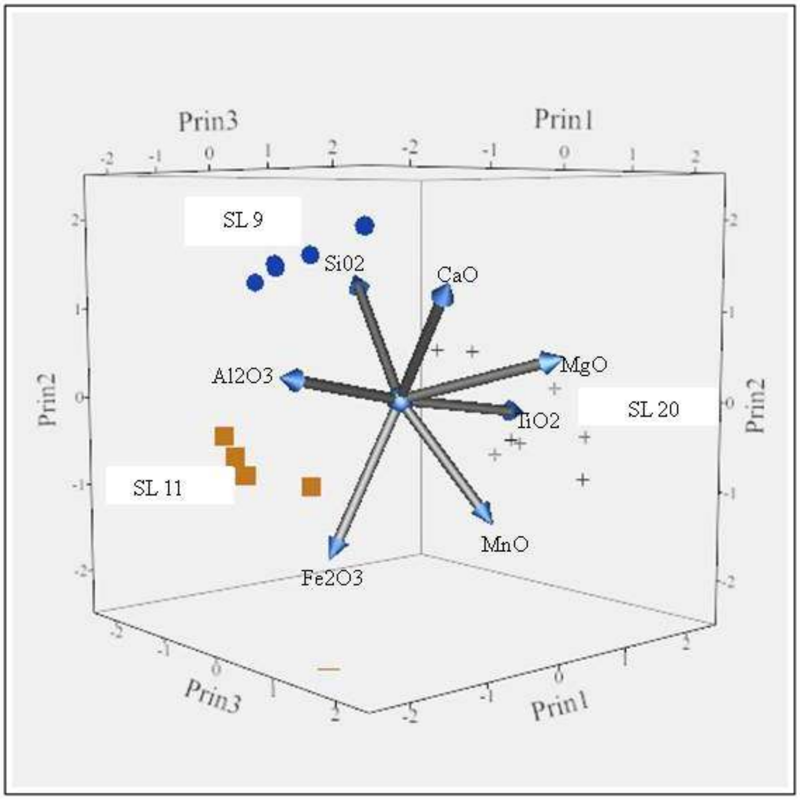


Figure 5.79: Scatterplot 3D of PC 1, PC 2, and PC 3 for objects and variables.

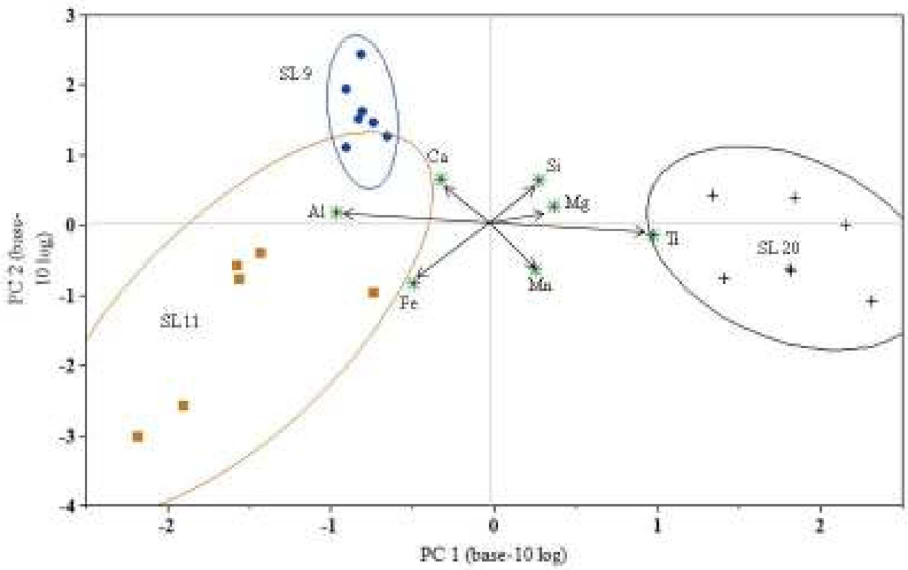


Figure 5.80: Biplot of PC 1 vs. PC 2 for Sample Localities (SL) 9, 11, and 20, with a 95% bivariate normal density ellipse drawn around each SL.

By inspecting the biplot we can determine the elements that best distinguish these compositional subgroups. In other words, we can see how far (the eigenvalue) and in what direction (the eigenvector) the data have been stretched to discriminate these sample localities. In this case, the data structure derives from a series of inverse relationships, with the inverse relationship between the concentration of aluminum and titanium, as captured by PC 1, being the most significant (Figure 5.80, Table 5.6). PC 2 seems to reflect the pull of iron (against silica) and calcium (against manganese).

Table 5.6: Eigenvalues and eigenvectors for PC 1 and PC 2, generated on base-10 logarithms. Structure-carrying eigenvectors are in italics.

	PC1	PC2
Eigenvalues	2.5044	2.0459
	Eigenvectors	
Si	0.17344	0.44995
Ti	*0.61447*	-0.09243
Al	*-0.61028*	0.13056
Fe	-0.31356	*-0.57291*
Mn	0.15847	-0.44444
Mg	0.23274	0.18772
Ca	-0.20567	*0.45932*

While these variable presentations of the same data may seem like statistical overkill, they allow the analyst to check different methods of pattern-recognition against each other and may provide alternative insights into the structure of the data, all of which may assist in the accurate source assignment of artifacts. Moreover, compositional analysis too easily becomes a "black box," as our data are input into sophisticated software packages that generate aesthetically-pleasing outputs ready-made for application to prehistory (Baxter 2006; Bishop and Neff 1989). Intervening decisions regarding selection of variables and method are often glossed (lost?) in presentation (Ward 1977). I hasten to add that this is no one's "fault;" many a journal article on the relevance of provenance analysis to questions of mobility, exchange, or other topics simply does not have room for an extended treatment of analytical protocol. Yet as Hector Neff (1998; also see Hughes 1998) has stated, assessment of validity and reliability in compositional analysis demands that provenance analysts are systematic and make explicit their approach to sourcing. While I streamline my presentation of compositional data obtained by LA-ICP-MS and PXRF to some degree, the exploratory nature of this research recommends detailed treatment of the analytical methods utilized to investigate these data.

Laser Ablation Inductively-Coupled Plasma Mass-Spectrometry (LA-ICP-MS)

LA-ICP-MS was the primary method I employed to determine the chemical composition of geological samples. Previous analysts have demonstrated the utility of this analytical method for the compositional analysis of a variety of materials (e.g., Junk 2001; papers in Speakman and Neff 2005), including stone tools (e.g., Evans et al. 2007; Mirti et al. 2009; Roll et al. 2005; Speakman et al. 2002:57), as well as its general agreement with XRF, neutron activation analysis (NAA), and scanning electron microscopy (SEM; Blet and Gratuze 1997; Gratuze 1999; Gratuze et al. 2001). Of additional significance, LA-ICP-MS has lower detection limits than other instrumental techniques for many elements (e.g., Sr, Sb, Ba, Zr; Kennett et al. 2001; Richner et al. 1994; Speakman et al. 2002; Speakman and Neff 2005).

The current analysis was conducted under the guidance of Dr. Ted Huston of the Keck Elemental Geochemistry Laboratory, Department of Geological Sciences, University of Michigan, Ann Arbor, Michigan. This facility includes a Finnigan Element high resolution ICP-mass spectrometer that provides for the quantitative analysis of most elements at incredibly low concentrations (parts per trillion to parts per billion). Table 5.7 provides the technical parameters for the equipment utilized in this analysis.

Table 5.7: LA-ICP-MS parameters.

Ablation Parameters	**Instrument: Merchantek (New Wave) LUV266X**	
Laser power	~1.4 mJ, ~17.3 J/cm2	~0.6 mJ, ~30.9/cm2
Laser frequency	20 Hz	
Laser speed	10 microns/second	
Laser diameter	100 microns	50 microns
Ablation pattern	Line, 500 microns in length	
ICP-MS settings	**Instrument: Thermo Scientific Element ICP-HRMS**	
Coolant (Ar)	~16 L/min	
Auxiliary (Ar)	~1L/min	
Carrier (Ar)	~1L/min	
RF Power	1400 W	
Analytical time per run	4 minutes	
Segment time	30 ms per run	
Mass settling time	~300 ms	
Analytical mode	Full peak scanning mode	
Isotopes Measured Li-7, Na-23, Mg-24, Al-27, Si-30, P-31, K-39, Ca-43, Sc-45, Ti-47, V-51, Cr-52, Mn-55, Fe-57, Co-59, Ni-60, Cu-63, Rb-85, Sr-88, Y-89, Zr-90, Ag-107, Cd-111, Sn-118, Sb-121, Cs0133, Ba-137, La-139, Ce-140, Nd-146, Sm-147, Eu-151, Dy-163, Ho-165, Er-167, Lu-175, Ta-181, Pb-208, Th-232, U-238		

In LA-ICP-MS, the sample (i.e., a flat, clean geological specimen) is placed inside a sample holder and introduced into the mass spectrometer using a UV laser ablation microsampler. Speakman and Neff (2005) found through their experimentation at the Research Reactor Center at the University of Missouri-Columbia (MURR) that ablating along lines and raster patterns, rather than spots, could accommodate some of the variation that results from sample heterogeneity while minimizing fractionation (i.e., the non-representative sampling of the target during ablation; also see Cromwell and Arrowsmith 1995). Additionally, line-ablation technique achieves significantly higher count rates and better signal stability than ablation of spots or rasters, which is critical for accurate quantification of the data (Perkins et al. 1997:Figure 4; Speakman and Neff 2005). This analysis, therefore, utilizes line-ablation. I ablated at least two lines on each geological sample analyzed. Another consideration favoring this method of sample introduction was the goal of comparing compositional data obtained using LA-ICP-MS with data obtained using PXRF, which is based on a bulk, surface sample (for a comparable consideration regarding ceramic analysis, see Larson et al. 2005).

While LA-ICP-MS is minimally destructive (i.e., it ablates a line that is minimally invasive), sample size is limited by the size of the sample cell (5 cm in diameter by 3 cm in height), which precludes the analysis of larger artifacts. The size restriction introduced by the sample cell bears particular notice, as lithic analysts begin to find that different types and sizes of artifacts attest to the utilization of different sources (e.g., Eerkens, Ferguson, et al. 2007; Tykot 2002:620). Moreover, the exploratory nature of this research demands demonstration that LA-ICP-MS is, in fact, a useful method for distinguishing cherts in east-central Nevada prior to any destruction to the artifacts, no matter how slight. At this stage in the research, therefore, I use LA-ICP-MS strictly for the analysis of geological samples in order to demonstrate the applicability of this method to chert provenance analysis in east-central Nevada. Compositional data obtained using LA-ICP-MS informs the analysis of data obtained using PXRF.

After sample introduction, the ablated material is flushed from the laser cell using an argon carrier gas and introduced into the ICP-MS torch where argon gas plasma, capable of sustaining electron temperatures between 6000 and 10,000 K, ionizes the injected sample (Gratuze 1999; Speakman and Neff 2005; Thomas 2001a). The ions then pass through the ICP-MS interface for detection and quantification. Once inside the mass spectrometer, the ions are accelerated by high voltage and pass through a series of focusing lenses, an electrostatic analyzer, and an electromagnet. The electromagnet generates a magnetic field that deflects the ions passing through it at an angle indicative of their mass-to-charge ratio (Gratuze 199; Speakman and Neff 2005; Thomas 2001b, 2001c). The electrostatic analyzer then focuses the ions onto an exit slit for detection. By varying the instrument settings (e.g., the strength of the magnet, the settings of the electrostatic analyzer), the entire mass range can be scanned in a short length of time.

Prior to data acquisition each day, the instrument is turned on and allowed to warm up for a minimum of one hour. This permits internal components to reach their optimum operating temperature, thereby reducing instrument noise and drift (Speakman et al. 2002). Still, ICP-MS is plagued by many sources of spectroscopic and non-spectroscopic interference (Gratuze 1999; Thomas 2002a, 2002b, 2002c). Spectroscopic interferences may be caused by ions that have the same mass-to-charge ratio as the analyte, either because of isobaric overlap (when two elements have ions of the same mass; Junk 2001), doubly charged ions (elements that undergo a second ionization in the plasma), and/or polyatomic ions (when two or more atoms, which may include the argon carrier gas, combine to make a larger ion; Evans et al. 2007:2165). Fortunately, many of these spectroscopic interferences can be avoided or corrected mathematically (Thomas 2002c). Oxides and doubly charged species can be significantly reduced through proper tuning of the plasma and torch conditions. Isobaric overlap may be avoided by choosing another isotope of the element of interest. For example ^{114}Cd (an isotope of cadmium) is interfered with by ^{114}Sn (an isotope of tin), so ^{111}Cd is used instead. Additionally, high resolution mass spectrometers can simply distinguish the analyte from interference by differences in mass, although at the expense of higher count rates (Speakman and Neff 2005; Thomas 2002c). Finally, sample introduction using laser ablation also helps to avoid interferences, as sample introduction by acid digestion typically introduces background noise into the samples during preparation, even when using the cleanest reagents available (Gratuze 1999; Gratuze et al. 2001; Kennett et al. 2001; Perkins et al. 1997; Raith and Hutton 1994; Thomas 2002c).

Non-spectroscopic interferences include the deposition of solids on the sampler cone as the amount of sample ablated increases, resulting in a decrease in the analyte signal over time (Thomas 2002c). This problem can be monitored by regularly analyzing standards with known concentrations throughout the course of analysis. Finally, matrix effects (e.g., texture of the sample, surface topography), the location of the sample in the laser cell, laser energy, and other factors that affect the amount of material introduced to the ICP torch may also suppress or enhance the analyte signal (Perkins et al. 1997; Speakman et al. 2002; Speakman and Neff 2005; Thomas 2001d, 2002c).

While many of these sources of interference can be avoided, they may complicate data normalization by hindering accurate quantification of the amount of material removed from an artifact (Kennett et al. 2001; Speakman et al. 2002). Internally, standardization can be achieved by subtracting the blank (i.e., argon gas passing through the machine) from the signal and averaging the value calculated from three ablations (Gratuze 1999). In other words, for every one ablation run by the analyst, three ablations are actually run, each focusing on different element subsets and each duplicating elements run from the other subsets to provide internal standardization (e.g., Gratuze et al. 2001; Thomas 2002c). Externally, the impact of these factors on the analysis can be assessed to some degree through calibration using National Institute of Standards and Technology (NIST) glass certified reference materials (CRM). Ideally, standards with the same composition as the sample under investigation are utilized to promote the best calibration of the machine (Perkins et al. 1997; Richner et al. 1994; Watling 1998).

Here, I follow Gratuze (1999; also Speakman et al. 2002) in using NIST 610 and NIST 612, which are glass wafers doped with trace elements to nominal concentrations of 500 and 50 µg/g, as the standards for this analysis. Because the base glass contains a significant level of certain trace elements prior to being doped to produce the desired trace element concentrations, there is some variability in isotopic composition within and between each CRM (e.g., Platzner et al. 2001; Woodhead and Hergt 2001). In fact, the certificate for NIST glasses states, "The certified values are for an entire wafer (no fragment thereof)" (Perkins et al. 1997:179); nevertheless, most studies using ICP-MS utilize these glasses for calibration, bolstered by several recent studies aimed explicitly at testing the suitability of these glasses as microanalytical standards (e.g., Hinton et al. 1995; Pearce et al. 1997). It bears noting, however, that the accuracy of ICP-MS for measuring certain elements (e.g., iron, potassium) cannot be assessed with the NIST glasses for the simple reason that the NIST glasses do not contain much of them (Gratuze 1999).

Pulse-to-pulse variations in laser energy and variations in laser coupling efficiency, dependent on sample color and the degree of compaction, result in differing amounts of sample reaching the plasma (Arrowsmith and Hughes 1988; Chenery et al. 1992; Mitchell et al. 1986; Perkins et al. 1997; Thompson et al. 1990). Comparison of

NIST 612 compositional data generated during this analysis with previously published compositional data for these standards (Pearce et al. 1997:Table 7) indicates that the laser did not effectively couple with the NIST 612 glass. As Figure 5.81 shows, using a laser diameter of 100 microns (black circles) did not achieve comparable results to previously

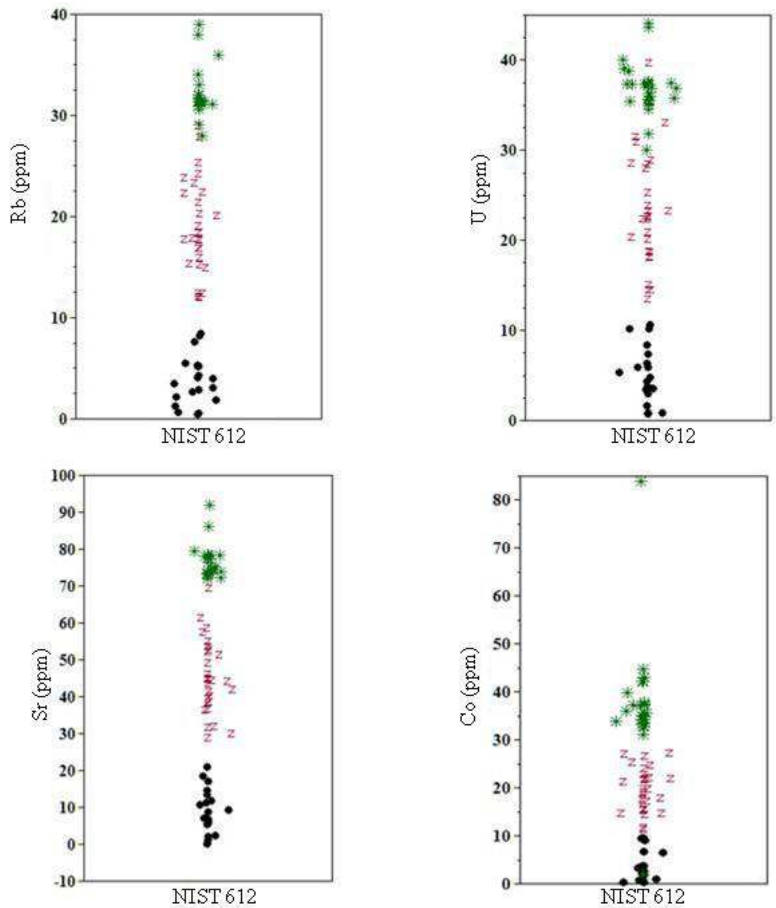


Figure 5.81: Comparison of some NIST 612 data from this study with previously published NIST 612 data (from Pearce et al. 1997:Table 7). Black circles represent NIST 612 data from this study obtained using a laser diameter of 100 microns. Red Zs represent NIST 612 data from this study obtained using a laser diameter of 50 microns. Green asterisks represent previously published NIST 612 data.

published analyses of NIST 612 (green asterisks). I decided, therefore, to try ablating the samples using a laser diameter of 50 microns. As shown in Table 5.7, decreasing the laser diameter decreases laser power in general, though by focusing the laser on a smaller area, the intensity of the laser actually increases. Additionally higher laser fluence (10-100 J/cm^2) has been found to reduce the extent of fractionation (Cromwell and Arrowsmith

1995). Using a laser diameter of 50 microns improved the NIST 612 data (the red Zs in Figure 5.81) obtained in this study, although these data still fall short of previously published standards. In other words, use of a laser diameter of 50 microns increased the amount of sample ablated, though NIST 612 still does not appear to be a good reference material for these analyses. In fact, Table 5.8 indicates that few analytes fall within the range of 38 ± 12 μg/g that Pearce et al. (1997) find in their review of previous analyses of NIST 612. In this case, the low counts achieved for many of these analytes suggests a difficulty in ablating light-colored, fairly translucent specimens (also see Speakman and Neff 2005); further experimentation with ablating light-colored cherts is required to address this problem.

Table 5.8: Comparison of NIST 612 compositional data obtained with a laser diameter of 100 microns and 50 microns with previously published data. Data are reported in ppm. Note that the means and standard deviations I report for previously published data are slightly different than those Pearce et al. (1997) report because I have included data they exclude in their summary statistics. (continued on next page)

	100 microns		**50 microns**		**Previously Published**	
Analyte	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Li	5.6	4.0	8.1	11.7	42.4	5.3
Mg	20.0	16.5	101.8	46.6	104.9	85.7
Rb	3.8	2.4	19.0	4.6	32.2	2.6
Sr	8.9	5.8	45.2	10.0	76.5	4.7
Y	3.0	2.0	21.6	4.3	37.4	4.7
Zr	4.2	2.6	24.2	5.2	37.3	3.8
Ag	13.4	8.8	18.1	7.3	20.2	7.2
Cd	6.5	4.5	29.9	7.3	29.8	4.3
In	5.7	3.8	29.2	6.4	35.9	11.1
Sn	6.0	3.8	28.6	6.0	35.3	7.5
Sb	5.8	3.8	29.4	6.3	37.0	4.2
Cs	6.7	4.3	31.5	8.8	44.1	13.4
Ba	6.2	3.2	24.1	5.9	37.9	4.1
La	4.2	2.7	22.8	6.2	35.9	3.2
Ce	5.0	3.1	24.4	6.6	38.1	3.6
Nd	4.2	2.7	22.5	5.7	36.5	6.5
Sm	4.1	2.7	23.2	5.6	38.0	6.0
Dy	3.8	2.5	22.5	5.4	35.5	2.1
Ho	4.0	2.6	23.7	5.9	38.0	2.8

Table 5.8 (continued): Comparison of NIST 612 compositional data obtained with a laser diameter of 100 microns and 50 microns with previously published data.

	100 microns		**50 microns**		**Previously Published**	
Analyte	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Er	3.9	2.6	23.5	5.5	37.8	2.5
Lu	4.0	2.6	23.4	5.9	37.3	3.1
Pb	5.3	3.0	23.7	6.1	41.1	8.8
Th	4.0	2.6	23.4	5.6	36.7	3.5
U	5.0	3.1	23.7	6.6	36.9	2.8
P	3.0	86.2	56.5	83.0	55.2	22.3
K	217.5	350.3	20.5	43.1	54.8	24.8
Sc	3.5	3.0	26.6	5.0	42.2	8.0
Ti	4.3	3.7	27.7	4.7	46.6	6.6
V	4.8	3.8	23.0	5.9	40.6	7.0
Cr	5.0	4.4	21.5	6.1	42.8	29.9
Mn	5.3	4.1	23.8	5.4	37.5	5.2
Fe	27.9	15.7	63.9	70.5	71.7	30.7
Co	3.5	3.0	19.7	4.4	37.0	11.8
Ni	5.3	3.9	23.6	5.8	36.6	7.8
Cu	7.2	5.3	21.8	5.2	37.1	9.7
Zn	11.3	11.3	25.0	5.1	36.3	9.3
Eu	3.9	3.4	21.3	5.0	35.2	4.3

A comparable consideration of NIST 610 reveals much better agreement between previously published data and those obtained here (Figure 5.82). Again, using a laser diameter of 50 microns improved the NIST 610 data obtained in this study (Figure 5.82). In contrast to NIST 612, Table 5.9 indicates that many analytes fall within the range of 400 ± 100 μg/g that Pearce et al. (1997) report in their review of previous analyses of NIST 610.

