University of Nevada, Reno

Fine-Grained Volcanic Toolstone Sources and Early Use in the Bonneville Basin of Western Utah and Eastern Nevada

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

by

David Page

Dr. Gary Haynes, Thesis Advisor

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DAVID J. PAGE

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Gary Haynes, Ph.D., Advisor

____
David E. Rhode, Ph.D., Committee Member

____
Kenneth D. Adams, Ph.D., Graduate School Representative

____
Marsha H. Read, Ph. D., Associate Dean, Graduate School

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Abstract

Identifying lithic sources is central to understanding toolstone use by prehistoric hunter-gatherer groups. The distribution of archaeological materials in relation to geologic sources creates a spatial pattern of use that varies through time. These patterns of distribution in conjunction with analysis of technological organization can be used to infer behavior, especially levels of mobility. This thesis presents geochemical data from a wide-scale sourcing study in the Bonneville basin of western Utah and eastern Nevada. Results of this investigation are presented, including discussion of newly identified geologic source groups and further characterization of previously identified sources, outcome of X-ray fluorescence analysis on approximately 600 fine-grained volcanic (FGV) artifacts from a host of open sites in the Old River Bed delta and from caves/rockshelters including Danger Cave, Bonneville Estates Rockshelter, and Camels Back Cave, and a brief look at how the inhabitants of this region varied FGV-toolstone use through time.

Acknowledgements

Many deserve my thanks. Diet Coke kept me well hydrated in the desert with a little sound of freedom in every can. Dave Rhode kept me employed for many years and motivated when I didn't think this ride would ever end. Craig Skinner at Northwest Research Obsidian Studies Laboratory extended the "student rate" to yet another begging UNR grad student and also analyzed all of my geologic samples at no cost; all of this with a rapid, if not superhuman turnaround. The Lander Trust provided funding to make this whole thing possible. Rachel Quist at the U.S. Army Dugway Proving Ground also provided support, kept me busy with survey projects, and allowed access to extensive archaeological collections. The Utah Museum of Natural History allowed me to source materials from Danger Cave and gave me a free ride in the oldest elevator in Salt Lake. Ted Goebel and the Sundance Archaeological Research Fund provided funding and allowed me to source materials from Bonneville Estates. Daron Duke shared sourcing data and a couple of long truck rides across Nevada, as well as some unsolicited golf advice along the way. My committee, Gary, Dave, and Ken, also put up with a lot and deserve many thanks. Last, but not least, I'm grateful to have a wife who is also my best friend, giving me reason to strive for more. To all I have forgotten, keep on, keeping on.

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Chapter 1

Introduction

This thesis addresses the following research problem: sources of 'basalt'-like lithic material used in stone tool production by prehistoric populations in the central Bonneville basin are unknown and hence human decisions about procuring an essential raw material are also unknown. The question is posed: what are the sources of archaeological fine-grained volcanics in western Utah and eastern Nevada and how were they used by prehistoric peoples living in the region? This question is important because its answer(s) will bear on human mobility, technological organization, and behavior in prehistory. It attempts to answer this and related questions through the analysis of geological and cultural materials via geochemical and spatial means.

As is the case across much of the western U.S., many of the types of raw materials used in the production of stone tools (herein referred to as toolstone) are volcanic in nature and consist primarily of obsidian and miscellaneous fine-grained volcanic (FGV) rocks (e.g., basalt, andesite, dacite, rhyolite, etc.). Toolstone was a significant resource used extensively by prehistoric hunter-gatherer populations. Recently, it has also become an important resource for the archaeologist interested in understanding behavior of prehistoric peoples.

The eastern Great Basin contains a rich archaeological record of human occupation beginning at the Pleistocene/Holocene transition, ca. 10,000 radiocarbon years before present (B.P.). Evidence of human occupation during this period is often found in association with the shorelines of extinct pluvial lakes. Within this region, the Bonneville basin shines as prime location for studies of early cultures with a plethora of more than a thousand open-air sites dating to the Paleoindian Period (ca. 11,000 – 7,500 B.P.), as well as multiple wave-cut caves and rockshelters that are well-dated and contain intact stratified deposits. Although most of these sites have assemblages dominated by flaked stone tools, including many made on FGV toolstone, to date there is limited knowledge of FGV sources in this part of the Basin. My study seeks to understand the regional sources of FGV toolstone, thus enabling researchers to view these resources in a more meaningful way.