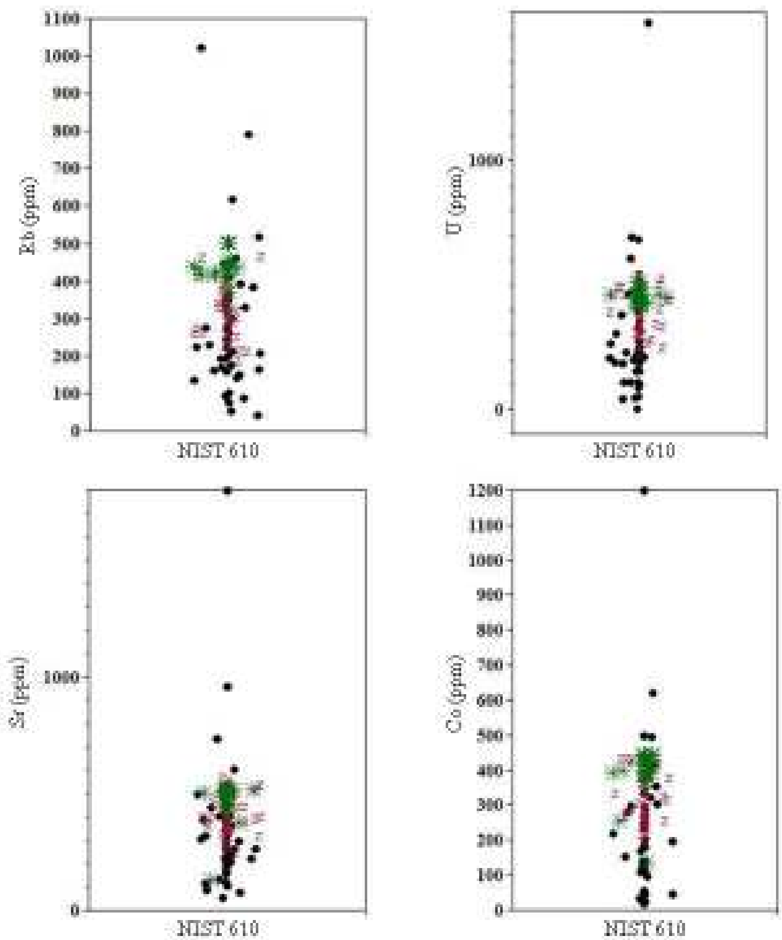


Figure 5.82: Comparison of some NIST 610 data from this study with previously published NIST 610 data (from Pearce et al. 1997:Table 6). Black circles represent NIST 610 data from this study obtained using a laser diameter of 100 microns. Red Zs represent NIST 610 data from this study obtained using a laser diameter of 50 microns. Green asterisks represent previously published NIST 610 data.

Table 5.9: Comparison of NIST 610 compositional data obtained with a laser diameter of 100 microns and 50 microns with previously published data. Data are reported in ppm. Note that the means and standard deviations I report for previously published data are slightly different than Pearce et al. (1997) report because I have included data they exclude in their summary statistics. (continued on next page)

	100 microns		**50 microns**		**Previously Published**	
Analyte	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Li	252.4	226.1	354.5	83.9	468.3	55.8
Mg	476.9	613.5	540.0	126.7	451.2	74.1
Rb	272.1	186.8	331.5	73.5	432.6	41.5
Sr	339.2	279.4	420.1	83.6	474.2	83.1

Table 5.9 (continued): Comparison of NIST 610 compositional data obtained with a laser diameter of 100 microns and 50 microns with previously published data.

	100 microns		**50 microns**		**Previously Published**	
Analyte	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Y	257.5	205.7	339.6	68.8	456.7	55.2
Zr	312.0	230.1	410.6	84.1	433.4	31.2
Ag	309.4	212.6	398.3	111.3	263.3	100.5
Cd	294.4	204.6	395.1	110.1	284.5	71.9
In	316.2	214.3	406.8	88.6	438.0	51.5
Sn	319.1	207.0	399.2	91.0	367.9	64.9
Sb	316.6	204.1	409.8	95.8	344.5	52.2
Cs	321.3	204.5	418.3	96.4	406.0	132.7
Ba	320.2	244.6	413.4	92.6	493.5	198.9
La	324.0	249.0	426.4	96.2	474.6	102.1
Ce	337.0	269.2	424.3	93.0	456.4	41.8
Nd	322.5	242.9	419.8	90.1	446.8	58.8
Sm	316.6	237.3	418.6	90.1	470.9	51.3
Dy	313.3	224.8	424.5	93.4	429.2	31.9
Ho	313.1	231.9	428.5	99.6	450.3	34.9
Er	311.6	228.8	424.2	93.7	442.3	45.3
Lu	314.5	237.3	424.5	90.7	439.7	39.9
Pb	263.0	182.7	358.6	82.1	415.4	93.8
Th	291.2	220.0	401.8	84.1	449.2	57.8
U	291.8	249.2	396.0	91.5	457.0	29.3
P	217.4	245.6	409.7	138.9	342.5	53.8
K	393.3	386.8	304.9	106.0	536.9	292.1
Sc	285.7	225.9	427.3	81.6	442.3	36.2
Ti	257.6	218.4	363.7	69.6	424.4	108.0
V	292.9	240.7	410.0	81.0	414.1	76.4
Cr	282.4	226.3	410.2	83.7	405.8	47.1
Mn	289.6	257.3	406.8	77.2	428.3	111.6
Fe	282.4	244.6	385.5	80.9	423.6	118.9
Co	227.1	200.8	323.5	70.6	393.5	66.8
Ni	262.5	223.4	389.4	82.3	432.8	67.8
Cu	248.3	194.3	370.9	85.3	432.9	58.3
Zn	237.9	184.2	353.8	88.2	548.6	535.9
Eu	294.0	547.8	430.3	82.8	462.4	74.0

Of particular significance for provenance analysis, consideration of these standards suggests the compositional data obtained using a laser diameter of 50 microns for sample ablation produces more reliable data than that obtained using a laser diameter of 100 microns. In fact, use of a laser diameter of 50 microns reduces the percent relative standard deviation of most of these analytes to a quarter of that achieved with a laser diameter of 100 microns (e.g., often from greater than 70% to less than 20%; see Thomas 2002b:33). Additionally, the NIST 612 and NIST 610 data consistently demonstrate that a laser diameter of 50 microns increases the amount of material ablated, thereby elevating the counts for many analytes. As a result, several analytes that often fall below the limit of detection using a laser diameter of 100 microns (e.g., lithium) are measurable using a laser diameter of 50 microns. Given the small size of the area ablated, I suppose that a phenocryst or another large inclusion may exert undue influence on the chemical profile of a geological sample or artifact. I will investigate this possibility in future analyses.

Despite the difficulty I experienced when using a laser diameter of 100 microns, the compositional data obtained with this laser setting may still be informative. It seems that the data obtained under these different laser settings maintain the same relationships relative to each other; that is, the data structure in relative space is maintained, though the absolute values change. This conclusion is supported by the strong correlations exhibited by these analytes (often $r > 0.90$), as would be expected since these standards have been doped with known amounts of trace elements. Thus, compositional data obtained from geological samples utilizing different laser settings may be compared if scaled accordingly. Figures 5.83-5.86 compare some of the data obtained for NIST 610 at laser diameters of 100 microns and 50 microns after transformation.

Inspection of these figures suggests that not all transformations are appropriate for each analyte. Since these laser settings are utilized to measure the same sample (i.e., a NIST 610 glass wafer), the utility of each transformation may be judged on how well it closes the gap between the data obtained using a laser diameter of 50 and 100 microns. Normalizing the data by dividing by the NIST 610 mean obtained for each analyte using the different laser settings renders these data most suitable for comparison. Indeed, this transformation amounts to calibrating these data to an external standard (i.e., NIST 610), thereby accounting for the different count rates achieved by a laser diameter of 100 or 50

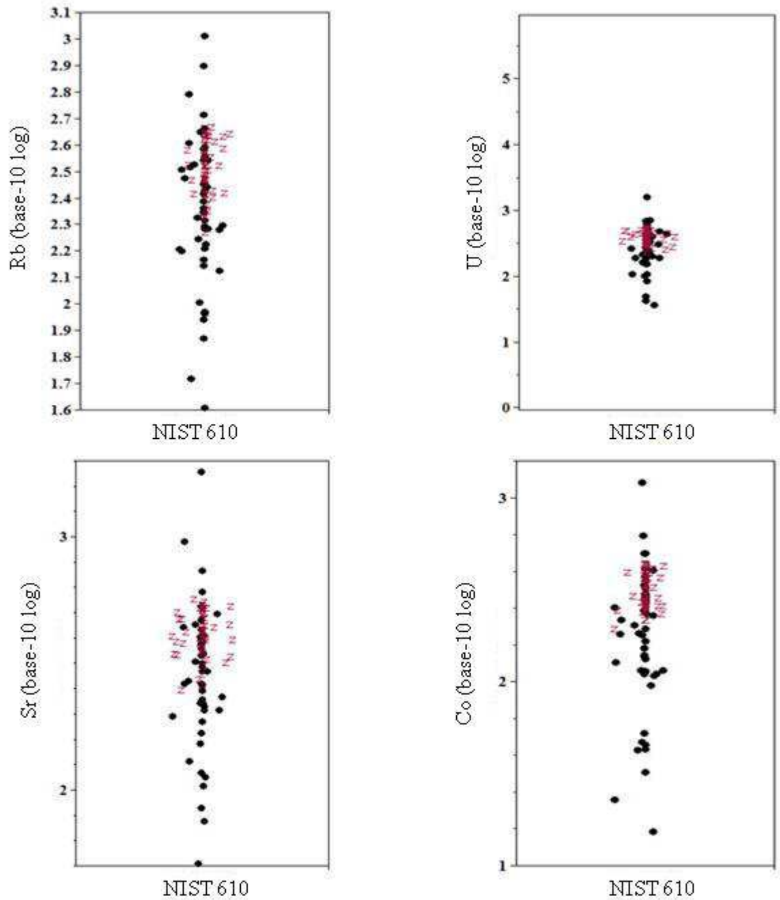


Figure 5.83: Comparison of NIST 610 data after transformation using base-10 logarithms. Black circles represent NIST 610 data obtained using a laser diameter of 100 microns. Red Zs represent NIST 610 data obtained using a laser diameter of 50 microns.

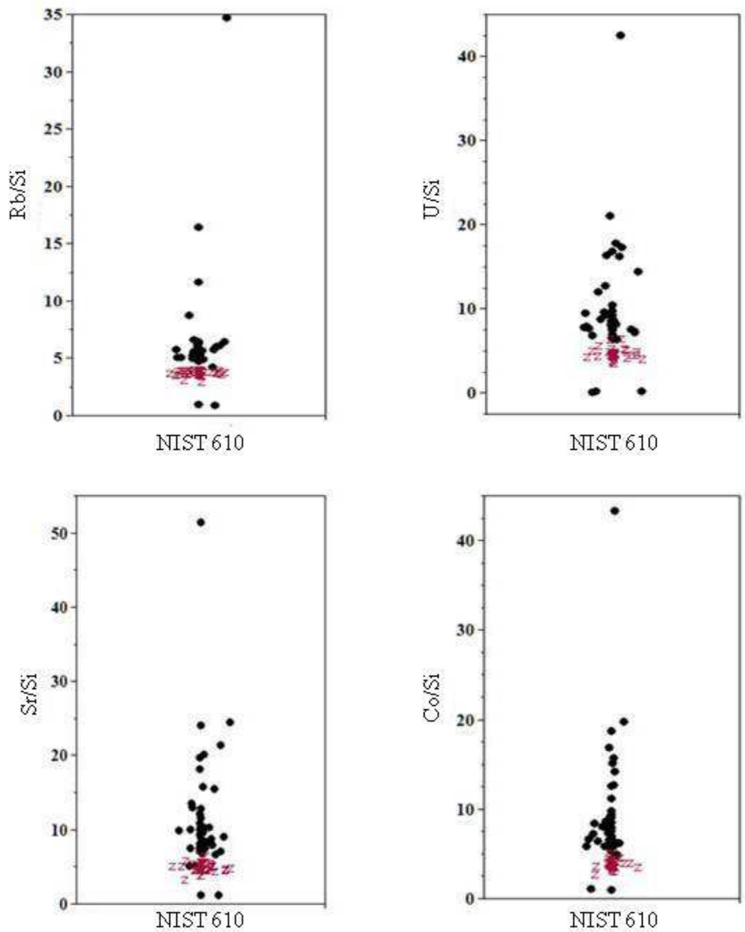


Figure 5.84: Comparison of NIST 610 data after normalization to silicon (Si). Black circles represent NIST 610 data obtained using a laser diameter of 100 microns. Red Zs represent NIST 610 data obtained using a laser diameter of 50 microns.

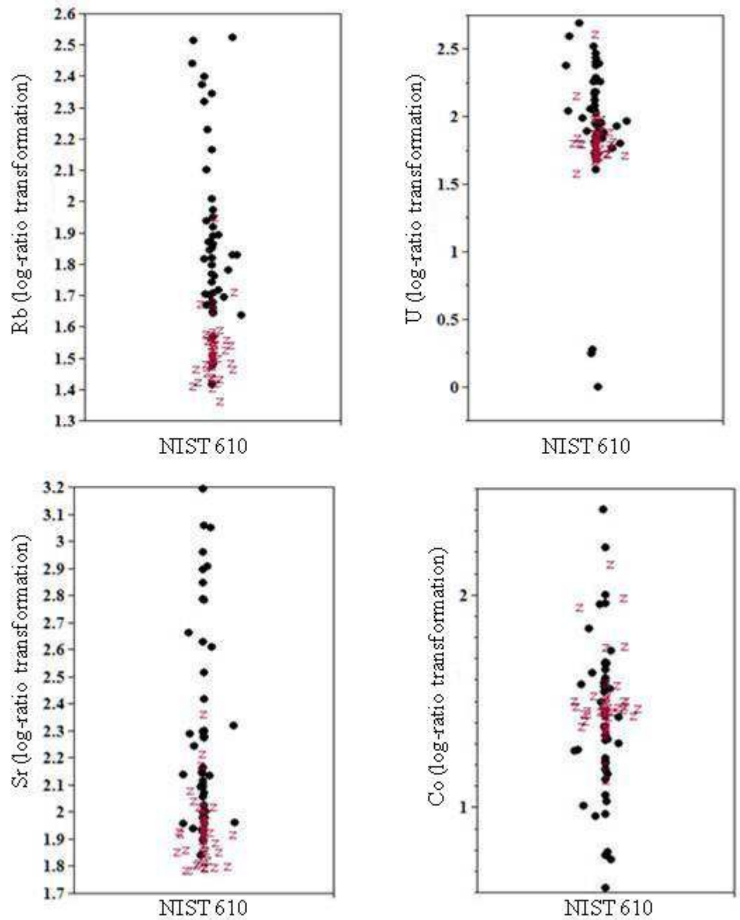


Figure 5.85: Comparison of NIST 610 data after log-ratio transformation. Black circles represent NIST 610 data obtained using a laser diameter of 100 microns. Red Zs represent NIST 610 data obtained using a laser diameter of 50 microns.

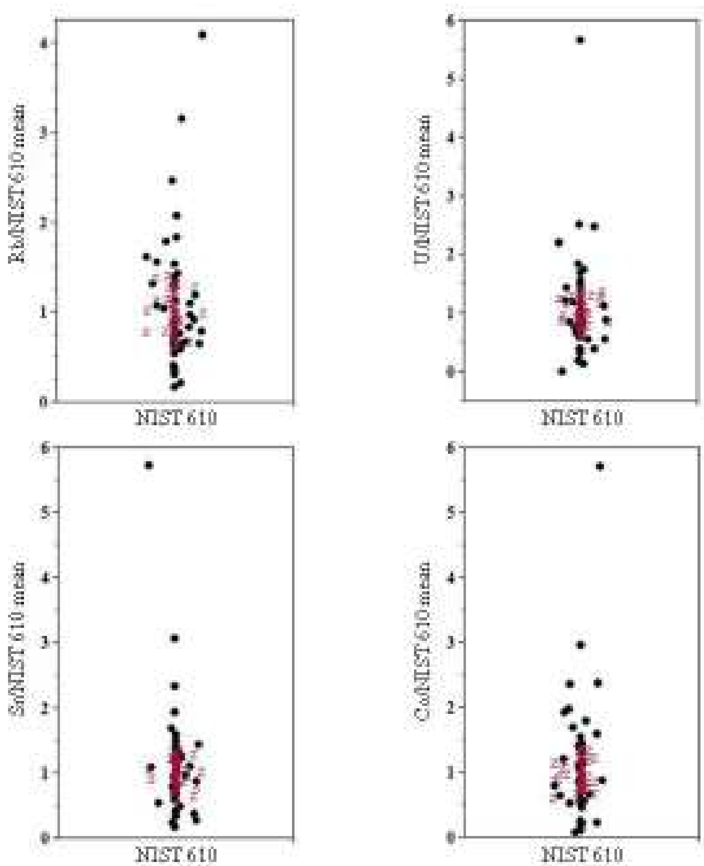


Figure 5.86: Comparison of NIST 610 data after normalization to the NIST 610 mean for each analyte obtained under the different laser settings. Black circles represent NIST 610 data obtained using a laser diameter of 100 microns. Red Zs represent NIST 610 data obtained using a laser diameter of 50 microns.

microns. Transformation using base-10 logarithms also seems to render these data suitable for comparison across laser settings. Logarithmic transformation does not completely eliminate the bias introduced into these data by the different laser settings; after all, the logarithm of a higher number will be higher. Nevertheless, this transformation seems to work for several analytes because the data obtained using these different laser settings are not sufficiently different to affect a large difference in their logarithms.

In theory, scaling the data by normalizing to silicon (Si), which is a common treatment of compositional data obtained using LA-ICP-MS (Pearce et al. 1997), or normalizing to the geometric mean (for log-ratio analysis) should permit comparison of data obtained using different laser settings, as the value for a particular analyte is expressed in relation to the values of other, similarly obtained analytes. In reality, the effectiveness of these transformations seems to depend upon the contribution of a particular analyte to the whole, as well as the difference obtained for that analyte under each laser setting. The danger these transformations pose is in maintaining the bias in the dataset, simply in inverted form. If a regular relationship obtains between the increase of an analyte and the increase in silicon, then normalization to silicon should permit comparison across the different laser settings. For example, imagine that a regular relationship obtains between the increase of rubidium (Rb) and the increase of silicon from a laser diameter of 100 microns (e.g., 300 ppm Rb, 60 wt% Si) to 50 microns (e.g., 400 ppm Rb, 80 wt% Si), then normalization to silicon yields the same ratio in each case (e.g., Rb/Si = 5). If a regular relationship does not obtain between the increase of an analyte and the increase in silicon from a laser diameter of 100 microns (e.g., 300 ppm rubidium and 56 wt% silicon) to 50 microns (e.g., 426 rubidium and 125 wt% silicon), then normalization to silicon may not be effective for comparing across the different laser settings. In this case, normalization by silicon yields a ratio of 5.36 and 3.41, which inverts the bias introduced into the data by the different laser settings. As Figure 5.85 demonstrates, scaling each analyte by the geometric mean seems similarly affected for some analytes (e.g., rubidium), although other analytes (e.g., cobalt, Co) are rendered comparable using this transformation.

Ultimately, the detailed inspection of the compositional data obtained for the NIST 610 and NIST 612 standards is aimed at avoiding the discrimination of sample localities as an artifact of the methods (i.e., the laser settings) utilized to obtain the data. To that end, it seems clear that the comparison of compositional data from different sample localities obtained utilizing the same laser settings may proceed in a straightforward manner. Comparison of compositional data from different sample localities obtained utilizing different laser settings requires judicious selection of appropriately transformed data. These considerations, along with the small sample sizes analyzed thus far, suggest that the analyses reported here, while capable of discriminating compositional subgroups in relative space, might best be viewed as qualitative or semi-quantitative (Cromwell and Arrowsmith 1995; Richner et al. 1994; Thompson et al.

1990); subsequent analysis will likely refine these subgroups in absolute space. For this reason, I do not report mean responses for these analytes (e.g., Huckell et al. 2011:Table 1); again, at this stage of analysis I am more concerned with the discrimination of compositional groups relative to each other than the absolute definition of these groups.

Prior to moving on to the analysis of the geological samples, a few more steps are required to screen the data. In the analysis that follows, elements at or below the limit of detection (defined as three times the standard deviation of "blanks;" i.e., argon carrier gas flowing through the machine; e.g., Pereira et al. 2001:1932; Thomas 2002d:31) in more than 50% of the samples were excluded from the statistical analysis (after Huckell et al. 2011). While only phosphorous (P) and tantalum (Ta) fit this criterion, lithium (Li) comes close; thus, lithium is used, albeit cautiously. Additionally, potassium (K) was not reliably measured in many samples due to spectral interference from the argon carrier gas. Finally, in order to transform these data for analysis, I replace zero and negative concentrations (i.e., data that are really below the level of 0.01%) with concentrations slightly lower than the lowest value observed for that analyte at that sample locality (Baxter 1989, 1991; Beardah et al. 2003; Kalnicky and Singhvi 2001:113). This is necessary because the log-ratio transformation, for example, requires calculation of the geometric mean of each sample, which cannot be performed with zeroes or negative values in the dataset.

With these preliminaries in mind, we may begin to explore these data through a comparison of Sample Localities 9, 11, and 20, paralleling the earlier presentation of compositional data obtained using XRF (Figure 5.87-5.90).

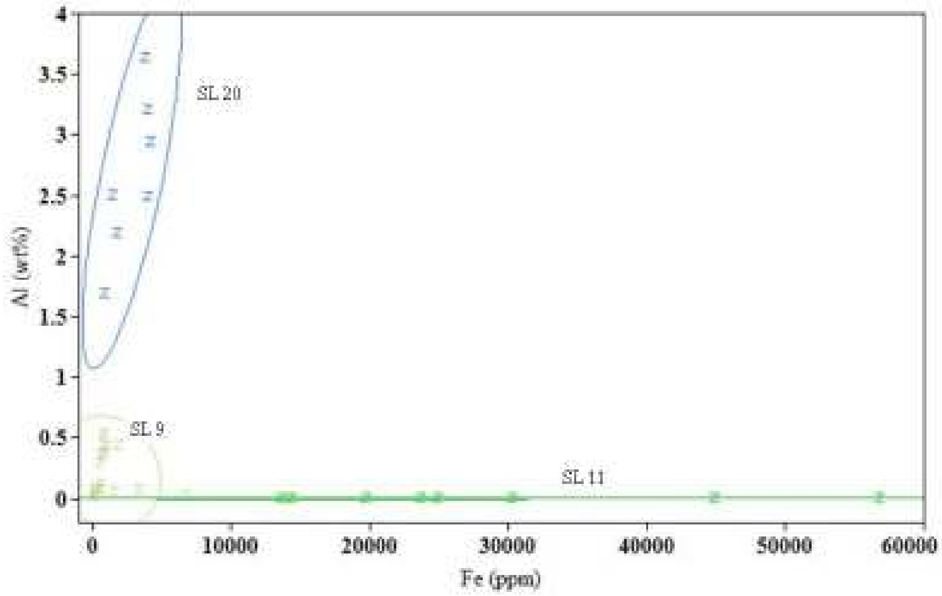


Figure 5.87: Scatterplot of Fe (ppm) vs. Al (wt%) for Sample Localities (SL) 9, 11, and 20, with a 95% bivariate normal density ellipse drawn around each SL.

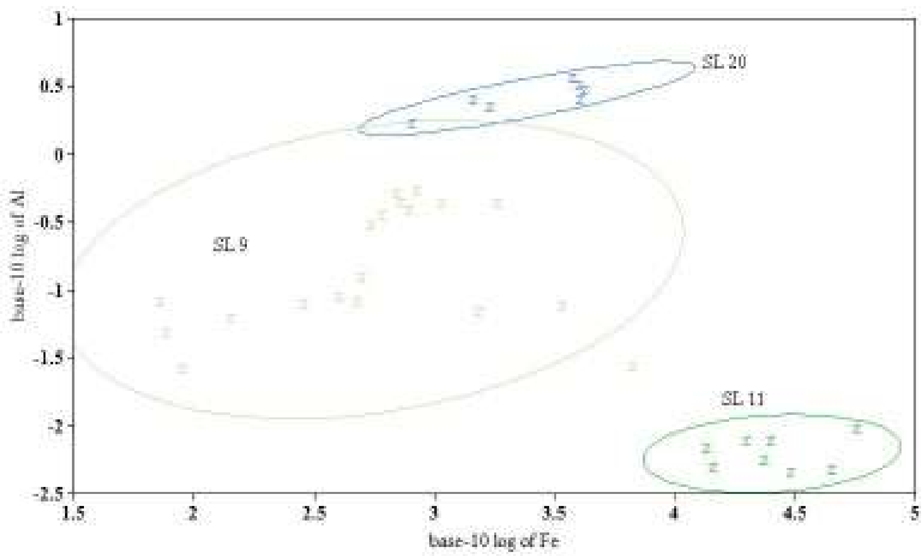


Figure 5.88: Scatterplot of base-10 log of Fe vs. base-10 log of Al for Sample Localities (SL) 9, 11, and 20, with a 95% bivariate normal density ellipse drawn around each SL.

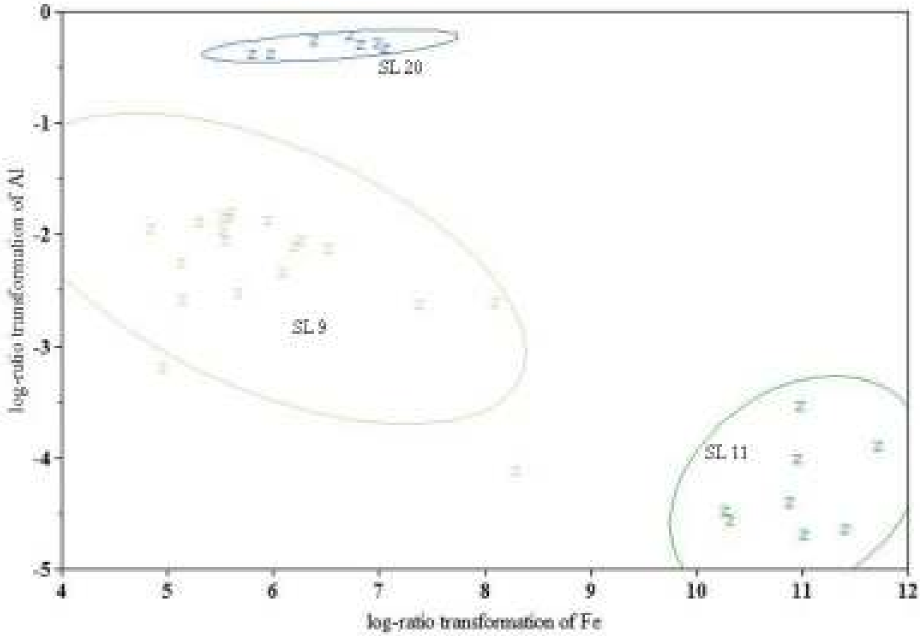


Figure 5.89: Scatterplot of Fe vs. Al (log-ratio transformation) for Sample Localities (SL) 9, 11, and 20, with a 95% bivariate normal density ellipse drawn around each SL.

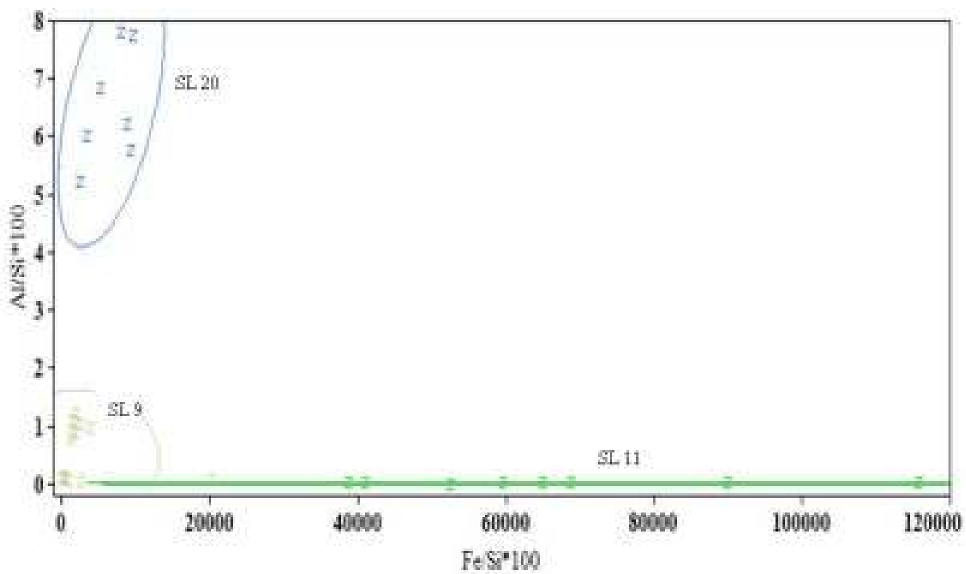


Figure 5.90: Scatterplot of Fe/Si x 100 vs. Al/Si x 100 for Sample Localities (SL) 9, 11, and 20, with a 95% bivariate normal density ellipse drawn around each SL.

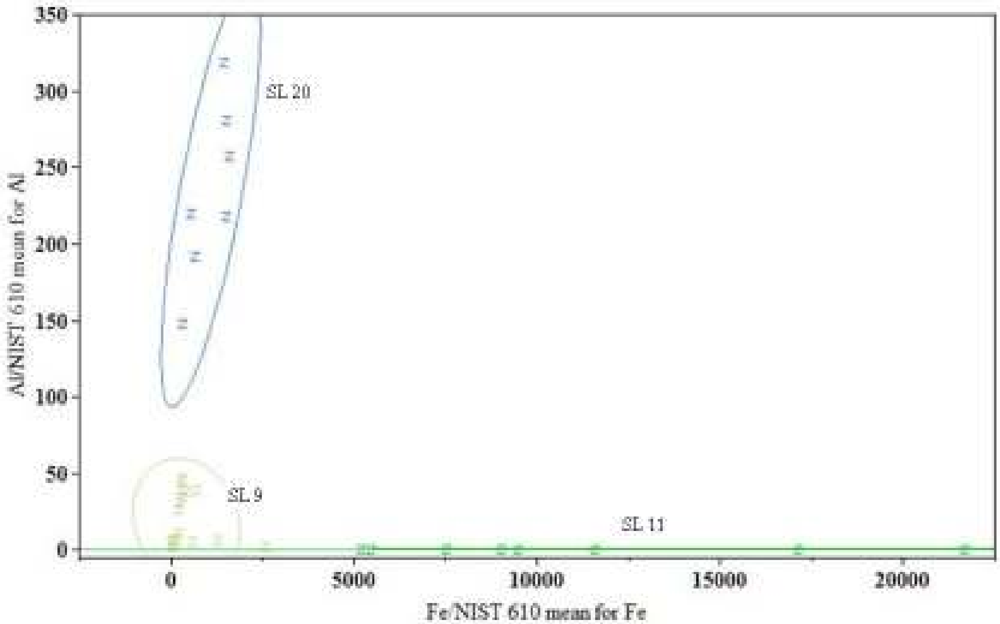


Figure 5.91: Scatterplot of Fe/NIST 610 mean for Fe vs. Al/NIST 610 mean for Al for Sample Localities (SL), 9, 11, and 20, with a 95% bivariate normal density ellipse drawn around each sample locality.

Sample Localities 9, 11, and 20 are easily discriminated utilizing the raw data for aluminum and iron, as well as each method of data transformation utilized here. Indeed, these scatterplots duplicate fairly well the positioning of these sample localities relative to each other seen in the XRF data, including the slight overlap of Sample Localities 9 and 11 according to some data transformations. Also, note that scaling the data to the NIST 610 mean for each analyte (Figure 5.91) duplicates the relationships between the sample localities seen in the scatterplot of the raw data (Figure 5.87). The only significant difference between the compositional data obtained using LA-ICP-MS and XRF is the inversion on the aluminum axis (i.e., the y-axis). According to the XRF data, Sample Localities 9 and 11 have higher concentrations of aluminum than Sample Locality 20, while according to the LA-ICP-MS data, Sample Localities 9 and 11 have lower concentrations of aluminum than Sample Locality 20. The difference in aluminum concentrations between these sample localities is roughly 1 to 3 weight percent (wt%) according to both methods. Thus, slight differences in the efficacy of each method for analyzing these samples (e.g., variation in the coupling efficiency of the laser for these samples) may account for the different aluminum concentrations obtained for these localities relative to each other. Significantly, this difference does not impede the discrimination of these localities in relative space, although it underlines the importance of increasing the number of specimens analyzed to define these sample localities in absolute space.

Sample Localities 9, 11, and 20 include specimens that are quite distinct macroscopically. A more difficult task for the method (and the analyst) is to distinguish cherts that are macroscopically similar but derived from different sources. Indeed, incorrect source assignments often occur when a chert artifact is assigned to a source of macroscopically similar cherts. An approximation of the grouping tendency in these data, obtained using a hierarchical cluster analysis (Ward's method and the average-linkage method) of raw and transformed data, indicates grouping tendencies that reflect the macroscopic similarity exhibited by these sample localities (the dendrogram is too large to display here). In other words, the sample localities that are not effectively segregated by this analysis behave as may be predicted from basic macroscopic similarities, including similarities in color. For example, while a few white/gray cherts (e.g., Sample Localities 1c, 9, 36) form exclusive clusters, incorrectly assigned specimens from some white/gray chert sample localities typically co-occur with other white/gray chert sample localities (e.g., Sample Localities 10, 16b). As may be expected, unique cherts (e.g., Sample Locality 21, the only green chert included in this analysis) form discernible, exclusive clusters. Additionally, some localities that include macroscopically variable cherts (e.g., Sample Locality 9, 24) still exhibit clustering that contains most of these specimens.

In short, these data behave largely as expected on the basis of macroscopic similarities: those sample localities that are most distinct macroscopically are captured by the cluster analysis, while those sample localities that are most similar macroscopically are the ones that are mixed up with each other (e.g., Bishop and Neff 1989). In fact, comparing the concentrations of macroscopically-similar chert subgroups, after scaling these data to their NIST 610 means, reveals patterning consistent with these macroscopic similarities. For example, a one-way analysis of variance indicates that red and orange cherts contain significantly higher concentrations of iron than white and gray cherts

(F=28.9981, p <0.0001; Luedtke 1992:63). Also, dark gray and black cherts contain a significantly higher concentration of manganese than other chert subgroups (F=2.6255, p = 0.02; Luedtke 1992:63). While cluster analysis reduces the dimensionality of these data to such a degree as to prohibit basing archaeological inferences on this analysis alone (Bishop and Neff 1989), cluster analysis does suggest that the dataset may be partitioned into macroscopically-similar subgroups prior to multivariate statistical analysis. I include Sample Locality 21 (the green chert) as an out-group in the following comparisons of these macroscopically-similar chert subgroups.

Beginning with the analysis of red cherts, we see that a scatterplot of base-10 logarithms of rubidium (Rb) versus strontium (Sr), for example, provides significant discrimination ($p < 0.05$) between many of these sample localities; however, some red chert specimens from sample localities that include macroscopically-variable cherts (i.e., Sample Localities 3, 5, 24, and 31) are mixed in with Sample Localities 18 and 20 (Figure 5.92). Bivariate scatterplots of other analytes (Figure 5.93) generate some separation between Sample Localities 3, 5, 18, 20, 24, and 31, suggesting that multivariate statistical analysis may be necessary to capture the structure in these data.

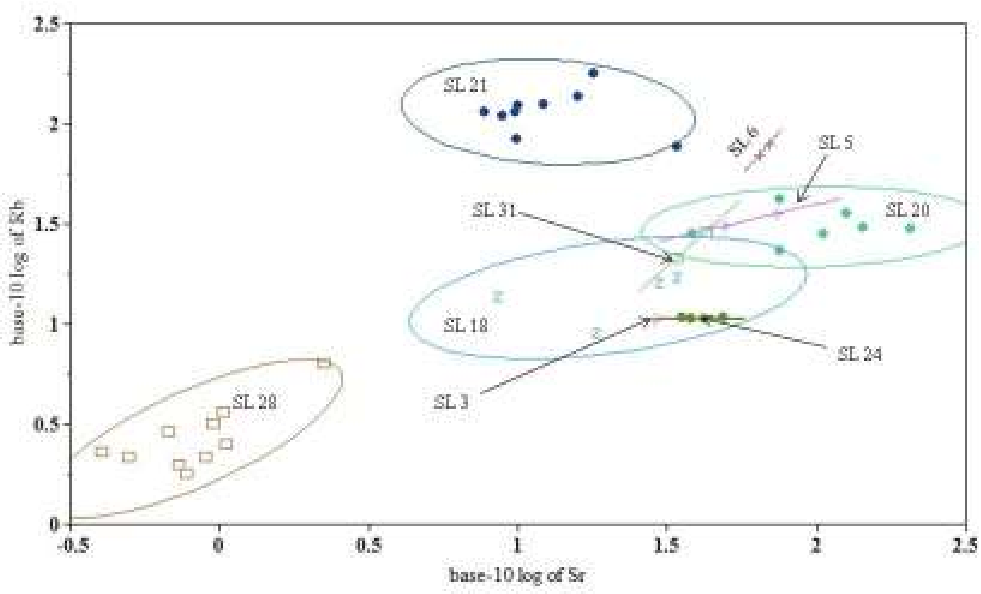


Figure 5.92: Scatterplot of base-10 logarithms of strontium (Sr) vs. rubidium (Rb) for the red chert subgroup, with a 95% bivariate normal density ellipse drawn around each sample locality.

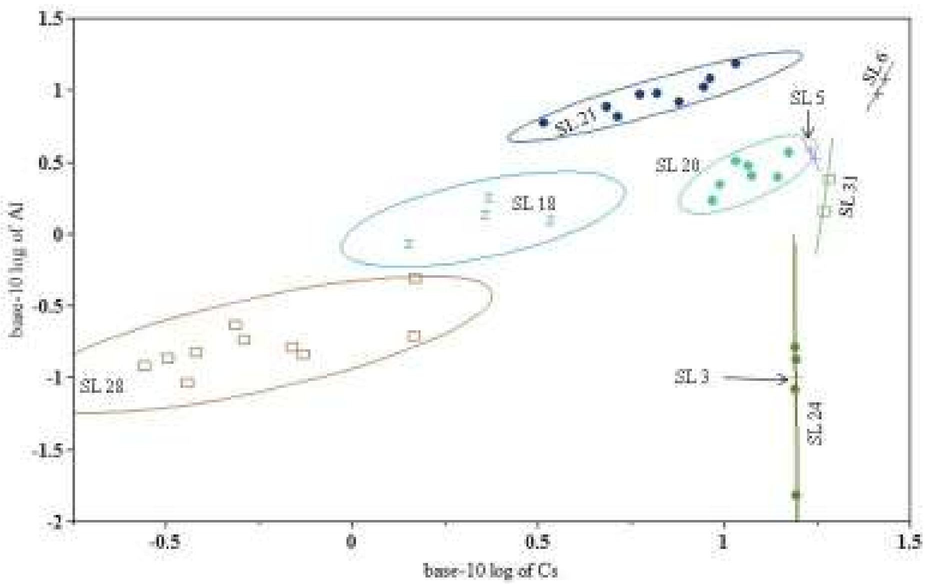


Figure 5.93: Scatterplot of base-10 logarithms of cesium (Cs) vs. aluminum (Al) for the red chert subgroup, with a 95% bivariate normal density ellipse drawn around each sample locality.

Consideration of the distribution of these compositional data indicates that a subset of analytes (e.g., Li, Al, Mg, Ca, Rb, Sr, Y, Cs, Ti, V, Mn, Co, Ni, Fe) contributes to the discrimination of these sample localities. PCA based on the base-10 logarithmic transformation of these analytes suggests that five PCs are required to capture over 90% of the cumulative variance in these data, although eight PCs are "practically significant" (i.e., they have eigenvalues greater than 1.00). Nevertheless, only three PCs (capturing 82.5% of the variance) are required to effectively segregate these sample localities graphically (Fig. 5.94).

All of the analytes load positively on PC 1, though strontium (Sr), yttrium (Y), lanthanum (La), and cesium (Cs) exert the strongest pull along this first dimension. PC 2 reflects the positive loading of aluminum (Al) in opposition to nickel (Ni), while PC 3 captures the positive loading of lithium (Li) in opposition to manganese (Mn) and calcium (Ca). Group-membership probabilities calculated using Mahalanobis distances based on these three PCs indicates no incorrect assignments. These results are reinforced by looking back at the distribution of these analytes across these sample localities. For

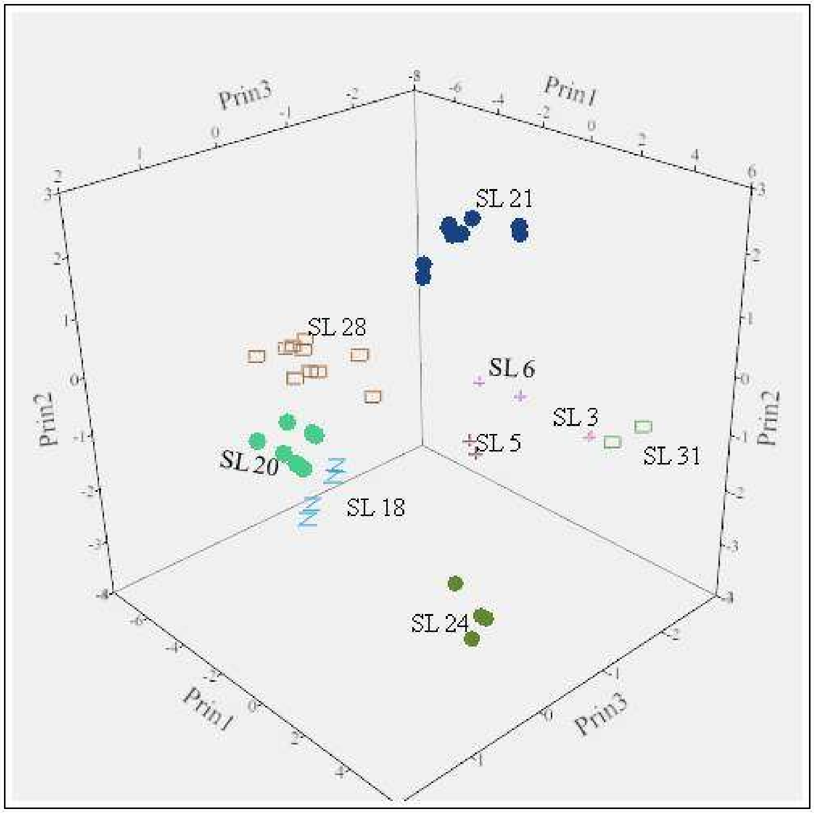


Figure 5.94: Three-dimensional scatterplot of the first three PCs that contribute to the segregation of the sample localities within the red chert subgroup.

example, a one-way ANOVA ($F = 72.9769$, $p < 0.0001$) of the distribution of the base-10 logarithm of aluminum reflects some of the discriminatory power captured by PC 2 (Figure 5.95). Pair-wise comparison of the means for each sample locality (shown at right in Figure 5.95) reinforces their significantly different ($\alpha = 0.05$) aluminum concentrations. Thus, it seems that the compositional data obtained using LA-ICP-MS can effectively discriminate the sample localities that contribute red cherts to this sample.

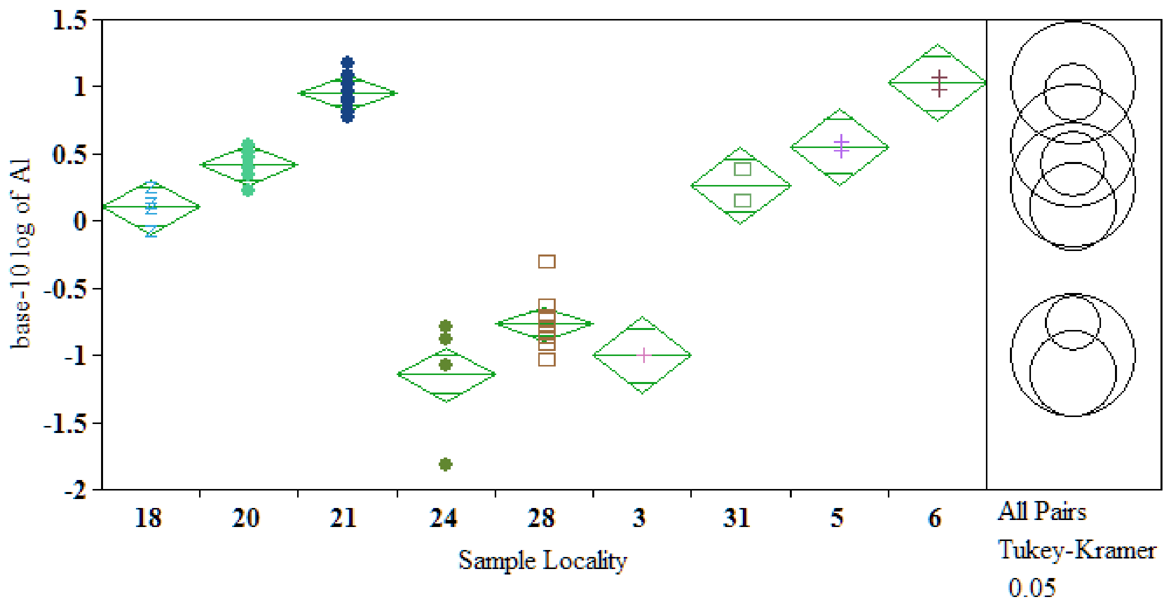


Figure 5.95: One-way ANOVA of the base-10 logarithm of aluminum for red cherts, separated by sample locality. A graphical representation of a pair-wise Student's t test is shown at right.