The remainder of this chapter introduces several key elements central to this study: toolstone sourcing, lithic conveyance zones, and regional Paleoindian studies. Concepts have been accommodated to research in the eastern Great Basin, specifically the Bonneville basin of western Utah and eastern Nevada, where I have conducted my research, but should transfer equally well to other areas of the western U.S. and beyond, if toolstone types are conducive to similar geochemical study.

1.1 Research Background

1.11 Toolstone Sourcing

Over the past 25 years, much effort has been put forth to identify and characterize sources of lithic raw material used in archaeological contexts throughout the Great Basin. Identifying the locations of primary and secondary sources of toolstone is central to understanding lithic raw material use and selectivity by prehistoric hunter-gatherer groups. The distribution of archaeological materials tied to geologic sources creates a spatial pattern of use (lithic conveyance zone) that varies through time. This pattern of distribution, in conjunction with analysis of technological organization, can be used to infer behavior, especially levels of prehistoric mobility. While lithic raw material sourcing studies may include assumptions about source assignments and methods on the part of the archaeologist, and have potential shortcomings, such as the cost of geochemical analysis or the amount of effort needed to identify unknown sources, they can be used to identify lithic conveyance zones, and, ultimately, address hunter-gatherer mobility (Hughes 1984).

Obsidian was a significant resource that was used extensively by prehistoric hunter-gatherer populations in and around the Great Basin. It has physical properties that make it conducive to tool making. It is widely distributed across the geologic landscape and it can be distinguished geochemically using a variety of techniques. For these reasons, a disproportional effort has been expended by researchers to understand the use of this raw material type. Much has been learned about the use of various obsidian geochemical types, and a great deal has been written about these studies (e.g., Amick 1993, 1995, 1999; Arkush and Pitblado 2000; Basgall 1989; Beck and Jones 1990, 1994, 1997; Beck et al. 2002; Elston 1990, 2005; Hughes 1984, 1998; Jones et al. 1997, 2002, 2003; Madsen and Schmitt 2005, Schmitt and Madsen 2002, 2005; Schmitt et al. 2003). Until recently, outcomes of basalt and other FGV rock characterization studies in the Basin have been less successful and the resultant literature to date is limited (Arkush and Pitblado 2000; Duke and Young 2005; Graff 2002; Jones et al. 1997). Clearly, additional studies are needed to gain an improved understanding of how other important lithic resources were used by prehistoric populations.

Central to this topic of toolstone use is the issue of landscape and location within the landscape. Raw material is distributed at fixed points within the geologic landscape. Toolstone is variably distributed within the cultural landscape. Lithic foraging territories are juxtaposed at the interface of a cultural landscape and a geological landscape. Fine-grained volcanic toolstone is a limited resource with a patchy distribution; in this case, sources are more common at edges of the Great Basin (Jones et al. 2003). Prehistoric archaeological sites containing lithic tools are distributed as palimpsests of human behavior, unrelated to the geochemical signatures of the toolstones themselves. Mobility cannot be directly addressed through raw material sourcing. It is inferred from the distribution of toolstone within ascribed lithic conveyance zones and is primarily based on attributes of preserved technology.

1.12 Lithic Conveyance Zones

To address and demarcate zones of lithic conveyance (also referred to loosely as ‘group demarcation and interaction territories’ [Anderson and Hanson 1988]; ‘geographic ranges of raw material procurement and use’ [Beck and Jones 1990]; ‘raw material distribution’ [Buck et al. 1998]; ‘lithic supply zones’ [Seeman 1994; ‘lithic foraging territories’ [Jones et al. 2003]), one must first identify geologic sources of lithic raw material that may be used as toolstone and then look to the areal distribution of these lithic materials in archaeological context. This process can then be followed with further inference to elements of prehistoric behavior, including mobility (Figure 1).