The analysis of compositional data for dark gray/black cherts requires more diligent variable selection, as some of these sample localities were analyzed using different laser settings. Preliminary inspection of these compositional data suggests that several analytes may be required to effectively discriminate these sample localities. As an example, Figure 5.96 shows the distribution of cerium (Ce, after normalization to the NIST 610 mean). A one-way ANOVA is significant ($F = 12.2865$, $p < 0.0001$), although this result is clearly driven by Sample Locality 9. This does not seem to be an artifact of the different laser settings, however; Sample Locality 9 and 21 were both analyzed using a laser diameter of 100 microns. As is clear from Figure 5.96, Sample Locality 21 exhibits counts for cerium that are comparable to specimens from Sample Localities 3, 5, 32, 33a, 33b, and 34, all of which were analyzed using a laser diameter of 50 microns. Plus, the data presented in this figure have been scaled to the NIST 610 mean for cerium prior to analysis, which eliminates the bias introduced into the data by the different laser settings. It is also worth noting that the similarities amongst these sample localities according to this analyte accord well with their geographic proximity to each other (e.g., Sample Localities 33a and 33b are located closest to each other, with Sample Localities 32 and 34 the next closest).

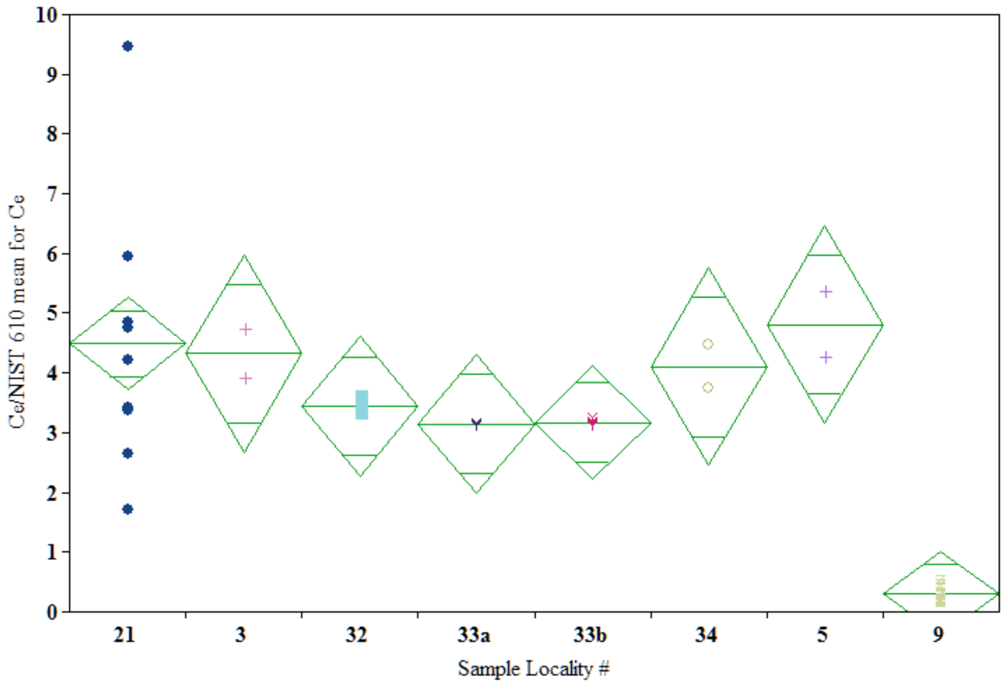


Figure 5.96: One-way ANOVA of cerium (Ce, scaled to its NIST 610 mean) within the dark gray/black chert subgroup, separated by sample locality.

Conducting PCA on all analytes (after scaling to the NIST 610 mean) requires six PCs to account for 90% of the cumulative variance in the data; however, group-membership probabilities calculated using Mahalanobis distances based on these PCs results in the misclassification of only 2 of 40 (5%) specimens, and both are specimens from Sample Locality 33a misclassified as from Sample Locality 33b. PCA on a subset of analytes that contribute to the segregation of these sample localities in two-dimensional space (e.g., Rb, Sr, Y, U, Ni, Li, Ce, Nd) further reduces the dimensionality of these data to three PCs of practical significance. PC 1 reflects positive loadings of rubidium (Rb), cerium (Ce), uranium (U), neodymium (Nd), and yttrium (y), opposed to a negative loading of strontium (Sr). PC 2 reflects the positive loading of lithium (Li) opposed to nickel (Ni) and PC 3 reflects the positive loading of silicon (Si). Group-membership probabilities calculated using Mahalanobis distances based on these three PCs indicates the same misclassification as noted earlier; that is, two specimens from Sample Locality 33a are misclassified as from Sample Locality 33b. Graphically, a scatterplot of PC 1 vs. PC 2 demonstrates clear discrimination of these sample localities

(Figure 5.97). Thus, it seems that the compositional data obtained using LA-ICP-MS can effectively discriminate the sample localities that contribute dark gray/black cherts to this sample.

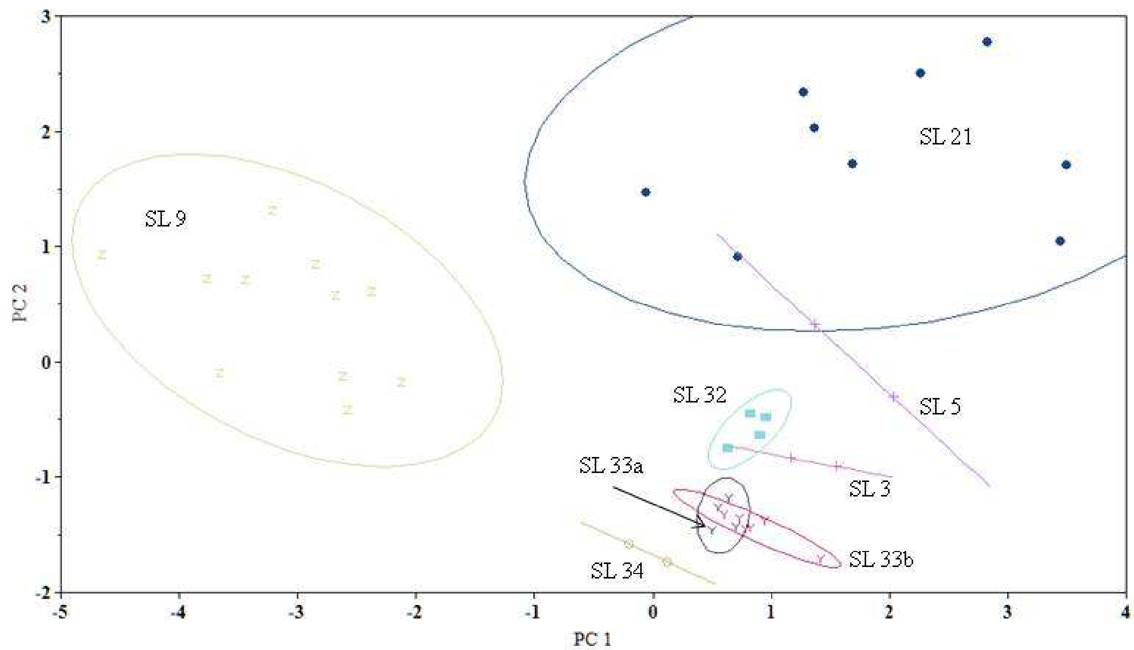


Figure 5.97: Scatterplot of PC 1 vs. PC 2 of dark gray/black chert subgroup, with a 95% bivariate normal density ellipse drawn around each sample locality.

Initial inspection of the compositional data obtained for orange/brown cherts and light-colored cherts suggest that discrimination of the sample localities that comprise these subgroups will be more difficult than the preceding analyses. Focusing presently on the orange/brown cherts, inspection of these compositional data after transforming them to their base-10 logarithms or standardizing the analytes by their NIST 610 means indicates that several analytes, including thorium (Th), some lanthanides (e.g., Sm, Eu, Dy, Ho, Er) and some transitional metals (e.g., Cd, Sn, Sc, Cs, Lu, Na), manifest significant differences because of the different laser diameters utilized in their analysis. These analytes are excluded from further consideration for this subgroup. PCA on the base-10 logarithms of the remaining analytes reduces the dimensionality of these data to four PCs of practical significance, though seven PCs are required to account for more than 90% of the cumulative variance in the data. The four PCs of practical significance are defined as follows: PC 1 reflects the positive loading of lanthanum (La), PC 2 reflects the positive loading of aluminum (Al), PC 3 reflects the positive loading of iron (Fe), and PC 4 reflects the negative loading of manganese (Mn). Group membership probabilities using Mahalanobis distances calculated on these four PCs indicates the misclassification of 14 of 75 specimens (18.67%).

Considering the next three PCs, PC 5 reflects the positive loading of lithium (Li), PC 6 reflects the negative loading of silicon (Si), and PC 7 reflects the negative loading of vanadium (V). Group-membership probabilities using Mahalanobis distances calculated on these seven PCs indicates the misclassification of 5 of 75 specimens (6.67%), including the classification of a specimen from Sample Locality 29 with Sample Locality 31 and vice versa, the classification of a specimen from Sample Locality 14a with Sample Locality 29, and the classification of two samples from Sample Locality 3 with Sample Locality 23. A scatterplot of PC 1 vs. PC 2 exemplifies the difficulty in distinguishing Sample Localities 29, 30, 31, and 32 in particular, with a few orange/brown specimens from Sample Localities 3, 33a, and 33b mixed in as well (Figure 5.98). A three-dimensional scatterplot on the first three PCs, however, segregates these sample localities more clearly (Figure 5.99).

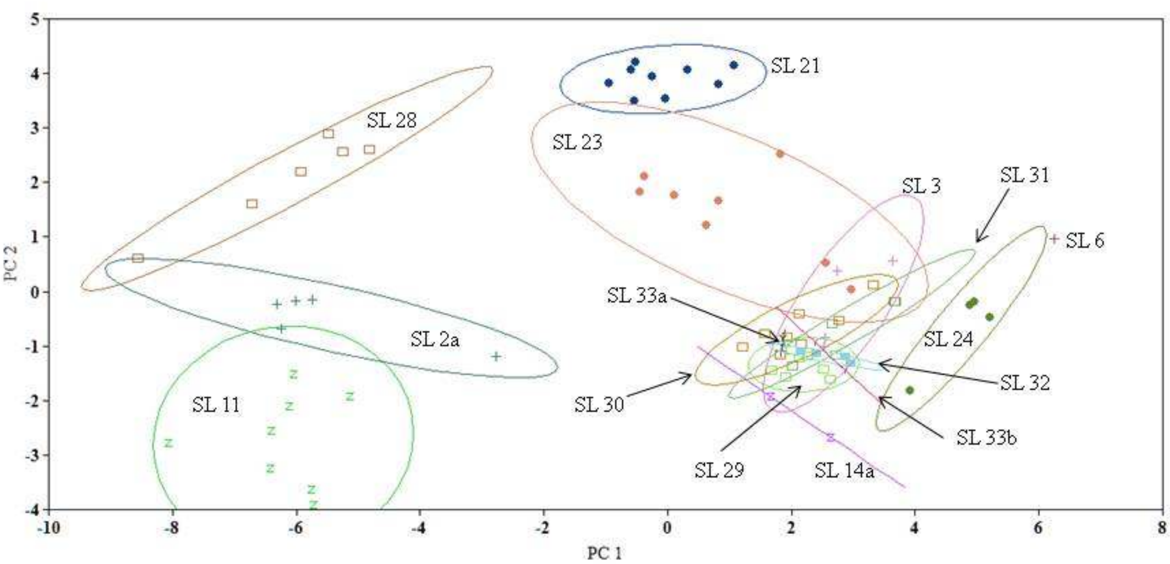


Figure 5.98: Scatterplot of PC 1 vs. PC 2 of orange/brown chert subgroup, with a 95% bivariate normal density ellipse drawn around each sample locality.

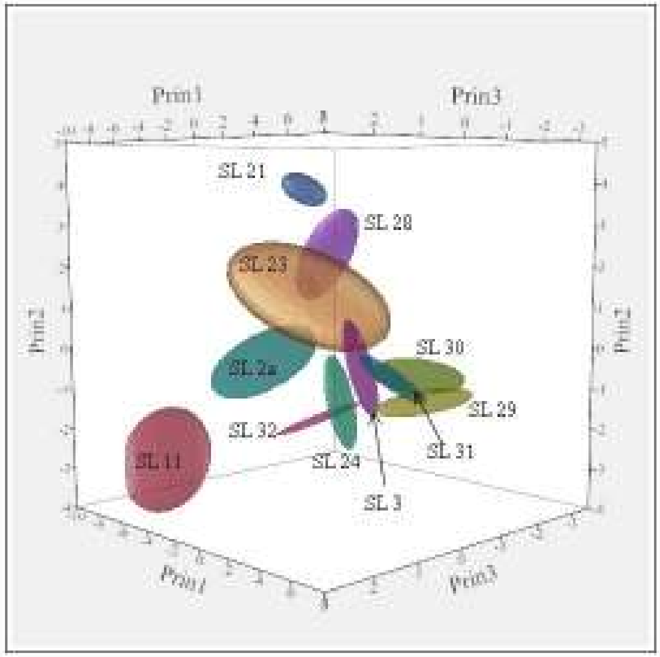


Figure 5.99: Three-dimensional scatterplot of the first three PCs that contribute to the segregation of the sample localities within the orange/brown chert subgroup.

As a next step in the analysis, I focus on resolving these misclassifications, especially on differentiating: (a) Sample Localities 3 and23; (b) Sample Localities 14a and 29; and (c) Sample Localities 29, 30, 31, 32, and 33. Inspection of the compositional data for Sample Localities 3 and 23 indicates that some analytes are capable of discriminating these sample localities. For example, Figure 5.100 presents a scatterplot of the base-10 logarithms of titanium (Ti) versus strontium (Sr), which clearly differentiates these sample localities. Thus, close inspection of the compositional data for Sample Localities 3 and 23 would allow the analyst to resolve the source assignment of a chert artifact initially assigned to either of these sample localities on the basis of multivariate statistical analysis.

Likewise, close inspection of the compositional data for Sample Localities 14a and 29 would allow the analyst to determine the correct source assignment of an artifact initially assigned to either of these sample localities utilizing multivariate statistical analysis. For example, Sample Locality 29 has a significantly higher concentration of thorium (Th; one-way ANOVA, $F = 5.0467$, $p = 0.0595$) and uranium (U; one-way ANOVA, $F = 4.5915$, $p = 0.0693$) than Sample Locality 14a.

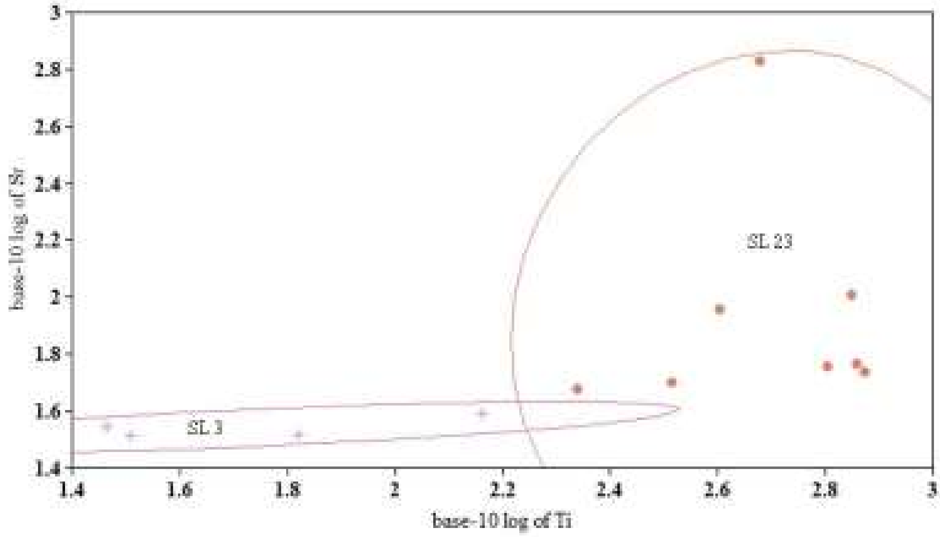


Figure 5.100: Scatterplot of the base-10 logarithms of titanium (Ti) vs. strontium (Sr), with a 95% bivariate normal density ellipse drawn around each sample locality.

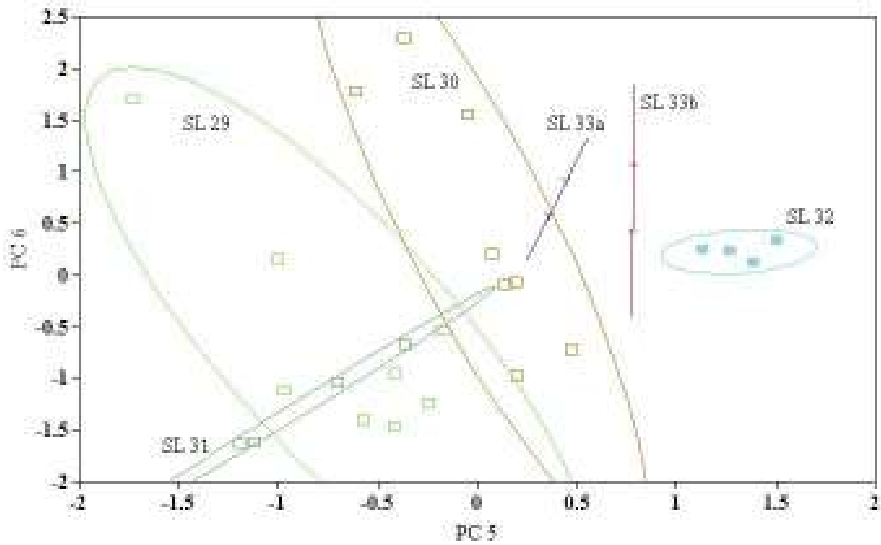


Figure 5.101: Scatterplot of PC 5 vs. PC 6 for Sample Localities (SL) 29, 30, 31, 32, 33a, and 33b, with a 95% bivariate normal density ellipse drawn around each SL.

Finally, scatterplots of some of the less significant PCs demonstrate further segregation of Sample Localities 29, 30, 31, 32, 33a, and 33b. For example, a scatterplot of PC 5 vs. PC 6 from the initial PCA presented above clearly differentiates Sample Localities 29, 30, 32, 33a, and 33b from each other, although segregation of Sample Localities 29 and 31 remains difficult (Figure 5.101). Indeed, these are the sample localities responsible for increasing the dimensionality of these data to seven PCs; as we saw above, two PCs are sufficient for distinguishing the rest of the sample localities within the orange/brown chert subgroup.

Further inspection of the compositional data for these sample localities, regardless of the transformation utilized, duplicates the difficulty depicted in Figure 5.101 in distinguishing Sample Localities 29 and 31. Significantly, the difficulty encountered in discriminating these sample localities, as well as Sample Localities 30, 32, 33a, and 33b, may be inconsequential for the provenance analysis of chert artifacts from the Eastern Nevada Study Area, at least for this study. All of these sample localities are located well south of the study area; therefore, any chert artifact assigned to these sources, even if the exact source cannot be confidently identified, would represent the introduction of nonlocal chert into the study area. Thus, although more troublesome than the preceding subgroups, it seems that the compositional data obtained using LA-ICP-MS can effectively discriminate most of the sample localities that contribute orange/brown cherts to this sample.

Discriminating the sample localities that contribute light-colored cherts presents similar difficulties to those seen in the analysis of the orange/brown chert subgroup. Additionally, several analytes appear to reflect biases introduced by the different laser diameters used in this analysis (e.g., Na, Cd, Sn, Sb, Cs, Sm, Dy, Ho, Er, Lu, Pb, Th, V, Sc, Co, Eu); thus, these analytes are not utilized when comparing sample localities analyzed using different laser settings. Conducting PCA on the base-10 logarithms of those analytes that contribute to the segregation of the sample localities in two-dimensional space (e.g., Li, Al, Ca, Rb, Zr, Ce, U, Si, Ti, Mn, Ni, and Zn), indicates that three PCs are practically significant and six PCs are required to account for greater than 90% of the cumulative variance in these data. PC 1 reflects the positive loading of rubidium (Rb), PC 2 reflects the positive loading of aluminum (Al), and PC 3 reflects the negative loading of calcium (Ca). Group membership probabilities using Mahalanobis distances calculated on the first three PCs results in the misclassification of 54 of 173 specimens (31.21%). Considering the next three PCs, PC 4 reflects the positive loading of silicon (Si), PC 5 reflects the negative loading of lithium (Li), and PC 6 reflects the positive loading of calcium (Ca). Group membership probabilities using Mahalanobis distances calculated on the first six PCs indicates the misclassification of 29 of 173 specimens (16.76%). Of these misclassifications, nine reflect a difficulty in segregating Sample Localities 14a, 14b, and 17, and three reflect a difficulty in segregating Sample Localities 4 and 22. Additionally, three specimens from Sample Locality 8 are misclassified, each to a different sample locality, and five specimens from Sample Locality 19 are misclassified to Sample Localities 5, 17, and 25. Thus, the majority of misclassifications are attributable to a few sample localities in close proximity to each other or to a couple sample localities that include variable specimens.

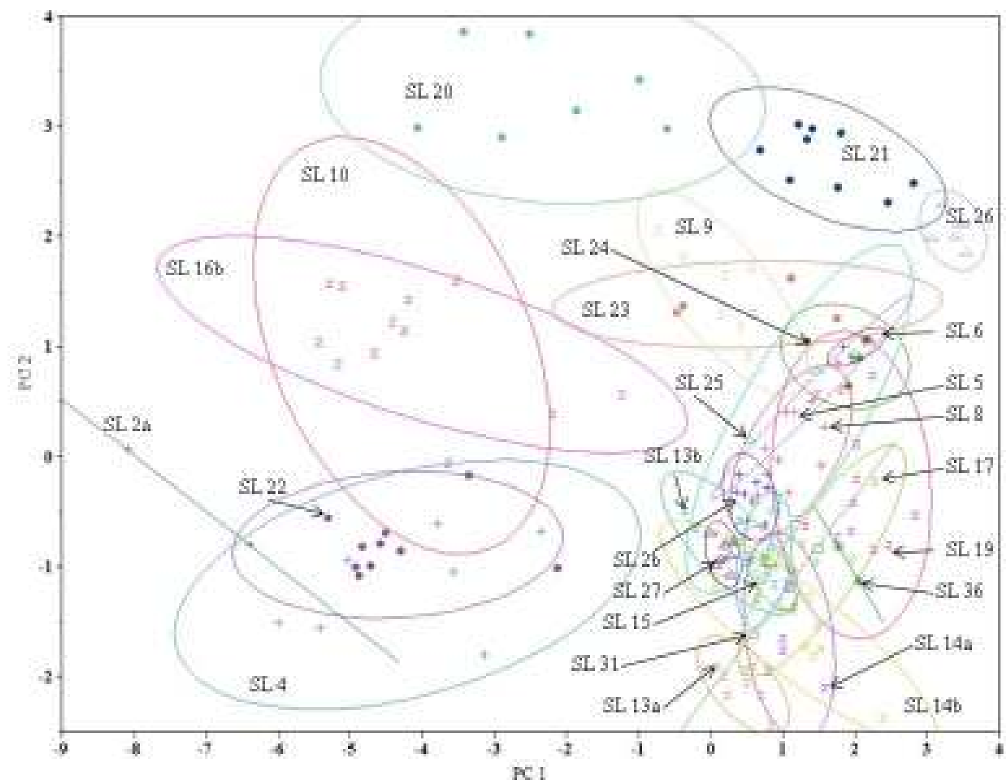


Figure 5.102: Scatterplot of PC 1 vs. PC 2 for light-colored chert subgroup, with a 95% bivariate normal density ellipse drawn around each sample locality.

The bivariate scatterplot of PC 1 vs. PC 2 (Figure 5.102) and the three-dimensional scatterplot of PC 1, PC 2, and PC 3 (Figure 5.103) illustrate the difficulty in discriminating some of these sample localities. Thus, as with the orange/brown chert subgroup, analysis proceeds by attempting to resolve some of the misclassifications indicated by the initial PCA, focusing especially on differentiating: (a) Sample Localities

4 and 22; (b) Sample Localities 14a, 14b, and 17; and (c) Sample Localities 5, 8, 17, 19, and 25.

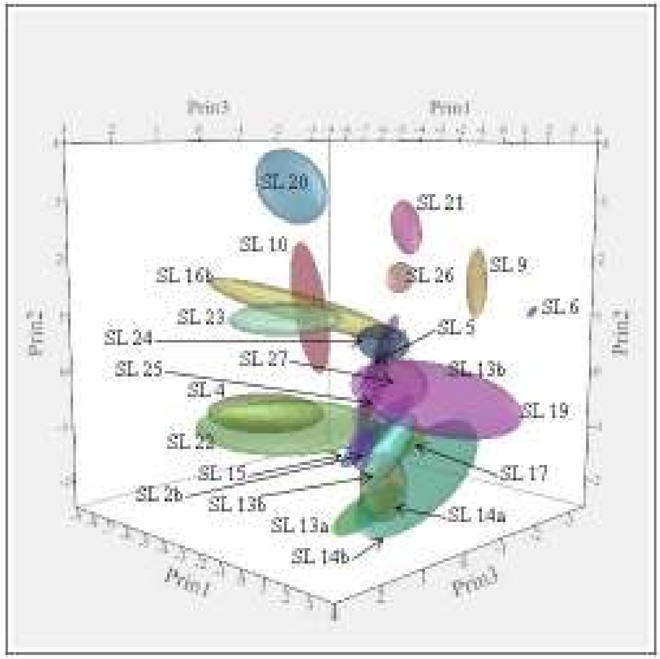


Figure 5.103: Three-dimensional scatterplot of the first three PCs that contribute to the segregation of the sample localities within the light-colored chert subgroup.

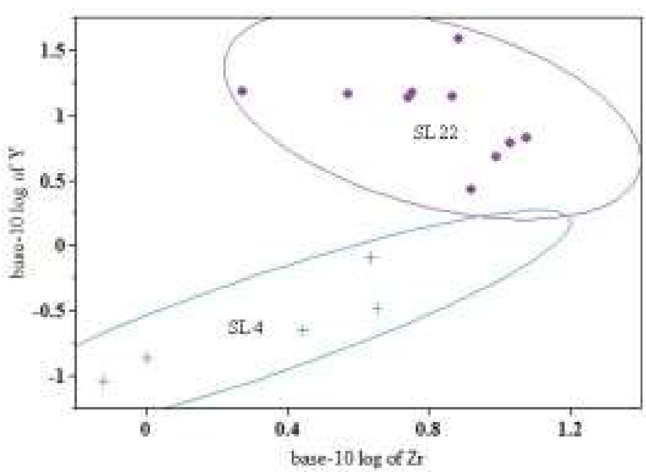


Figure 5.104: Scatterplot of the base-10 logarithms of yttrium (Y) vs. zirconium (Zr) for Sample Localities (SL) 4 and 22, with a 95% bivariate normal density ellipse drawn around each SL.

Further inspection of the compositional data for Sample Localities 4 and 22 indicates that several analytes can effectively discriminate these sample localities, an example of which is depicted in Figure 5.104.

Interestingly, inspection of scatterplots of several different analytes, regardless of the transformation utilized, indicates that Sample Localities 14a and 14b are more easily discriminated, despite their close proximity, than either are from Sample Locality 17 (Figure 5.105, Figure 5.106). In short, these sample localities remain difficult to discriminate from each other.

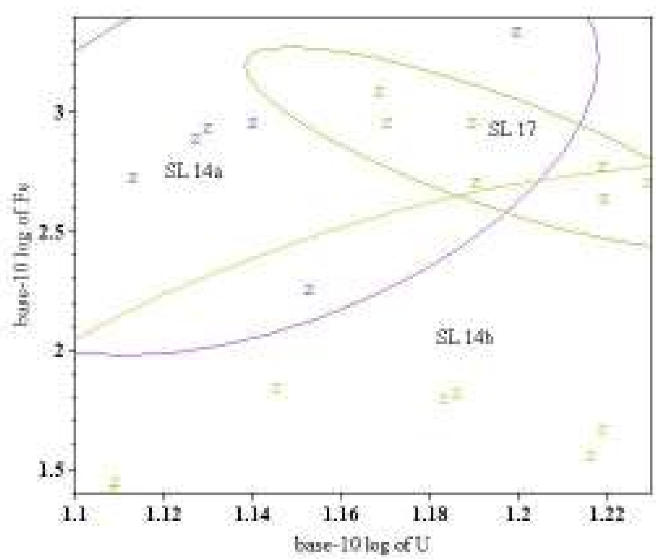


Figure 5.105: Scatterplot of the base-10 logarithms of uranium (U) vs. iron (Fe) for Sample Localities (SL) 14a, 14b, and 17, with a 95% bivariate normal density ellipse drawn around each SL.

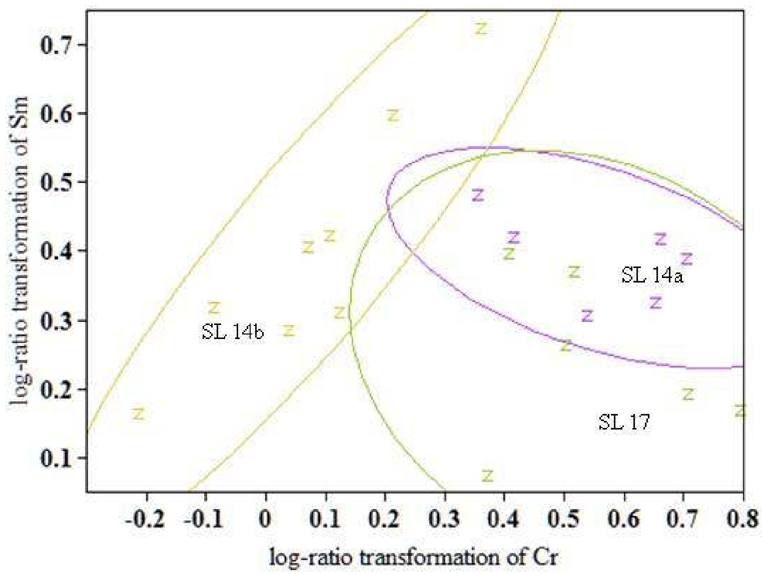


Figure 5.106: Scatterplot of chromium (Cr, log-ratio transformation) vs. samarium (Sm, log-ratio transformation) for Sample Localities (SL) 14a, 14b, and 17, with a 95% bivariate normal density ellipse drawn around each SL. Note that these sample localities were analyzed using the same laser settings; therefore, Sm is an unbiased analyte.

Finally, because Sample Localities 5, 8, 17, 19, and 25 were all analyzed using the same laser settings, the analytes excluded from earlier consideration can be used to help discriminate these sample localities. A linear discriminant analysis that includes these analytes (after transformation to their base-10 logarithms) defines two canonical variates that effectively discriminate these sample localities and result in no misclassifications (Figure 5.107). Horizontal segregation (canonical variant 1) is defined by the negative pull of samarium (Sm) and the positive pull of lutetium (Lu); vertical segregation (canonical variant 2) is defined by the negative pull of cesium (Cs) and the positive pull of holmium (Ho). In sum, although clearly the most troublesome of the chert subgroups, it seems that the compositional data obtained using LA-ICP-MS can effectively discriminate most of the sample localities that contribute light-colored cherts to this sample. Although discriminating some of these sample localities requires extra statistical effort, it is telling that the majority of the geological samples within this subgroup are correctly assigned to their sample localities utilizing standard PCA.

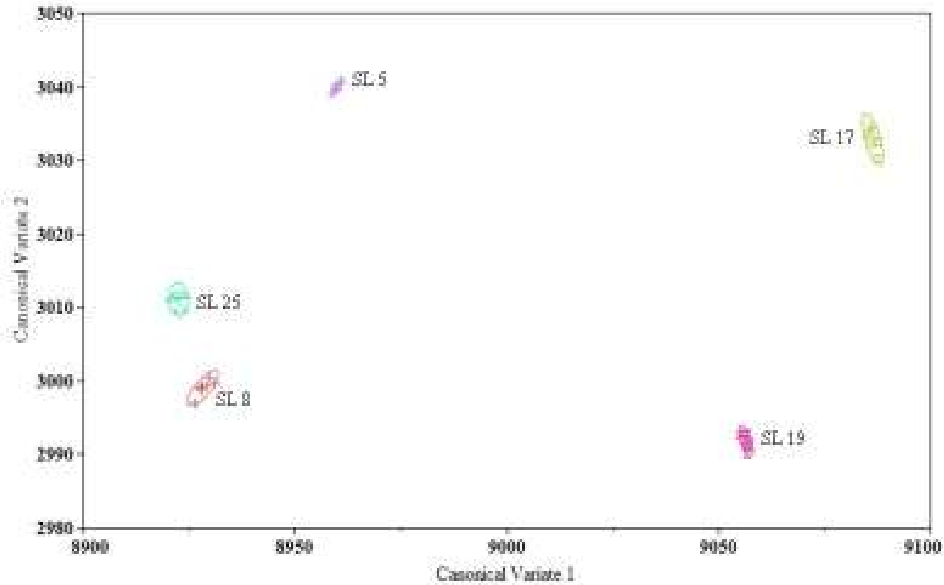


Figure 5.107: Scatterplot of Canonical Variant 1 vs. Canonical Variant 2 for Sample Localities 5, 8, 17, 19, and 25, with a 95% bivariate normal density ellipse drawn around each SL.

While the preceding analyses have demonstrated that it is possible to discriminate macroscopically-similar cherts from different sample localities, it is also worth considering if the compositional data place together macroscopically-dissimilar cherts that derive from the same sample localities. In the following analyses, I focus on Sample Localities 3, 5, 6, 9, 20, 21, 23, 24, 28, 31, 32, 33a, and 33b, each of which include macroscopically-variable cherts. Given the previous analyses, I expect that some of these sample localities will overlap and I have demonstrated that most of the potential misclassifications that would result from this overlap can be resolved. Here, then, I am interested in observing if the variable specimens within these sample localities result in diffuse clusters that may preclude the recognition that these macroscopically-dissimilar cherts derive from the same sample locality. For example, Sample Locality 24 includes red, orange, gray, and purple cherts. Despite this macroscopic variability, I expect these specimens to cluster together in reflection of the single sample locality they represent, rather than present diffuse subgroups that may be confused for distinct sample localities.

As above, several analytes reflect the biases introduced by the different laser settings utilized in this analysis (e.g., Na, Mg, Cd, Sn, Cs, Sm, Dy, Ho, Er, Lu, Pb, Th, U, Sc, Co, Eu). Inspection of scatterplots of various combinations of the remaining analytes illustrates the aforementioned concern. For example, Figure 5.108 presents a scatterplot of the base-10 logarithms of strontium (Sr) vs. rubidium (Rb), with the red boxes highlighting the divergence within Sample Locality 9. If we did not know otherwise, these data might lead us to conclude that these specimens derive from two different sample localities.

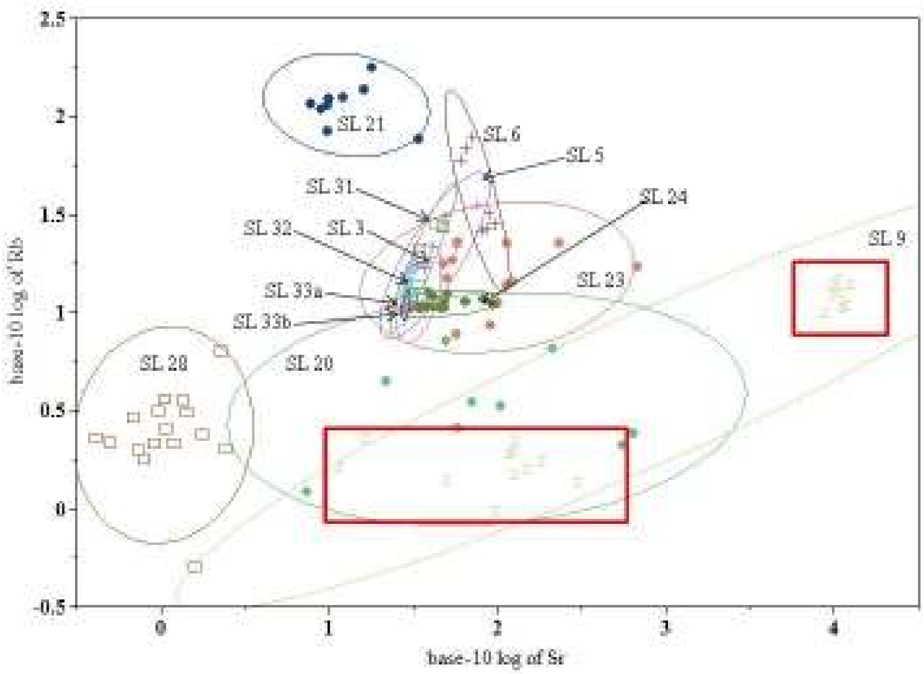


Figure 5.108: Scatterplot of the base-10 logarithms of strontium (Sr) vs. rubidium (Rb) for macroscopically variable localities, with a 95% bivariate normal density ellipse drawn around each sample locality. The red boxes highlight the divergence within Sample Locality 9.

Fortunately, multivariate statistical analysis does not duplicate this divergence. A linear discriminant analysis of the base-10 logarithms of the not-excluded analytes defines two canonical variates that effectively discriminant many of these sample localities (Figure 5.109). The negative pull of cesium (Ce) and lithium (Li) versus the positive pull of yttrium (Y) and lanthanum (La) generates the horizontal separation in these data (canonical variate 1). The negative pull of rubidium (Rb) versus the positive pull of strontium (Sr) generates the vertical separation in these data. PCA duplicates these results. The overlap seen amongst Sample Localities 3, 5, 6, 23, 32, 33a, and 33b reflects the difficulty in distinguishing orange/brown cherts, as seen in earlier analyses. For present purposes, a more significant observation is that these internally-variable sample localities do not manifest diffuse clusters in multivariate space (perhaps with the exception of Sample Locality 23). The specimens from Sample Localities 9 and 24, for example, are tightly clustered, despite their macroscopic variability.

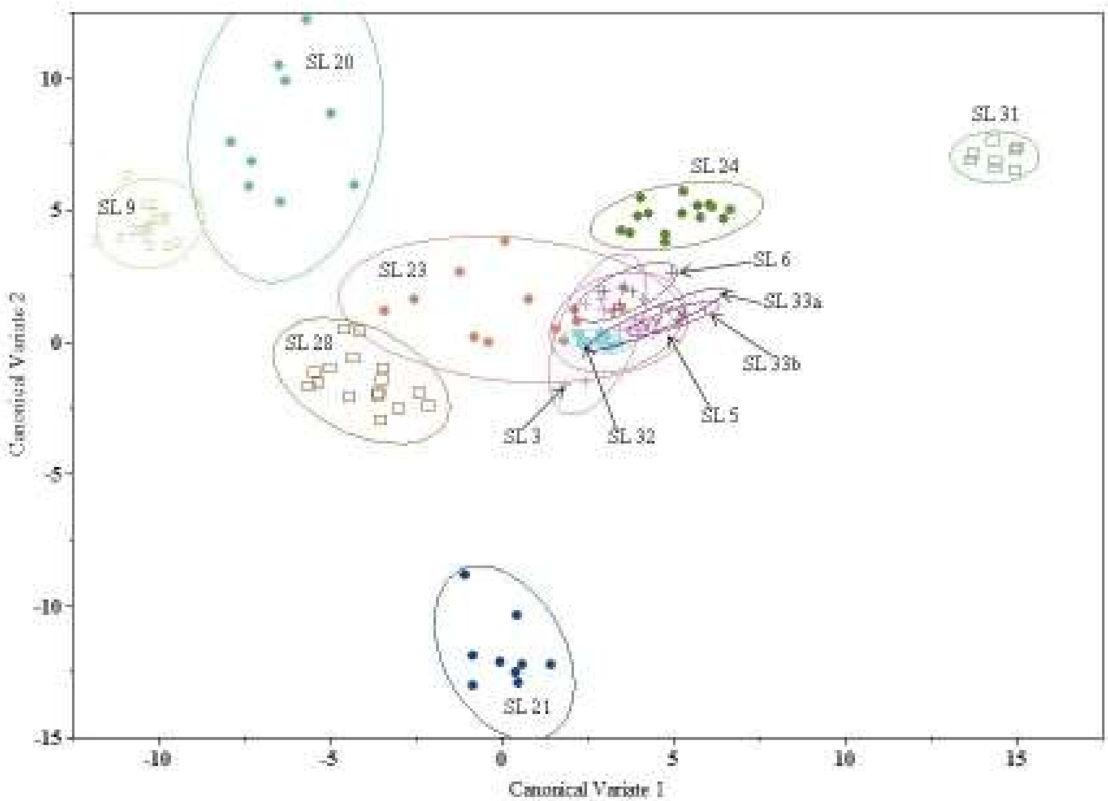


Figure 5.109: Scatterplot of Canonical Variate 1 vs. Canonical Variate 2 as defined for macroscopically-variable sample localities, with a 95% bivariate normal density ellipse drawn around each sample locality. Compositional data obtained using LA-ICP-MS.

In sum, these analyses suggest that the compositional data obtained utilizing LA-ICP-MS can effectively discriminate these sample localities. Although some sample localities require more statistical effort than others, macroscopically-similar cherts derived from different sample localities are effectively discriminated and macroscopically-dissimilar cherts derived from the same sample localities cluster in multivariate space. These data suggest that the provenance analysis of chert artifacts from eastern Nevada may prove successful. In the next section, I utilize the results of these analyses to inform the analysis of compositional data obtained by PXRF; in turn, these data are used for the provenance analysis of chert artifacts from the Eastern Nevada Study Area.

PORTABLE X-RAY FLUORESCENCE (PXRF) SPECTROMETRY

I also obtained compositional data for the geological specimens and a sample of chert debitage using PXRF. The recent development of PXRF technology holds promise for the non-destructive compositional analysis of artifacts both in the lab and in the field. The principles of x-ray fluorescence are well-known: an excitation source irradiates a sample which emits a fluorescent response that is characteristic of the sample's composition (e.g., Kalnicky and Singhvi 2001:Figure 2). In this study, PXRF analysis was conducted using an Innov-X Omega series portable energy dispersive XRF system. The excitation source for this system is an x-ray tube (Ag or W anode, 10-40 keV, 5-50 μA) powered by lithium-ion batteries. X-rays are detected by a thermo-electrically cooled Si PIN diode detector (resolution < 280 eV).

Blanks were run frequently during the data collection process using a 316 stainless steel alloy standardization clip. These tests verify that there is no contamination on the analyzer window that would adversely affect the scanning of geological samples and artifacts. Resolution (eV) and rate (cps, counts per second), recorded for each blank, were found to be consistent for soil and mining modes over the duration of analysis. Consistent performance according to these metrics also suggests that the data have not been compromised due to equipment fatigue or malfunction. Nevertheless, the calibration of compositional data obtained using PXRF suffers from many of the same interferences as LA-ICP-MS (Kalnicky and Singhvi 2001; Shackley 2010). Fortunately, factory-based calibration avoids some of these interferences.

The analyzer is calibrated in the factory utilizing the Compton Normalization method, whereby a well-characterized standard is analyzed and the data normalized for the Compton peak. The Compton peak, produced from incoherent backscattering of x-ray radiation from the excitation source, is present in the spectrum of every sample. The intensity of the Compton peak changes due to the affect of the sample matrix on the scattering of source radiation; therefore, normalizing to the Compton peak can reduce interferences introduced by matrix effects. The Compton Normalization method provides an internal calibration for elemental concentrations ranging from the ppm level up to 2-3 wt%. The fundamental parameters calibration method, a standard-less calibration, is used for higher elemental concentrations. The fundamental parameters calibration relies on the known physics of the spectrometer's response to pure elements to set the calibration. Built-in mathematical algorithms are used to compensate for matrix effects.

For this analysis, polished and cleaned geological samples and artifacts were scanned using soil and mining modes, each of which measures different elements. In order to promote comparison across these analytical methods, I used the same geological samples for PXRF and LA-ICP-MS. Artifact analysis was limited by a size constraint: I analyzed only those artifacts large enough to completely cover the x-ray beam path (~2 sq. cm). I positioned each sample with as much contact as possible with the instrument's surface; irregularly shaped specimens were placed with the flattest side positioned for analysis. Positioning the artifacts in this way ensures that the specimens are bombarded with the greatest amount of x-rays possible, thereby optimizing the count rate (Kalnicky and Singhvi 2001; Sheppard et al. 2011). Samples were scanned for two minutes, which improves detection capabilities (e.g., Kalnicky and Singhvi 2001:Table 4), using soil mode and mining mode. Soil mode returns concentrations (ppm) for ~30 elements; mining mode returns concentrations (wt %) for ~20 elements, with the measurement of light elements (e.g., Al, Ca, Si) aided by a vacuum system. Many elements found in environmental settings (e.g., C, O, N) are not measurable with PXRF instruments (Kalnicky and Singhvi 2001); thus, PXRF yields a smaller suite of analytes than LA-ICP-MS. Additionally, I excluded from analysis several elements that fall below the limit of detection in more than half of the samples (V, W, Bi, I, P).

As a new technology, PXRF requires continued testing in order to assess the validity and reliability of the technique, as well as the accuracy of the compositional data it produces. To this end, Nazaroff et al. (2010), in their study of obsidian from southern Belize, found that PXRF is not, in itself, a reliable technique; that is, comparison with laboratory XRF suggests that PXRF introduces systematic error into the data. Nevertheless, PXRF intra-instrument consistency is sufficient to obtain compositional data that allowed Nazaroff et al. (2010) to assign obsidian specimens to their source groups with the same accuracy as laboratory XRF (also see Jia et al. 2010; Kalnicky and Singhvi 2001:116). Similarly, PXRF using the instrument employed in this analysis has duplicated the results obtained using laboratory XRF for obsidian and FGV artifacts from the Eastern Nevada Study Area (George T. Jones, personal communication, 2010; also see Goodale et al. 2012). In short, PXRF seems to work, although this has been demonstrated primarily through the analysis of obsidian and other volcanics, which are some of the more "well-behaved" materials archaeologists analyze. As I demonstrate here, statistical analysis of compositional data obtained using PXRF yields results that are quite similar to those obtained using LA-ICP-MS.