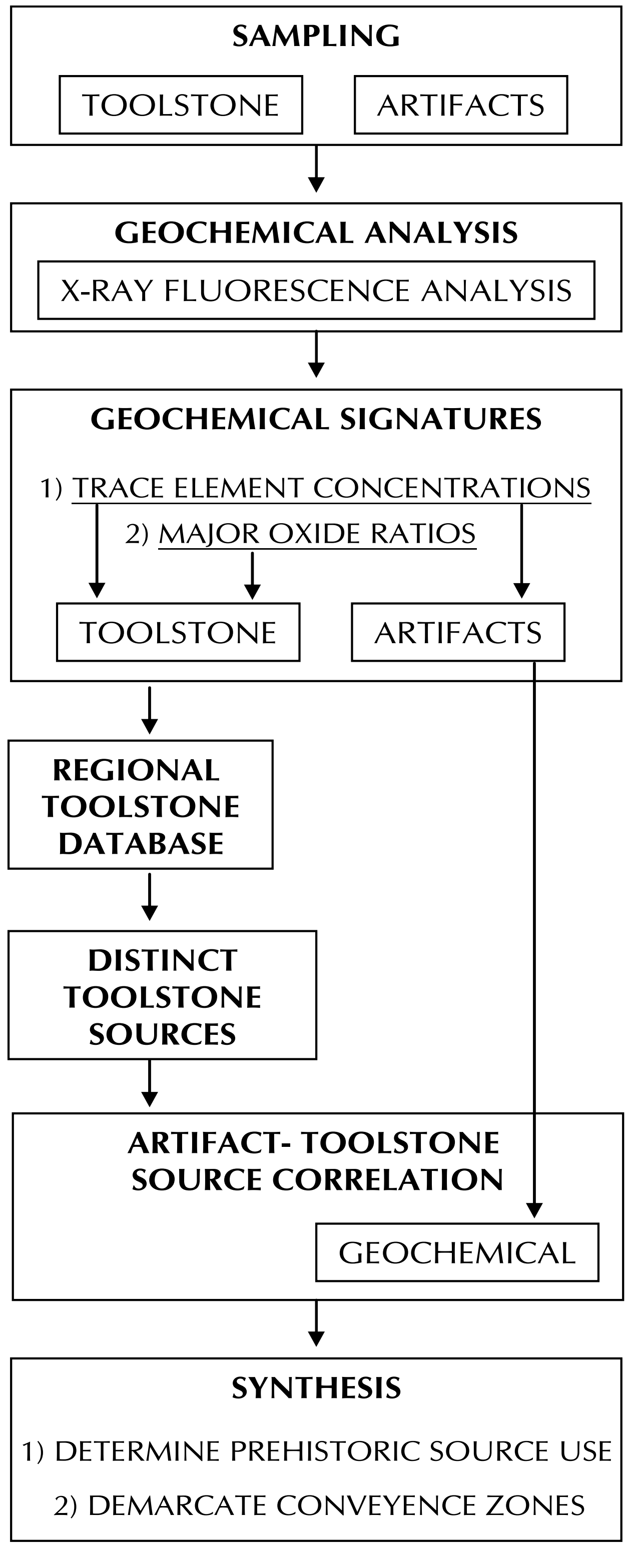

Figure 1. Generalized flow chart of geochemical approach to toolstone sourcing (modified from Malyk-Selivanova et al. 1998).

Source Identification

It is important to identify and characterize sources of lithic raw materials, but it is equally important to identify and characterize toolstone types used in cultural contexts. It is likely that the latter may be possible in part before the complete geologic characterization of any given region. Increasingly, geochemical investigations of toolstone in sites are being conducted as part of cultural resource management projects.

The initial step in a source characterization study is addressing lithic raw materials within their geologic context. Geochemical trace element characterization is usually conducted by means of X-Ray Fluorescence (XRF) spectroscopy, which has been in continued development and refinement since the early 1900s. It has become an established method of geochemical characterization within geology and archaeology and is employed extensively in obsidian and other toolstone investigations (Hughes 1984, 1998; Shackley 1998). The investigative technique of XRF analysis, in a simplified view, consists of exposing the sample (cultural or geologic) to a source of radiation, which causes the atoms in the sample to react in a way that emits atoms (fluorescence) of a particular characteristic. The quantification of these chemical signatures enables the identification of specific trace elements present in the sample (Thomsen and Schatzlein 2002). Comparison of element ratios across samples using both data tables and simple bivariate (XY scatter) plots provides distinction of various geochemical source groups. In addition, the size, shape, quality, and availability of lithic raw material must be addressed, as it relates directly to the second part of a sourcing study, which is addressing toolstone selectivity within the cultural context (Elston 1990). These various physical attributes of lithic raw material, including toolstone availability, toolstone quality, and toolstone durability affect tool production types and designs and appear quite influential on lithic production technology, perhaps more so than the level of mobility or sedentariness (Andrefsky 1994).

Toolstone Distribution and Conveyance Zones

The next step in a sourcing study is to identify the distribution of raw materials within their archaeological contexts. This is accomplished through detailed archaeological survey, site recordation, and the collection of a sample of archaeological materials of various toolstone types; alternatively, one could work with existing collections, either through museums or private individuals, given the collection is well provenienced. A sample of the collected artifacts can then be submitted for XRF analysis. To determine what should be sourced (e.g., formal tools, bifaces, unifaces, debitage, etc.), one should consider the scale of inquiry and review the research questions posed. It is important to determine the scale of inquiry, as it is possible to investigate toolstone use through a site specific viewpoint, a broader regional viewpoint (e.g., valley-wide or multi-valley viewpoint), or through an even larger perspective (e.g., eastern Nevada or Great Basin-wide). The results of this analysis, in conjunction with the previous identification and sourcing of geologic materials, are used to estimate the distribution of artifacts in relation to toolstone sources represented in the sample. Thus, in a simplified view, the correlation of artifacts to source areas should be representative of the general zone of toolstone conveyance.

When specific artifacts can be matched to specific raw material sources, additional analysis including calculation of distance and direction to the sources of lithic raw material is important. Based on distance, a distinction can be made between local and non-local resources and one can begin to differentiate between additional factors that may have influenced how lithic technology was organized by prehistoric populations.

Further examination of lithic technology is important as there may be correlations between specific tool types/forms and specific material types, and preference for one material over another for certain tool classes (e.g., obsidian may be preferentially selected for production of stemmed points). It is also necessary to classify assemblages by age to be able to monitor changes in particular source use through time (e.g., 'basalt' is perceived to have been used in higher frequencies in the Paleoindian period; perhaps the use of a specific source diminished over time).

Inferred Behavior & Mobility

The final step in the process is being able to tie the sourcing of lithic artifacts to prehistoric behavior (e.g., mobility, quarrying behavior, provisioning practices, etc.). Geochemical sourcing of obsidian and other fine grained volcanic artifacts can be used to address resource procurement strategies, settlement patterns, and population mobility, although there is not a direct link between the artifact and mobility. This is the problem – archaeologists, in fact, study artifacts, not mobility. Geochemical sourcing data are used as a proxy for behavior (Hughes 1998). The ability to address other issues about distribution mechanisms is purely non-geochemical. Geochemical data only identify varieties of toolstone. The geochemical data, in conjunction with artifact provenience, place an object in space in relation to the original source of raw material. Aspects of behavior are inferred through additional analysis of the lithic assemblage. Through this, the understanding of lithic technological organization can be advanced and one can address issues of provisioning and mobility (Madsen et al. 2006).