As above, I begin the analysis of these compositional data by attempting to duplicate the structure evident in the analysis of compositional data for Sample Localities 9, 11, and 20 obtained using XRF and LA-ICP-MS. In my preceding treatment of the compositional data, I utilize aluminum (Al) and iron (Fe) to discriminate these sample localities; however, the aluminum concentrations obtained using PXRF for these sample localities are often negative values. As above, if we suppose that these negative concentrations are data that are really below the level of 0.01%, we can utilize the standard deviation provided for these analytes to generate useable data. In other words, I am supposing that these negative concentrations are really indicative of concentrations that are approaching zero, to which I am then adding the standard deviation for these concentrations for each sample. Admittedly, this is not an ideal treatment of these data; however, it is necessary to duplicate my earlier treatment of the LA-ICP-MS and XRF data for these sample localities. Significantly, the result of such a treatment of these data is a bivariate scatterplot of aluminum and iron that very closely duplicates the structure evident in the analysis of the LA-ICP-MS and XRF data (Figure 5.110). Likewise, transformation of these data using base-10 logarithms (Figure 5.111) and normalizing to silicon (Figure 5.112) also closely duplicates the structure evident in the LA-ICP-MS and XRF data for these sample localities. (Note that I did not utilize the log-ratio transformation and log-ratio analysis with the PXRF data because this approach was not found to be helpful in the analysis of the compositional data obtained using LA-ICP-MS.)

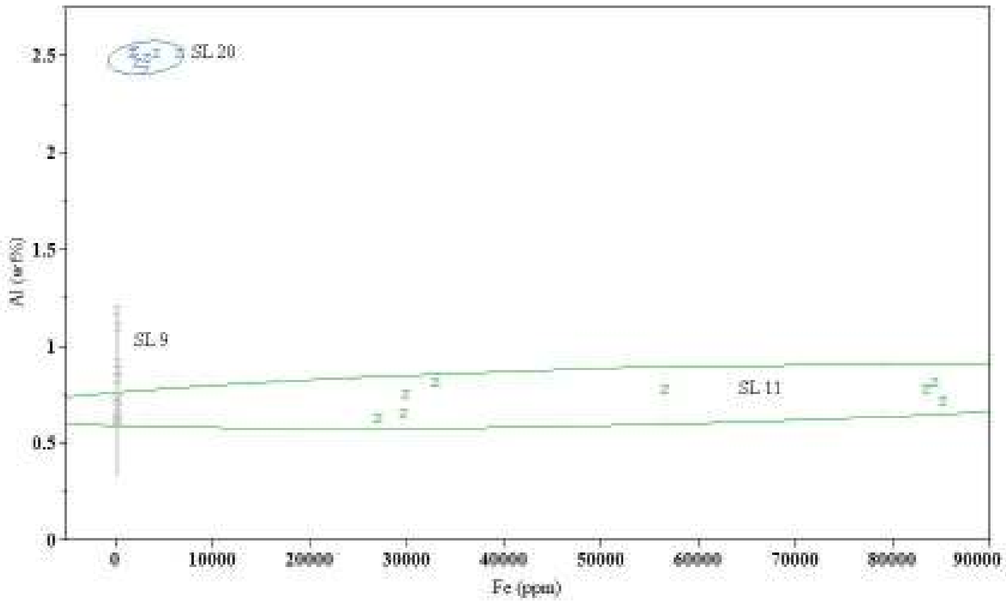


Figure 5.110: Scatterplot of Fe (ppm) vs. Al (wt%) for Sample Localities (SL) 9, 11, and 20, with a 95% bivariate normal density ellipse drawn around each SL.

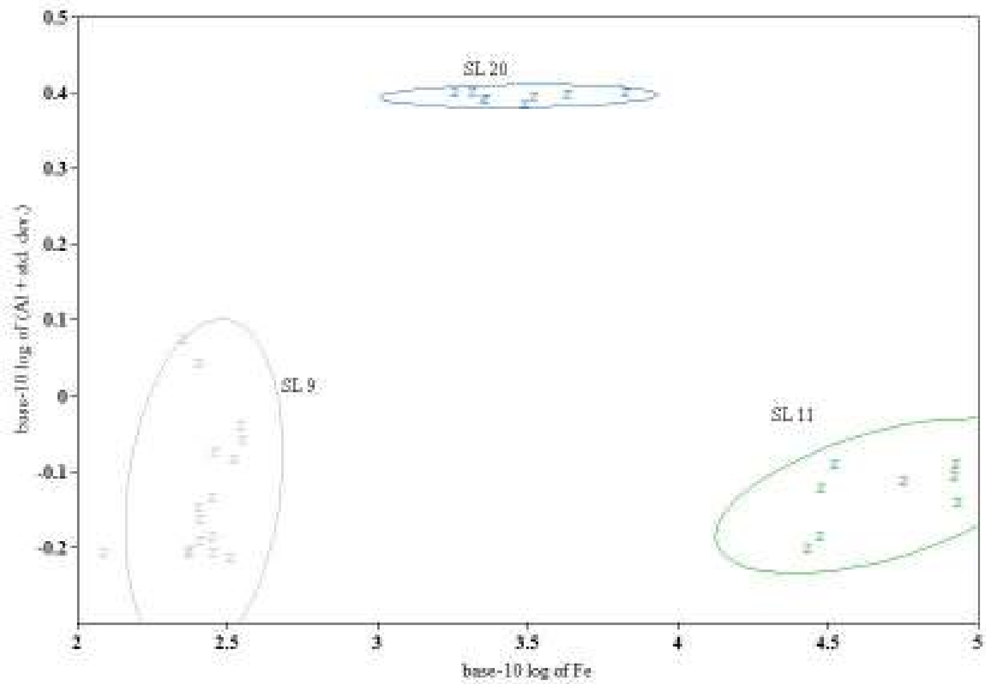


Figure 5.111: Scatterplot of base-10 log of Fe vs. base-10 log of Al for Sample Localities (SL) 9, 11, and 20, with a 95% bivariate normal density ellipse drawn around each SL.

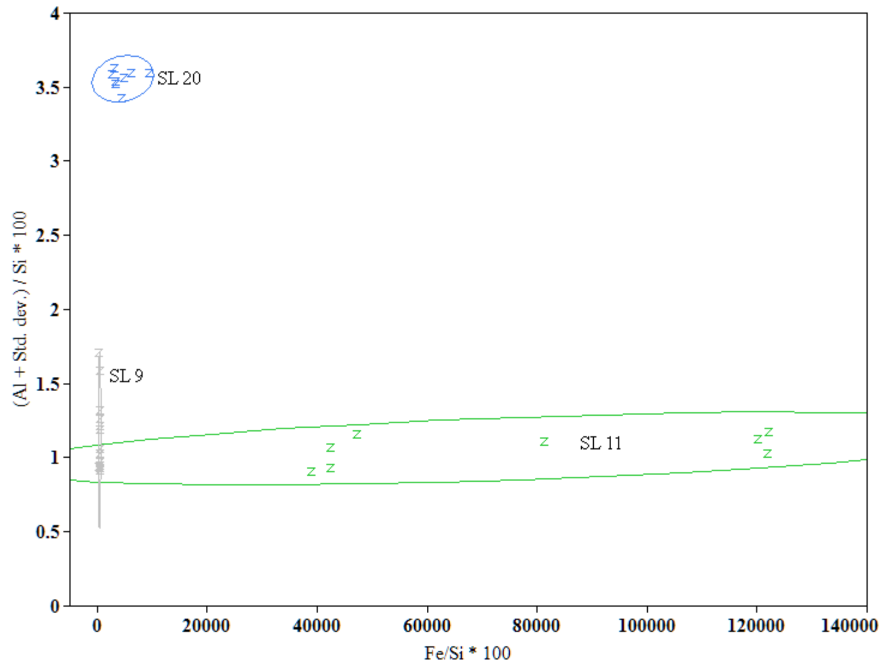


Figure 5.112: Scatterplot of Fe/Si x 100 vs. Al/Si x 100 for Sample Localities (SL) 9, 11, and 20, with a 95% bivariate normal density ellipse drawn around each SL.

In sum, analysis of the compositional data obtained using laboratory XRF, LA-ICP-MS, and PXRF for Sample Localities 9, 11, and 20 suggest that these methods are internally consistent and can effectively capture the structure in these data, even if they do not replicate exactly the absolute values obtained for each of the geological samples analyzed here.

Analysis of the PXRF data for the other chert subgroups also captures the structure evident in the compositional data obtained using LA-ICP-MS. For example, a scatterplot of the base-10 logarithms of strontium (Sr) vs. rubidium (Rb) (Figure 5.113) effectively duplicates the data structure evident in the red chert subgroup, as depicted in Figure 5.92. While Figure 5.113 is not an exact copy of Figure 5.92, the sample localities are distributed relative to each other in much the same way as seen in the analysis of the compositional data obtained using LA-ICP-MS. The only significant difference evident between these graphics is the addition of some specimens, due to the simple fact that I analyzed more geological samples using PXRF than LA-ICP-MS.

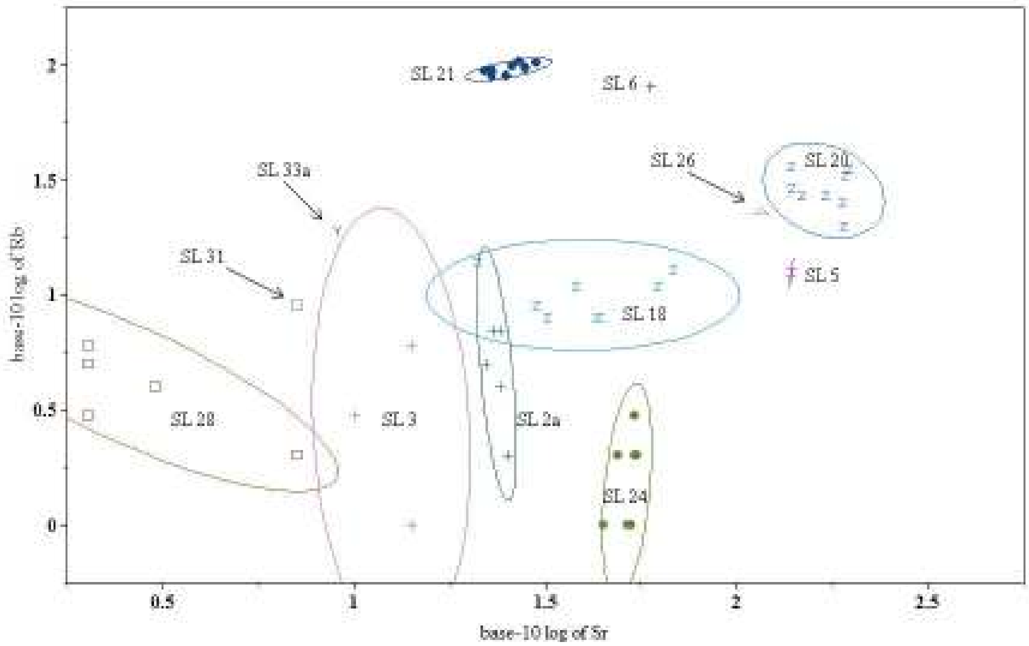


Figure 5.113: Scatterplot of base-10 logarithms of strontium (Sr) vs. rubidium (Rb) for the red chert subgroup, with a 95% bivariate normal density ellipse drawn around each sample locality.

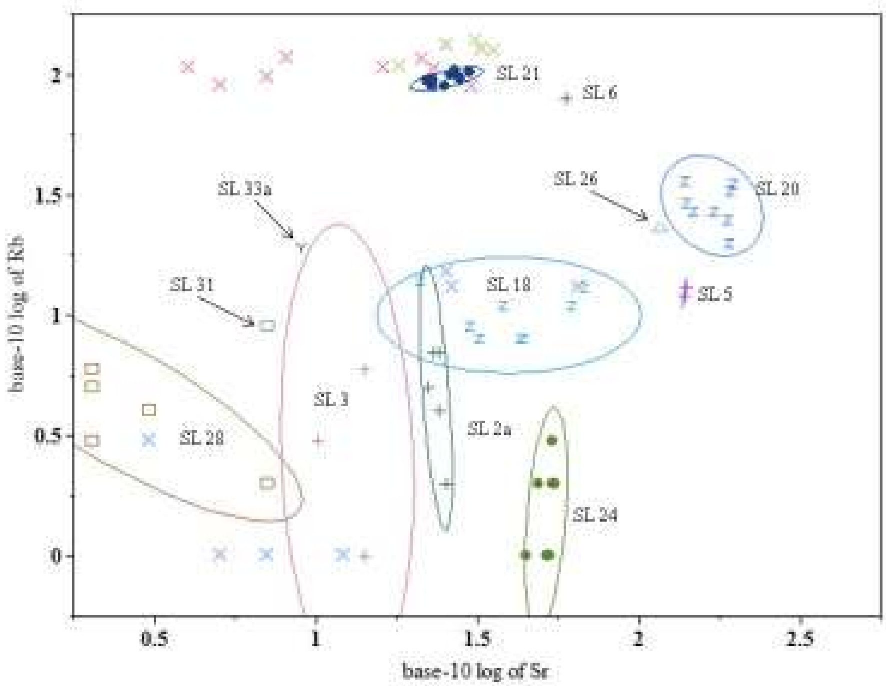


Figure 5.114: Scatterplot of base-10 logarithms of strontium (Sr) vs. rubidium (Rb) for the red chert geological samples and artifacts (Xs), with a 95% bivariate normal density ellipse drawn around each sample locality.

When artifacts are added to this scatterplot, some interesting results emerge (Figure 5.114). I begin with Sample Locality 21, which is the green chert source included as an out-group in my treatment of each macroscopically-similar subgroup. With the notable exception of the group of four artifacts (Xs) located to the left of Sample Locality 21, the green artifacts (MANs H and G) plot with Sample Locality 21, as expected. The consideration of other analytes does bring the four outlying green artifacts into line with Sample Locality 21. Thus, it would seem that the green artifacts within the Paleoarchaic localities in Butte and Jakes valleys do indeed derive from Sample Locality 21, located at the south end of Long Valley (Figure 5.35).

The red artifacts (MAN B) seem to derive from three different sample localities. This result suggests that analytical nodule B needs revision; however, this revision will require the compositional analysis of more artifacts than my resources permitted for this study. At present, note that one artifact from CCL9 and one artifact from HPL2 may be sourced to Sample Locality 18, located ~60 km distant at the south end of Jakes Valley (Figure 5.21). One artifact from LPL1 may be sourced to Sample Locality 18 (a distance of 20 km) as well; however, PCA indicates that Sample Localities 18 and 2a overlap in multivariate space. Thus, this artifact may derive from Sample Locality 2a, located ~75 km to the north (Figure 5.4), although this is the less likely alternative statistically. One artifact from HPL3 can be sourced to Sample Locality 3, located ~30 km distant on the northwest side of Butte Valley (Figure 5.4). Significantly, one artifact from CCL9 seems to derive from Sample Locality 28, located at a distance of ~220 km at the southern end of Coal Valley (Figure 5.50). While this extraordinary finding warrants further investigation, other bivariate and multivariate plots not depicted here repeatedly place this artifact firmly within Sample Locality 28. In sum, the analysis of compositional data obtained using PXRF (1) can effectively discriminate the sample localities that contribute red cherts to this sample, (2) can effectively assign artifacts to some of these sample localities, and (3) confirms the expectation that green chert artifacts are derived from Sample Locality 21.

In the case of the dark gray/black chert subgroup, I could not duplicate the PCA conducted on the compositional data obtained using LA-ICP-MS because the requisite analytes were not all effectively measured using PXRF. Nevertheless, PCA conducted on the base-10 logarithms of several analytes (Cl, K, Ca, Ti, Cr, Mn, Fe, Co, Ni, Zn, Ag, Cd, Sn, Sb, Nb, Si, and Ba) effectively discriminates most of these sample localities (Figure 5.115). Also notice that the purple specimens from Sample Locality 24 are clearly distinguished from other sample localities. PC 1 reflects the positive loading of iron and PC 2 reflects the positive loading of calcium. Group membership probabilities using Mahalanobis distances calculated on these two PCs results in the misclassification of 3 of 53 specimens (5.66%), due to the overlap of Sample Localities 32 and 33b and the inclusion of a dark gray specimen from Sample Locality 6 within Sample Locality 35 (Figure 5.115). Including PC 3 (reflecting the positive loading of manganese) in the calculation of group membership probabilities using Mahalanobis distances removes the misclassification of the specimen from Sample Locality 6. Thus, multivariate analysis of compositional data obtained using PXRF can effectively discriminate the sample localities that contribute dark gray/black and purple cherts to this sample. Unfortunately, these sample localities do not seem to account for any of the dark gray/black (MAN C, D) or purple (MAN F) artifacts identified within the Paleoarchaic lithic assemblages analyzed in Chapter 4 (Figure 5.116).

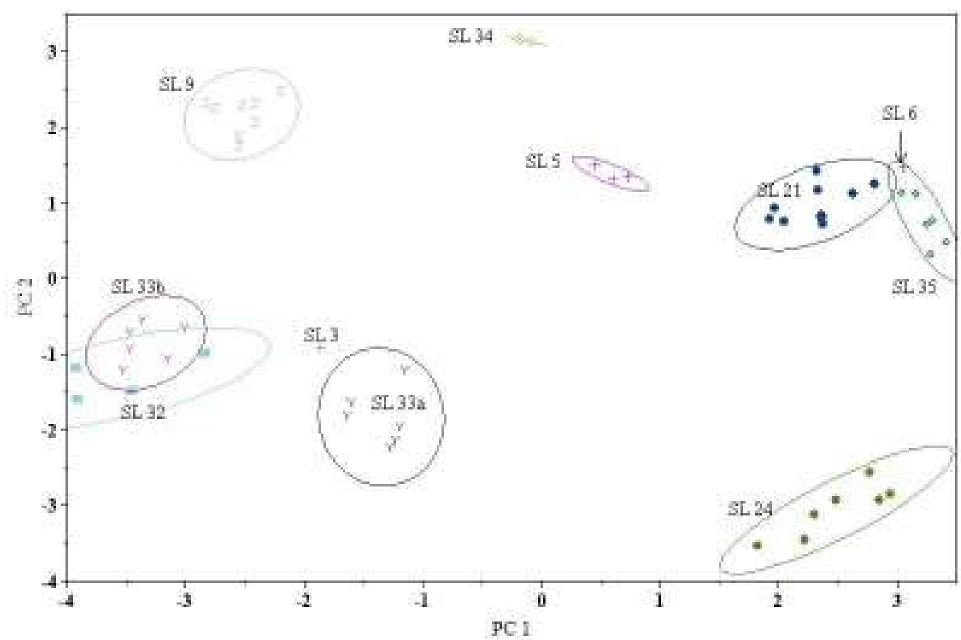


Figure 5.115: Scatterplot of PC 1 vs. PC 2 for the dark gray/black chert subgroup, with a 95% bivariate normal density ellipse drawn around each sample locality (SL). Compositional data obtained using PXRF.

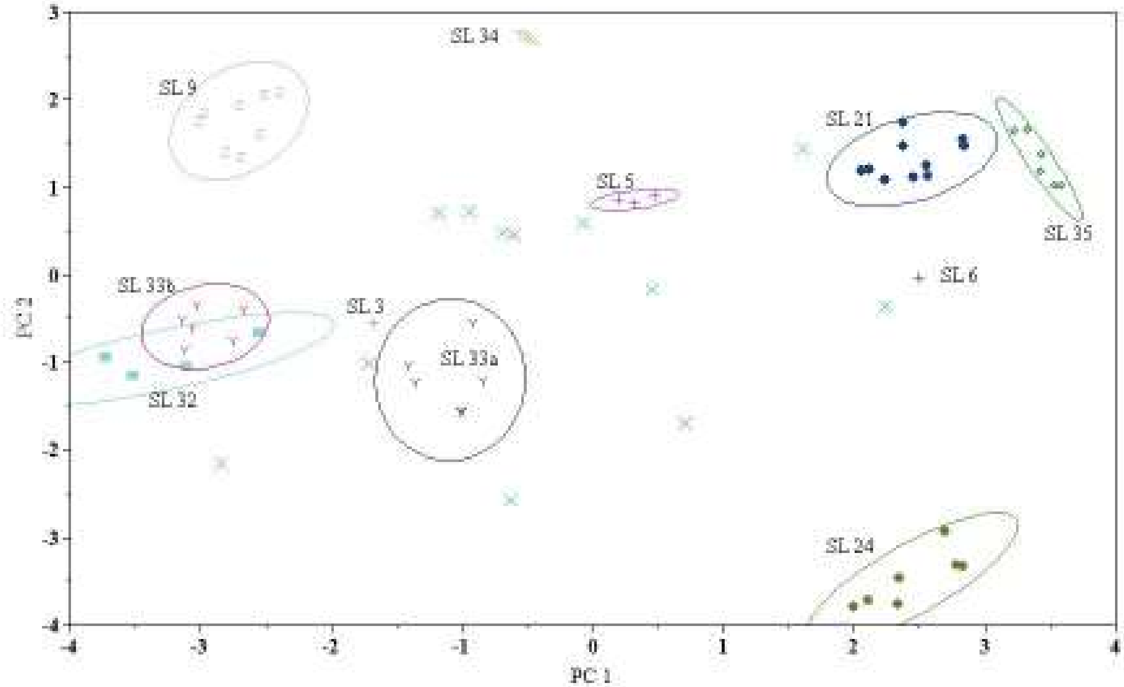


Figure 5.116: Scatterplot of PC 1 vs. PC 2 for the dark gray/black and purple chert geological samples and artifacts (Xs), with a 95% bivariate normal density ellipse drawn around each sample locality.

Turning to the orange/brown chert subgroup, compositional data obtained using PXRF effectively discriminates these sample localities as well. Many of the sample localities can be clearly distinguished using the base-10 logarithms of iron (Fe) and manganese (Mn) (Figure 5.117), although Sample Locality 3 overlaps with Sample Localities 2a, 6, 14a, 23, 31, and 33a – much as seen with the LA-ICP-MS data. Fortunately, a scatterplot of the base-10 logarithms of iron (Fe) vs. titanium (TI) further discriminates these sample localities (Figure 5.118). In fact, these bivariate scatterplots do a better job of discriminating the orange/brown chert sample localities than PCA.

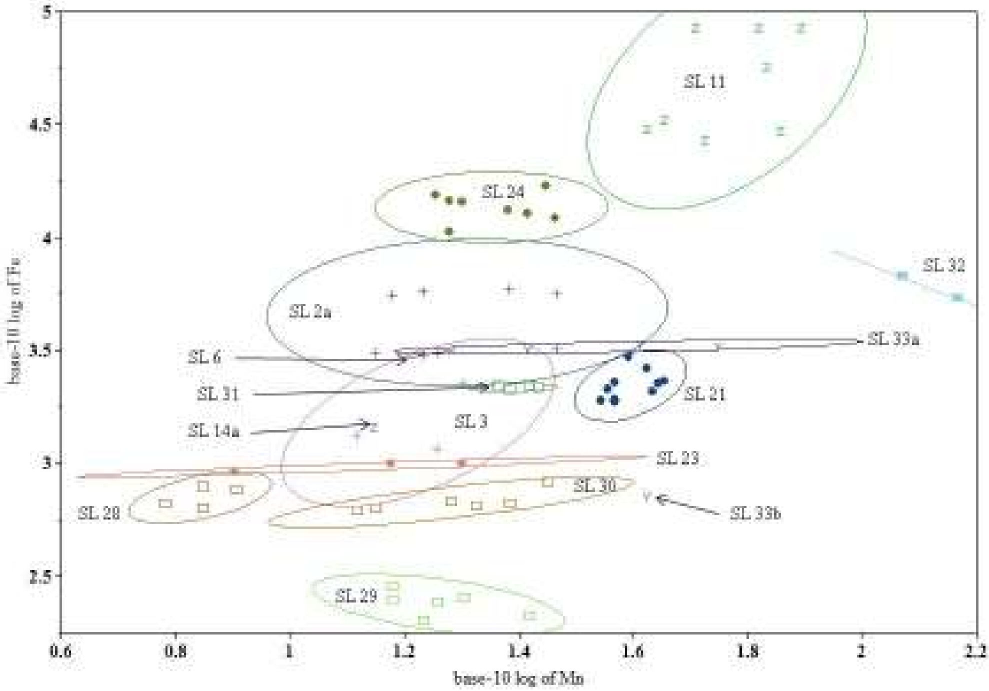


Figure 5.117: Scatterplot of base-10 logarithms of iron (Fe) vs. manganese (Mn) for the orange/brown chert subgroup, with a 95% bivariate normal density ellipse drawn around each sample locality.

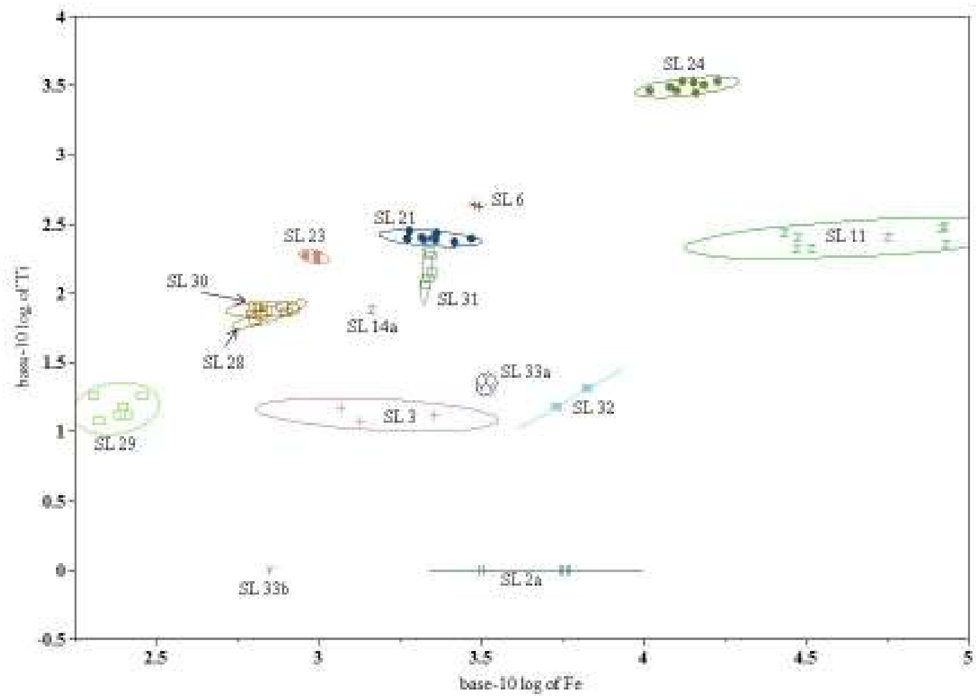


Figure 5.118: Scatterplot of base-10 logarithms of iron (Fe) vs. titanium (Ti) for the orange/brown chert subgroup, with a 95% bivariate normal density ellipse drawn around each sample locality.

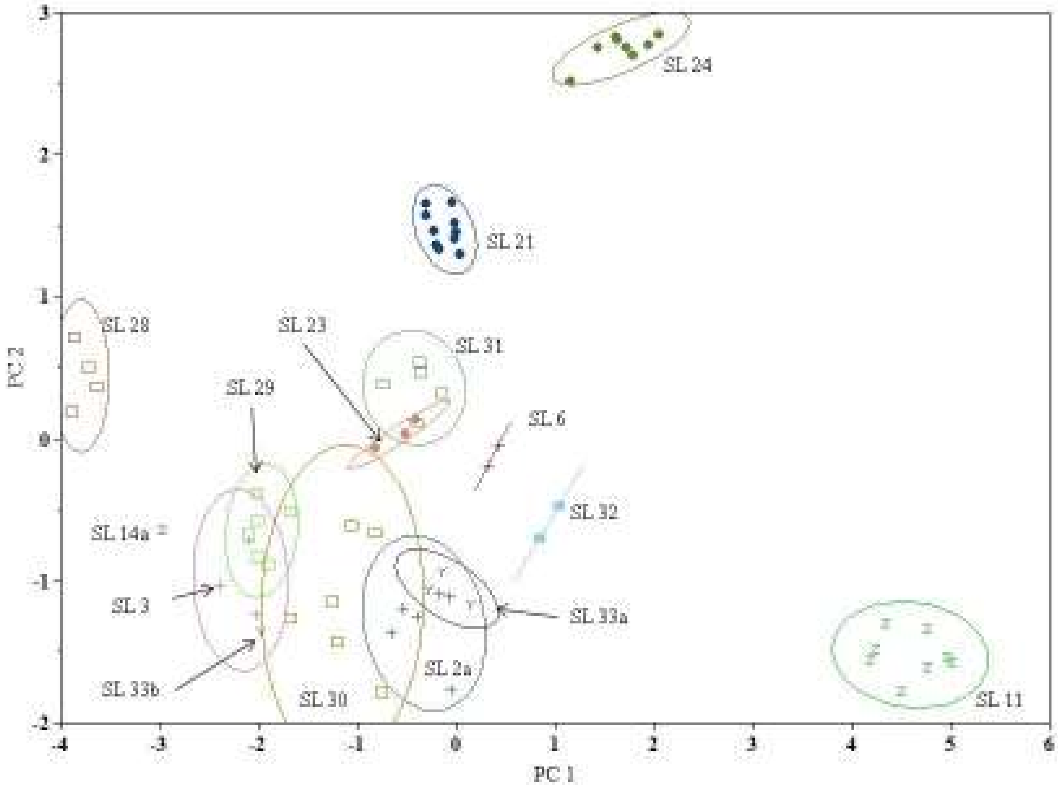


Figure 5.119: Scatterplot of PC 1 vs. PC 2 for the orange/brown chert subgroup, with a 95% bivariate normal density ellipse drawn around each sample locality.

Figure 5.119 depicts the scatterplot of PC 1 vs. PC 2 for a PCA of the base-10 logarithms of several analytes (S, Ti, Cr, Mn, Fe, Co, Ni, As, Zr, Ag, Sn, Sb, Nb, and Si). PC 1 reflects the positive loading of cobalt (Co), while PC 2 reflects the positive loading of zirconium (Zr). As with the dark gray/black chert subgroup, I cannot duplicate the PCA of the compositional data obtained by LA-ICP-MS; nevertheless, the PCA of the PXRF data indicates a similar structure within the orange/brown chert subgroup as achieved with the PCA of the LA-ICP-MS data (Figure 5.98). Group membership probabilities using Mahalanobis distances calculated on the first two PCs for the orange/brown chert subgroup results in the misclassification of 7 of 68 specimens (10.29%). Including the third PC (reflecting a positive loading on silicon) results in the misclassification of 3 of 68 specimens (4.41%), attributable to the overlap of Sample Localities 2a, 3, 29, 30, and 33a.

Using these variables to source orange/brown chert artifacts from the Paleoarchaic localities within the Eastern Nevada Study Area provides some unexpected results

(Figure 5.120). One artifact from WSWL1 can be sourced to Sample Locality 3, located ~25 km distant on the northwest side of Butte Valley. One artifact from CCL5 can be sourced to Sample Locality 2a, located ~40 km distant on the northwest side of Butte Valley. Most interestingly, nine artifacts (one each from CCL4, CCL5, CCL9, HPL1, HPL2, HPL3, and LPL, and two from HPL5) seem to match Sample Localities 29, 30, and 31, all located more than 200 km to the south in southern Coal Valley. While this finding is provocative, the small sample sizes considered thus far preclude making too much of this result. Nevertheless, this analysis does suggest that compositional data obtained using PXRF can effectively discriminate the sample localities that contribute orange/brown cherts to this sample, and may indicate that some of the orange/brown artifacts within the Paleoarchaic localities studied here derive from sources greater than 200 km distant.

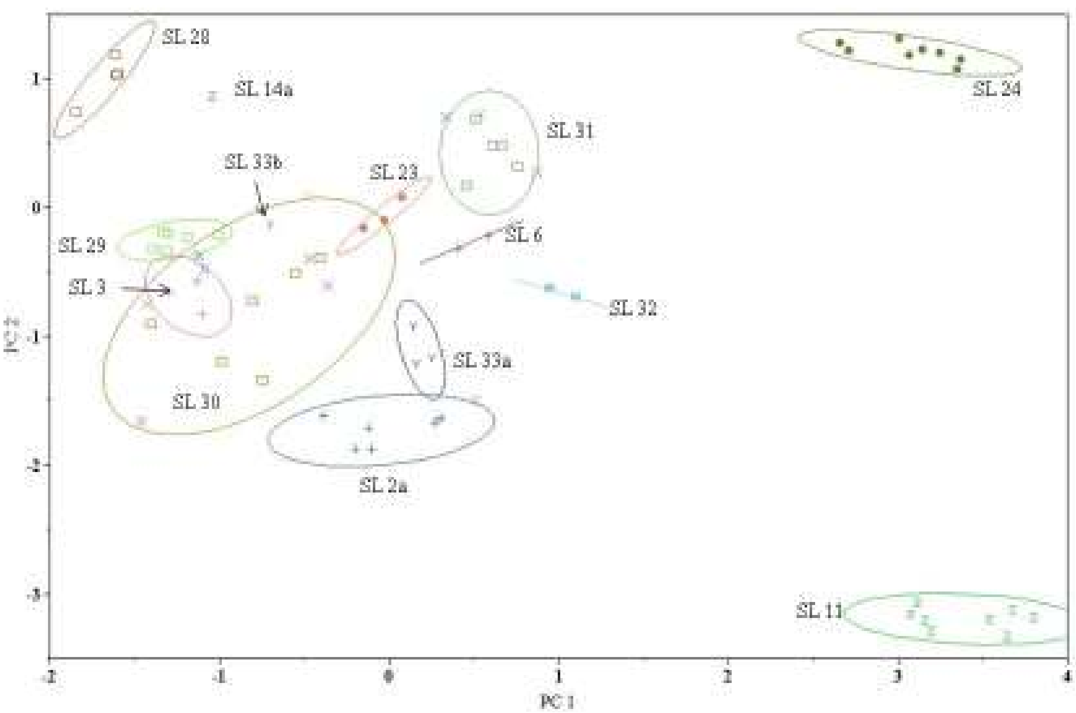


Figure 5.120: Scatterplot of PC 1 vs. PC 2 for the orange/brown geological samples and artifacts (Xs), with a 95% bivariate normal density ellipse drawn around each sample locality. Only those artifacts that fall within the 95% bivariate normal density ellipse for a sample locality are depicted here.

The PCA (including all analytes) of compositional data obtained using PXRF for light-colored cherts produces much the same mess as the analysis of the data obtained using LA-ICP-MS (Figure 5.121). Many of the misclassifications generated by the significant overlap of these sample localities in multivariate space can be resolved with extensive statistical effort, as with the LA-ICP-MS data; these efforts are not duplicated here.

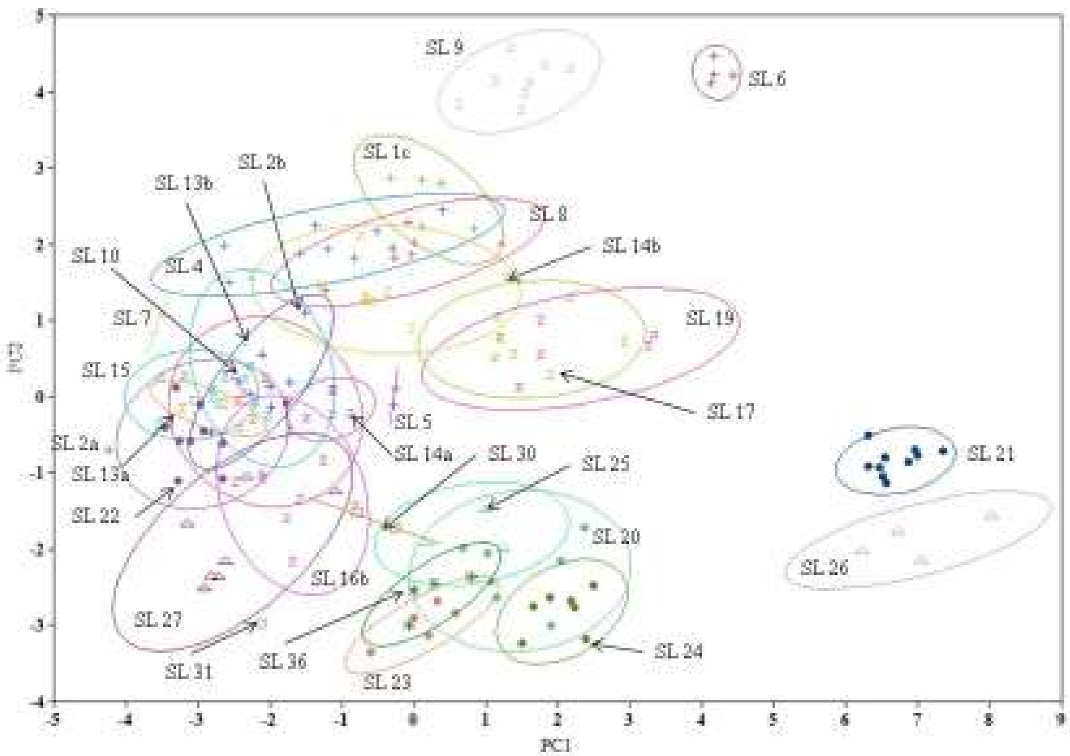


Figure 5.121: Scatterplot of PC 1 vs. PC 2 for the light-colored chert subgroup, with a 95% bivariate normal density ellipse drawn around each SL.

When the artifacts are added into this dataset, two sets of sample localities require differentiation to determine if some of the light-colored artifacts can be sourced. First considering the sample localities in the bottom center of Figure 5.121, a scatterplot of the base-10 logarithms of iron (Fe) vs. titanium (Ti) effectively discriminates these sample localities (Figure 5.122). Moreover, this scatterplot suggests that one artifact from HPL5 may be sourced to Sample Locality 23 and one artifact from HPL3 may be sourced to Sample Locality 20, both of which are distances of ~30-35 km to the southwest in southern Long Valley. Second, considering the sample localities in the bottom left of

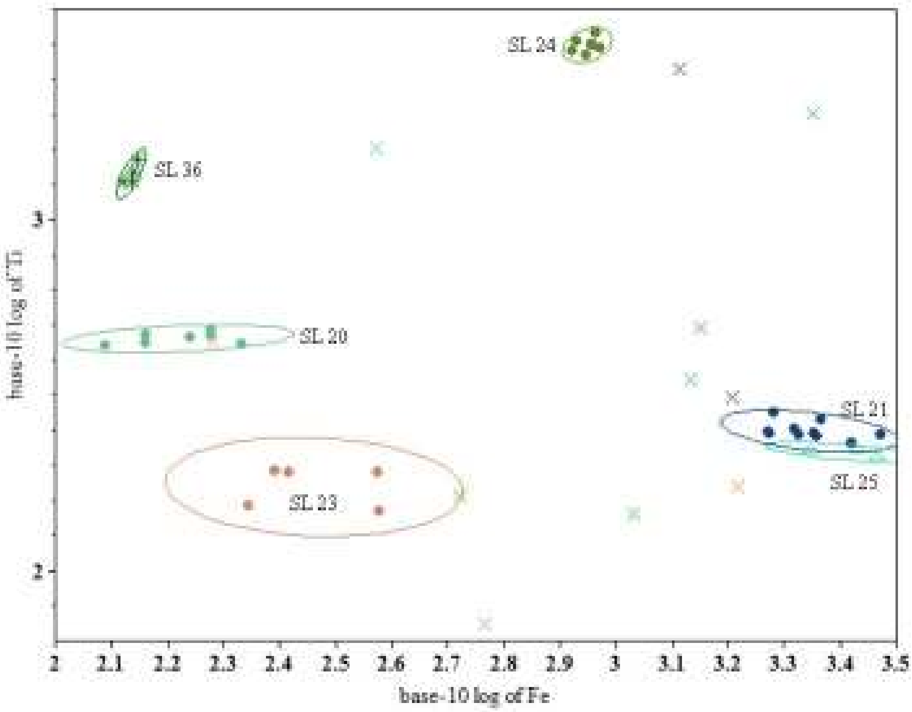


Figure 5.122: Scatterplot of base-10 logarithms of iron (Fe) vs. titanium (Ti) for a subset of light-colored geological samples and artifacts (Xs), with a 95% bivariate normal density ellipse drawn around each sample locality.

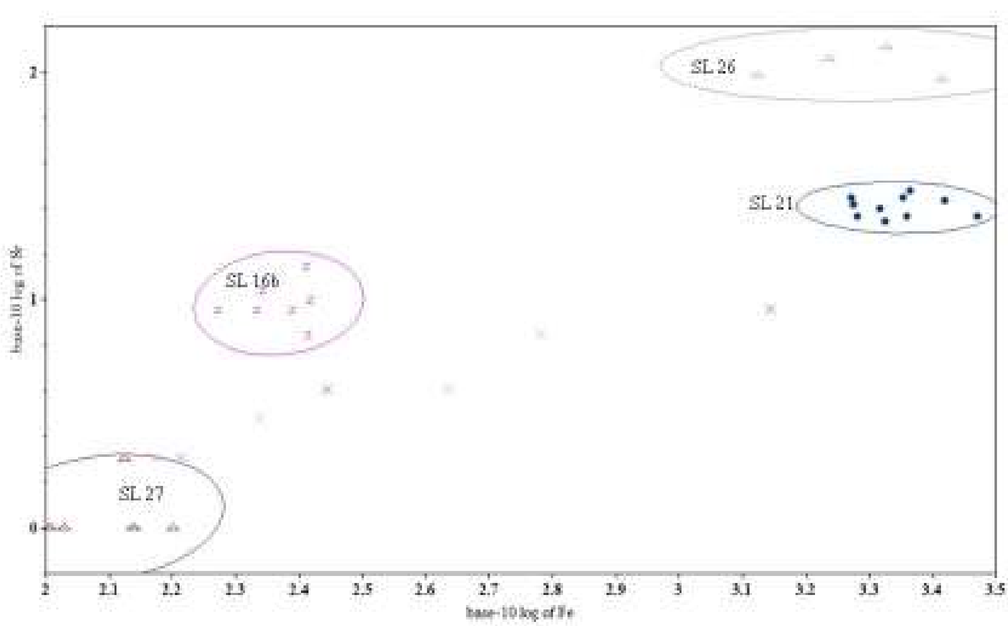


Figure 5.123: Scatterplot of base-10 logarithms of iron (Fe) vs. strontium (Sr) for a subset of light-colored geological samples and artifacts (Xs), with a 95% bivariate normal density ellipse drawn around each sample locality.

Figure 5.121, a scatterplot of the base-10 logarithms of iron (Fe) vs. strontium (Sr) effectively discriminates these sample localities (Figure 5.123). Additionally, this scatterplot suggests that three artifacts may be sourced to Sample Locality 27, located ~65 km to the southwest.

In sum, as with the LA-ICP-MS data, the light-colored chert subgroup presents the most difficulties in discriminating the contributing sample localities. Nevertheless, it is possible to discriminate these sample localities if sufficient statistical effort is used. Additionally, this analysis suggests that three artifacts may derive from a chert source in Railroad Valley, consistent with evidence for the procurement of FGVs from sources in Railroad Valley.

Conclusion

Survey and sampling of chert-bearing geological formations within east-central Nevada resulted in the documentation of several sample localities from which tool-quality chert may have been procured. Nevertheless, the widespread availability of chert-bearing geological formations within east-central Nevada does not equate to the widespread availability of tool-quality chert. Thus, the procurement and technological organization of chert should be investigated with the same rigor Great Basinists typically apply to FGVs and obsidian.

Regarding provenance analysis, this survey suggests that macroscopic properties are helpful but not sufficient for distinguishing chert derived from the different sample localities described here, perhaps with the exception of Sample Locality 21. Additionally, fluorescent responses to shortwave and longwave ultraviolet light do not seem particularly useful for distinguishing chert from these sample localities either (also see Church 1994). Thus, I undertook the compositional analysis of geological samples from several of the sample localities considered here in order to determine if these localities could be distinguished geochemically, which would facilitate the sourcing of chert artifacts. The analysis of compositional data obtained using laboratory XRF, LA-ICP-MS, and PXRF indicated that most of these sample localities could be distinguished from each other, even when located within a few kilometers of each other. This finding is consistent with Lyons et al. (2003:1156), who find that cherts from southeastern Oregon present measurable differences that permit source distinctions and artifact assignments over a scale as small as 17 km (also see Evans et al. 2007:2168).

Furthermore, I found that the analysis of compositional data obtained using XRF, LA-ICP-MS, and PXRF often replicated the structure apparent in these datasets in relative space, even if the absolute values obtained by these methods differed. While small sample sizes preclude absolute certainty on this point, it seems that compositional analysis can effectively distinguish many chert sources within eastern Nevada. In turn, the geochemical methods utilized in this analysis can be used to source chert artifacts. For example, I was able to match 36 artifacts to chert sample localities, albeit preliminarily. In many cases, the distance to the source is no less than 20 km and, in the case of a few red and orange/brown artifacts, perhaps in excess of 200 km. In fact, if the artifacts from the Butte Valley localities really do derive from chert sources in southern Coal Valley, as suggested here, this would be a significant finding on two accounts: (1) it would suggest the distribution of chert over distances comparable to that seen for obsidian; and (2) it would document movement and/or interaction across the revised, smaller OCZs for eastern Nevada (Jones and Beck 2010; Jones et al. 2012). Thus, the provenance analysis of chert artifacts from the Paleoarchaic localities in the Eastern Nevada Study Area seems to record both (a) smaller chert procurement ranges operating within the FGV and obsidian procurement ranges (as in the case of the green artifacts) and (b) interaction and/or movement across OCZs. Unfortunately, too few chert artifacts can be sourced at this time to conduct a fall-off analysis in order to determine the means of chert distribution. Nevertheless, the sourcing of chert artifacts seems possible and, as such, can complement ongoing analyses of FGVs and obsidian.

These efforts represent the first steps toward building a database of chert sources on par with our current understanding of obsidian and FGVs. In turn, an increased understanding of the availability and utilization of chert sources will provide the context within which alternative models of Paleoarchaic subsistence-settlement patterns may be evaluated. At present, the combination of minimum analytical nodule analysis and provenance analysis presented here suggests that we can define ranges of mobility and/or interaction that operate within and/or crosscut OCZs. By combining the analysis of different toolstone types, we can build toward a robust model of Paleoarchaic toolstone procurement, mobility, and intergroup interaction that incorporates a comprehensive understanding of the lithic landscape. Of course, much more fieldwork must be done to locate the chert sources utilized by prehistoric peoples in the Great Basin and many more samples must be subjected to geochemical analysis before too much is made of these results, yet the start is promising.

Chapter 6: Conclusions

Recently, George T. Jones and colleagues (2003) amassed obsidian provenance data from across the Great Basin to reconstruct the area over which obsidian was transported during the Terminal Pleistocene/Early Holocene (TP/EH), defining a series of obsidian conveyance zones (OCZs). These data are used to support widely divergent views of Paleoarchaic subsistence-settlement patterns. Jones et al. (2003:19) propose that these zones "delimit geographically the foraging territories of Paleoarchaic populations," who practiced high residential mobility geared to the distribution of significant wetlands. They suggest that Paleoarchaic hunter-gatherers, operating in small groups under conditions of low population density and high mobility, moved between resource-rich patches (e.g., wetlands and contiguous steppe), focusing on few, rapidly depleted resources, before moving on to a new patch.

David Madsen (2007), however, has recently questioned this interpretation, recognizing that it remains unclear whether long-distance obsidian transport reflects the movement of Paleoarchaic groups as a whole or task groups composed of a subset of the population. Madsen (2007) suggests that the Paleoarchaic record of the central Great Basin, including the Eastern Nevada Study Area, reflects a scenario where large, productive marsh habitats supported more sedentary Paleoarchaic groups, who traversed short distances between residential camps. Male hunting parties may have procured resources that they brought back to these relatively permanent wetland base camps. According to Madsen's (2007) model, then, OCZs may delineate the spatial extent of male logistical forays to provision the rest of the Paleoarchaic group, with obsidian procurement embedded in these forays.

Consideration of these models against the backdrop of ethnohistorically- and ethnographically-known hunter-gatherers, however, raises several questions regarding the presumed scale of human behavior. Both Jones et al.'s (2003) model and Madsen's (2007) model envision foraging ranges much larger than anything reflected in the hunter-gatherer literature. With this in mind, I explored the possibility that OCZs reflect the areal extent of Paleoarchaic social networks maintained through non-utilitarian mobility and exchange, which may account for the distribution of obsidian over these large areas. Thus, I conceived this project in order to address some of the problems I see in the current models of Paleoarchaic subsistence-settlement and to lay the groundwork for a rethinking of Paleoarchaic mobility, intergroup interaction, and technological organization.

In Chapter 2 I reviewed the context within which these models of Paleoarchaic adaptation operate, describing the environments inhabited by Paleoarchaic hunter-gatherers and presenting the research trajectory that has led to our current understanding of Paleoarchaic behavior. The Great Basin records dramatic, though regionally and temporally complex, climatic and biotic changes during the TP/EH. In many parts of the Great Basin, effective moisture remained high throughout the TP/EH, supporting "expanses of shallow lakes and marshes, and flowing streams and springs [that] must have provided attractive habitats for exploitation until perhaps as late as 8000 B.P." (Beck and Jones 1997:172). Disagreement persists, however, over exactly how Paleoarchaic populations would have incorporated these highly productive, though regionally and temporally variable, localities into their subsistence regimes, as exemplified by the models of Jones et al. (2003) and Madsen (2007).

In my consideration of the paleoenvironmental data, I suggested that the earliest Paleoarchaic populations in much of the Great Basin may have utilized small foraging ranges centered on river, marsh, and other rich localities. Then, as marshes and lakes regressed and biotic communities reorganized, later Paleoarchaic populations may have become more mobile, even if still geared toward these decreasingly productive habitats. Locational data and subsistence data seem to support a focus on rivers, marshes, lakes, and other mesic habitats in much of the Great Basin during the TP/EH, perhaps in support of lower residential mobility. Great Basinists often interpret lithic technology and obsidian provenance data to suggest high mobility, however. The lack of unambiguous evidence for occupational permanency may also indicate high mobility. Interestingly, perishable technology and the distribution of shell ornaments may suggest a level of regional interaction and exchange typically denied Paleoarchaic populations, despite the incredible distances over which obsidian travelled. Thus, I concluded Chapter 2 by suggesting that the divergent lines of evidence derived from the archaeological record suggest we need to look more closely at the environmental, demographic, and social factors that structure hunter-gatherer mobility and intergroup interaction. While some elements of the models of Jones et al. (2003) and Madsen (2007) may apply to particular temporal and spatial contexts within the ~4000-year span encompassed by the TP/EH, I suggested that the paleoenvironmental, subsistence, locational, and technological data do not require the level of residential or logistical mobility necessary to account for the large areas circumscribed by obsidian provenance.

Thus, in Chapter 3 I considered the OCZs against the backdrop of ethnohistorically- and ethnographically-known hunter-gatherers, entertaining the possibility that long-distance obsidian transport might reflect mobility associated with social and/or ideological pursuits. Specifically, I presented hunter-gatherer data to suggest that (1) if reflecting residential mobility, OCZs circumscribe areas far greater than anything documented ethnographically, and (2) if reflecting logistical mobility, OCZs document long-distance forays in an environmental context (i.e., rich wetland and contiguous steppe) that does not tend to necessitate such long forays among modern hunter-gatherers occupying similarly rich habitats. Thus, I suggested that the areas circumscribed by obsidian provenance may simply be too big to be accounted for by the behavioral processes currently advanced to explain the distribution of obsidian across the Paleoarchaic landscape. Recognizing this problem, Great Basinists have begun working to revise the OCZs that were initially proposed by Jones et al. (2003), though the expectation that obsidian procurement and transport was embedded in residential and/or logistical mobility for subsistence pursuits remains. One useful alternative presented by Steven Simms (2008) is that the areas circumscribed by obsidian provenance may reflect lifetime ranges. Yet the revised OCZs are still larger than even the lifetime range of the Nunamiut. Thus, I suggest that the OCZs may delineate regional networks maintained through non-utilitarian mobility and/or exchange.

Accordingly, I used H. Martin Wobst's (1974, 1976) insights into Paleolithic social systems to consider the spatial organization of Paleoarchaic groups, thereby "populating" the OCZs. I then presented several examples of non-utilitarian mobility and exchange amongst modern hunter-gatherers, arguing that the maintenance of informational and social networks is fundamental to hunter-gatherer adaptation and is firmly rooted in the behavioral ecological perspective that dominates the study of Paleoarchaic and Paleoindian lifeways. With these examples in mind, I suggested that Paleoarchaic intergroup interactions and exchange are significant, recurrent behavioral processes and, contrary to the prevailing Paleoindian wisdom, cannot simply be dismissed as “risky.” I also found that the ethnographic and ethnohistoric records often suggest that non-utilitarian mobility and exchange can account for the procurement and transport of large quantities of resources, often quite heavy and bulky ones, many for everyday use, over much longer distances than those utilized for subsistence pursuits. Thus, I suggested that we may have to face the fact that the best archaeological correlate for distinguishing alternative types of mobility and resource acquisition may not be the quantity of toolstone we find at an archaeological site (e.g., Meltzer 1989). Instead, distance of toolstone transport may be more informative. More specifically, when we document the transport of materials over incredibly long distances, it is increasingly likely that such behaviors are motivated by social and/or ideological concerns. What we end up with in considering these hunter-gatherer examples is a multi-tiered model of mobility, much as Binford (1983b) and others developed years ago, but with attention paid more explicitly to interaction with neighboring social groups through non-utilitarian mobility and/or exchange.

In order to build a such an understanding of prehistoric mobility and toolstone procurement, we must be able to (1) partition the archaeological record into units that permit us to recognize multiple modes of resource acquisition within a single lithic assemblage and (2) reconstruct the distribution of the different toolstone types present within an assemblage through a comprehensive program of provenance analysis. Thus, in Chapters 4 and 5 I demonstrated how current analytical methods can help us build the model of Paleoarchaic adaptation developed in Chapters 2 and 3.

In Chapter 4, I presented the technological analysis of more than 18,000 lithic artifacts from several Paleoarchaic localities in east-central Nevada. Separating these lithic assemblages by toolstone type, I suggested that obsidian, fine-grained volcanics, and chert were all utilized differently by the Paleoarchaic groups who inhabited this area.

The abundance and size (weight) distribution of obsidian bifaces, cores, and flakes all support the results of obsidian provenance analyses, which suggest that obsidian was derived from distant sources (Jones et al. 2003). Yet the preferential utilization of obsidian for projectile points, for which they are not necessarily well-suited, may suggest that nonlocal obsidian was introduced into this area through non-utilitarian mobility and/or exchange.

I found that the abundance and size distribution of FGV bifaces, cores, and flakes suggest that the area regularly utilized by Paleoarchaic groups during their subsistence pursuits actually may be circumscribed by FGV provenance rather than obsidian provenance. Significantly, the ranges defined in this way are still larger than the ranges of most modern hunter-gatherers, consistent with the long-held expectation that Paleoarchaic (and Paleoindian) populations were highly mobile.

The abundance and size distribution of chert bifaces, cores, and flakes suggest that much chert may derive from sources that are closer than obsidian sources, but not necessarily any closer than the sources of FGVs. And some cherts may, in fact, derive from sources that are as distant as the obsidian sources. Even so, chert is utilized most often for unifaces, perhaps in association with a different subset of the Paleoarchaic group performing different activities than the activities for which FGVs and obsidian were used. The variability evident within the chert assemblage from these Paleoarchaic localities led me to conduct a minimum analytical nodule analysis (MANA) of these cherts. Using MANA, I was able to partition the chert assemblage into analytical nodules (i.e., chert subgroups) that may represent cherts acquired from different sources using different methods. By comparing the analytical nodules defined for the Paleoarchaic localities in Butte and Jakes valleys, I discerned two distinct chert procurement ranges that operate within the ranges defined using FGV and obsidian provenance.

To support this finding, I reported the results of a survey, sampling, and sourcing study of chert-bearing geological formations from east-central Nevada. During the course of this survey, I found that tool quality chert is not as ubiquitous as many Great Basinists seem to think. Additionally, I found that those chert sources that are available can be distinguished by compositional data obtained using laboratory x-ray fluorescence (XRF) spectrometry, laser ablation inductively-coupled plasma mass-spectrometry (LA-ICP-

MS), and portable x-ray fluorescence (PXRF) spectrometry. While preliminary, I was able to source several artifacts using PXRF, confirming the existence of chert procurement ranges that operate within the ranges defined by FGV and obsidian provenance, while also documenting the long-distance transport (> 200 km) of some cherts. The latter is particularly intriguing as it represents the only example of the long-distance transport of chert by Paleoarchaic peoples of which I am aware. Of additional significance, the long-distance transport of chert would serve to connect the recently revised OCZs in eastern Nevada (Jones et al. 2012). Finally, the results of this chert sourcing study support the building of a multi-tiered model of Paleoarchaic mobility and intergroup interaction, perhaps with (a) the distribution of cherts used for gravers and scrapers reflecting the local areas regularly exploited for subsistence pursuits, (b) the distribution of FGVs reflecting annual or territorial ranges, and (c) the distribution of obsidian and high-quality cherts reflecting the spatial extent of Paleoarchaic social networks maintained through non-utilitarian mobility and/or exchange.

Ultimately, the research presented here suggests that Great Basinists continue to think hard about the nature of Paleoarchaic mobility, intergroup interaction, and technological organization. While elements of both Jones et al.'s (2003) and Madsen's (2007) models may apply to particular times and places within the TP/EH Great Basin, the Paleoarchaic record does not require the degree of residential or logistical mobility supposed by these models, nor does it preclude the operation of extensive Paleoarchaic social networks. Indeed, hunter-gatherer data suggest that we should expect widespread exchange and intergroup interaction as a fundamental component of Paleoarchaic adaptation. Accordingly, the scale over which obsidian travels in the Great Basin aligns more closely with hunter-gatherer non-utilitarian mobility and/or exchange than the annual or territorial ranges defined, primarily, by the pursuit of subsistence. This interpretation represents a dramatic departure from current thinking amongst Great Basinists; as such, these ideas may prove to be wrong. Nevertheless, I am hopeful that this research demonstrates the value of questioning some of our long-held views regarding Paleoarchaic adaptation. In turn, I am hopeful that this research also demonstrates the efficacy of some of the analytical methods we may utilize to contextualize obsidian-based models of Paleoarchaic adaptation within a comprehensive understanding of the lithic landscape and lithic technological organization.

Analytical Implications

The methods of analysis utilized in this study – MANA and source provenance analysis – can be applied to a number of questions about prehistory. MANA, for example, provides a means of assessing the technological variability present within a lithic assemblage through the definition of analytical nodules. In turn, the analysis of these analytical nodules can suggest how technology is organized at a site and how different types of toolstone flowed through the site. The ability to partition a lithic assemblage into analytical nodules that, in turn, may be characterized by distinct modes of toolstone acquisition, production and maintenance trajectories, and, perhaps, different groups of people, holds much promise for the study of prehistoric hunter-gatherers. As Robert Kelly (1992) reminds us, mobility is universal, variable, and multi-dimensional; mobility is a property of individuals who may move in different ways. Similarly, Colin Renfrew (1975, 1977) reminds us that exchange is universal, variable, and multi-dimensional. By defining analytical nodules that may be indicative of different types and scales of mobility and exchange, MANA seems ready-made to help archaeologists move beyond a univariate understanding of prehistoric mobility, intergroup interaction, and technological organization.

As Craig Skinner and colleagues (2004:227) write, provenance analysis:

> may provide information about seasonal procurement ranges, acquisition strategies, territorial or ethnic boundaries, the locations of prehistoric trails and travel routes, the curation value of particular sources or formal artifact types, cultural preferences regarding…quality and color, the presence of trade and exchange systems, the existence of intergroup interaction, and the exchange of prestige items between elites of different groups.

Significantly, the source provenance analysis of cherts, as a complement to similar analyses of obsidian and FGVs, may be brought to bear on these topics wherever and whenever archaeologists ask them. Additionally, the extension of provenance analysis to cherts, when considered in parallel to other toolstone types, can account for the variability of acquisition strategies, curation value, cultural preferences, trade and exchange, and intergroup interaction that the ethnographic and ethnohistoric records tell us we should expect amongst prehistoric societies. Finally, the ability to duplicate the structure evident in the compositional data obtained using LA-ICP-MS with compositional data obtained using PXRF suggests that PXRF, while still in the early stages of application to archaeological problems, may prove to be a useful method for provenance analysis.

Theoretical Implications….

Generally speaking, I have suggested that (1) the areas utilized by Paleoarchaic groups in the pursuit of subsistence may be much smaller than typically imagined and (2) the large areas circumscribed by obsidian provenance may reflect Paleoarchaic social networks. If these suggestions are accurate, then they have significant implications both for our understanding of later Great Basin prehistory and for our understanding of Paleoindians outside of the Great Basin.

…FOR LATER GREAT BASIN PREHISTORY

Great Basinists typically interpret Paleoarchaic lithic technology as designed to minimize risks associated with high mobility, when foraging groups must operate within areas lacking sources of suitable toolstone (Elston et al. 1995). In Chapter 2 I suggested that this interpretation may be out-of-step with the locational and subsistence data, which suggest a focus on lowland occupation during the Terminal Pleistocene, as rich wetlands and contiguous steppe may have supported decreased residential mobility. While this preference for lowland occupation persists through the Early Holocene, Paleoarchaic sites from this period become more variable in size and content, and are increasingly found in a wider range of valley and upland settings. These changes in settlement patterns, combined with continuing biotic reorganization through the Early Holocene, can be interpreted to reflect more frequent range shifts as Paleoarchaic groups continue to seek game; however, other lines of evidence suggest that Paleoarchaic groups adapted to biotic reorganization by expanding the suite of resources they utilized (Beck and Jones 1997). For example, ground stone artifacts first appear in the archaeological record relatively late in the Early Holocene. Presuming the presence of ground stone artifacts reflects an expanded use of seeds—low-ranking resources compared to large game and marsh resources (e.g., Simms 1987; Zeanah and Elston 1995)—their appearance likely corresponds to a time when large game and marsh resources were on the decline (Beck and Jones 1997). In some parts of the Great Basin, the contraction of sagebrush steppe and the drying of marshes began by 9000 BP; throughout most of the Great Basin, this process was completed by 7500 BP.

Accordingly, one predicted outcome of this biotic reorganization and the concomitant increase in the procurement of low-ranked resources may be longer occupation spans and correspondingly decreased residential mobility (Beck and Jones 1997). To the extent that the Paleoarchaic localities from the Eastern Nevada Study Area can be used to reflect changes over time, they record a decrease in the variety of exotic obsidian types over time (Beck and Jones 1992, 1997; Jones et al. 2003). Locally available FGVs, however, show an increase in source variety over time (Jones et al. 1997). Charlotte Beck and George T. Jones (1997) interpret this pattern as an indication of longer occupation spans in combination with logistic organization. In fact, Jones and colleagues (2003:26) suggest that it is at this point that we would see exchange in the archaeological record:

> In attempting to cope with conflicting subsistence and scheduling issues brought about by changing biophysical conditions, peoples living in adjacent valleys would very likely have come into more frequent contact with one another, increasing the probability that material exchanges (in addition to subsistence-related information gathering) would have taken place.

But what if we are over-stating the degree of Paleoarchaic residential mobility? How do we interpret these changes in locational, subsistence, and provenance data if Paleoarchaic groups are not as mobile as typically imagined? In Chapter 3 I suggested that intergroup interaction and exchange amongst hunter-gatherers is fundamental if these groups are to remain reproductively and cultural viable. Certainly, this is no less true during the Terminal Pleistocene, when population densities presumably would have been at their lowest.

If we suppose that Paleoarchaic groups (1) were not as mobile as typically suggested and (2) engaged in exchange and intergroup interaction, then changing patterns of subsistence, settlement patterns, and technological organization might best be understood in regards to changing social relations on an increasingly populated landscape. As population density increased within the Great Basin, Paleoarchaic groups may have increasingly impinged upon one another. The decreased variety of exotic obsidian may reflect, in part, increased territorial circumscription, but also a decrease in the spatial extent of the social network. As the Great Basin fills-in, Paleoarchaic groups would have had to travel less to encounter the number of neighboring groups required to maintain reproductive and cultural viability. Accordingly, the concomitant increase in the variety of FGV sources represented in Paleoarchaic localities in east-central Nevada may reflect a reorganization of the social network as population density increased.

…FOR PALEOINDIANS

Most Paleoindianists disregard the role of exchange and non-utilitarian mobility for the procurement and transport of resources that is not embedded in subsistence pursuits. As discussed in Chapter 3, this sentiment can be traced to Lewis Binford (1979:259), who suggests that "Raw materials used in the manufacture of implements are normally obtained incidental to the execution of basic subsistence tasks." David Meltzer (1984-1985, 1989) builds on this insight to suggest that eastern Paleoindian assemblages reflect direct procurement by highly mobile residential groups. Of 29 eastern Paleoindian assemblages, Meltzer (1989) finds that only three even hint at indirect acquisition—that hint being low amounts of exotic stone. In fact, in some cases, Meltzer (1989) finds that exotic stone dominates the assemblage, which he suggests precludes exchange and implies direct, cyclical acquisition from primary outcrops. The ethnographic examples I considered in Chapter 3, however, suggest that exchange, at least a directed exchange, can account for the introduction of large quantities of nonlocal material into an archaeological site. Nevertheless, let us consider Meltzer's (1989) criterion for distinguishing direct procurement and exchange for the present. Specifically, can we extend Meltzer's (1989) interpretation to the majority of the Paleoindian record? In asking this question, note that Meltzer (1989) focuses on eastern North America; nevertheless, the sentiment he voices is echoed by many Paleoindianists.

In their recent attempt at chronological hygiene, Waters and Stafford (2007:Table 1) provide a sample of Clovis sites that we can draw on to explore how applicable Melter's (1989) criterion is to the Paleoindian record. In short, we can consider if these sites are dominated by exotic stone and, therefore, preclude exchange? For example, the "exotics" at Blackwater Draw for which Hester (1972:Fig. 86) provides provenance data (Alibates chert, Edwards chert, Tecovas jasper, Dakota quartzite) represent 70% (n = 147) of the Clovis artifacts. Thus, a large proportion of the Clovis artifacts derive from sources 160-320 km (100-200 miles) from the site (also see Condon 2006), perhaps indicative of high residential mobility.

Several significant archaeological sites do not duplicate this pattern, however. Although thirty discrete raw material sources were identified in the lithic assemblage at Hell Gap (Kornfeld 2009:Table 16.9; Miller 2009), the majority of the assemblage consists of locally available cherts. Major Spanish Diggings quarries are within 30 km of the site and the entire Hartville Uplift, in which the site is located, offers many types of quarriable cherts and quartzites. Similarly, local silicified limestone and Madison cherts dominate the lithic assemblage at Indian Creek, with only a handful of artifacts attributable to distant sources (Alibates, the Hartville Uplift, Obsidian Cliff obsidian, Camas/Dry Creek obsidian) (Davis 1986; Davis et al. 1985; Davis and Greiser 1992:Table 7.1). Likewise, the Mill Iron lithic assemblage is dominated by toolstone that occurs within a few kilometers of the site, including silicified wood and cobble cherts (Francis and Larson 1996). Finally, at Murray Springs much of the chert has not been sourced, though the most abundant material used at the site (St. David Chalcedony) has been traced to a generalized local source area (Huckell 2007:Table 8.4).

In short, even if we utilize the logic that underlies current Paleoindianist thinking, the archaeological record does not require the high level of residential mobility often advanced to explain the introduction of exotic toolstone, nor does it preclude the importance of non-utilitarian mobility and exchange in distributing toolstone amongst Paleoindian groups. Again, intergroup interaction and exchange are fundamental components of hunter-gatherer adaptation, the material correlates of which we should be able to recover in the archaeological record. Recently, C. Vance Haynes (2006) wrote that the ever present question for the first Paleoindians would have been "When and where are we to meet other people?" I submit that Paleoindians, even the first ones, would have always known the answer to this question.

The Last Word

My goal in pursuing this research has been to contextualize obsidian-based models of Paleoarchaic subsistence-settlement within a broader understanding of lithic technological organization, informed by examples of modern hunter-gatherer mobility and exchange. Additionally, the analyses presented here suggest that our analytical methods may be up to the task of building a multi-tiered, multi-dimensional model of Paleoarchaic adaptation from the surface lithic scatters that so dominate the archaeological record for this period. In turn, this research raises the challenging, but fruitful, task of developing new models of Paleoindian mobility, technology, economy, and intergroup interaction.

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