Addressing mobility is a complicated issue. One must consider many factors that contribute to the complex system of hunter-gatherer adaptive behavior. Sourcing tells us how far a piece of rock moved from its original location. It does not tell us whether it was directly procured by a mobile or sedentary individual/group, indirectly procured by a mobile or sedentary individual/group in the round of other subsistence related activities, or whether it was acquired through exchange/trade by mobile or sedentary individual/group, etc. (Binford 1980). Additional factors including population density through time also affect subsistence activities including raw material procurement and overall settlement systems. The degree to which a population is mobile in reference to toolstone acquisition depends in part on the general level of sedentism and in the way other resources are procured. For example, one must ask: were people tethered to a particular locality and branched out from this point to hunt/gather for subsistence resources? Was the level of mobility higher than this, and perhaps people were highly mobile often on the move from place to place and hunting and/or gathering for resources as they were encountered (Binford 1980; Madsen 1982)? Addressing strategies of toolstone procurement is integral to understanding mobility and understanding mobility is central to understanding the distribution of toolstone within a conveyance zone (Jones et al. 2003; Kelly 1983, 1992, 1995; Kelly and Todd 1988). The degree of forager mobility is a continuum that varies throughout the year and throughout a forager's lifetime. The practice of logistical and/or residential mobility is also variable. Raw material acquisition patterns, imbedded versus direct strategies of procurement, lithic conveyance zones, possibility of trade and exchange, and consumption patterns change in relation to these other systems (Jackson 1989; Jones and Madsen 1989; Kelly 1988; Kuhn 1993; Newman 1994; Rhode 1990).

The way a group organized its lithic technology also speaks about its degree of mobility and resource transportation. This is manifest in the inclusion of formal or informal tools, the degree of tool curation, the use of expedient tool technology, and addition of multifunction tools to the toolkit, the degree of tool reuse and recycling, etc. (Bamforth 1986; Binford 1979; Kelly 1985; Odell 1996; Shott 1986, 1989).

1.13 Regional Paleoindian Studies

The Bonneville basin of western Utah and the adjacent pluvial valleys to the west in eastern Nevada have been host to a number of archaeological investigations into prehistoric mobility and lithic raw material use since the mid-1980s (Beck and Jones 1988, 1990, 1997; Beck et al. 2002; Elston 2005; Hughes 1984; Jones et al. 1997, 2002, 2003; Madsen and Schmitt 2005). Research by Jones et al. (2003) places this region of the eastern Great Basin within a single lithic conveyance zone (Eastern Zone). The paleoenvironment and climatic conditions of the Great Basin influenced prehistoric hunter-gatherer settlement and resource acquisition systems and had an effect on mobility (Aikens and Madsen 1986; Grayson 1993; Madsen et al. 2001; Oviatt et al. 1992, 2003; Rhode and Wigand 2002). The physiography and topography of the Basin and Range province influenced the archaeological distribution of raw materials and constrained the flow of materials between and within regions of the Great Basin (Grayson 1993; Jones et al. 2003). Beck and Jones (1990; Beck et al. 2002; Jones et al. 2003) have conducted extensive projects involving late Pleistocene/early Holocene (LPEH) lithic technology and differential lithic material use in eastern Nevada.

Research done on the late Paleoindian Old River Bed (ORB) assemblages of western Utah by T. Jones and colleagues provides a good synthesis regarding obsidian use in the Paleoindian period (pre-Archaic) and Archaic period, but does not present a synthesis of other volcanic toolstone use: “As no survey of more local toolstone has been conducted, and the locations of [fine-grained volcanics] FGV toolstone in the area are currently unknown, not much more can be said of this material difference” (Jones et al. 2002:40). Based on analysis of ORB assemblages, Jones et al. proposed two main patterns of toolstone use:

> One, the earlier pattern, follows a common and widespread pattern--material use practices indicating high mobility and large territorial use, with tools designed for long use-lives and multiple uses. The other, later, pattern is of recycling and expedient manufacture, occasioned by shortages of raw material and designed for immediate deployment [Jones et al. 2002:50].

In addition, Jones et al. propose that FGV sources are likely local and thus potentially identifiable within the region for two reasons: volcanic rocks are common in the region, and previous studies indicate similar Paleoindian artifacts made on ‘basalt’ tend to be from local sources, rather than transported from distant sources (Jones et al. 2002) (see also Beck and Jones et al. 1997; Jones et al. 2003).

Further investigations have been conducted at the distal end of the ORB delta on the Utah Test and Training Range (UTTR) by B. Arkush and B. Pitblado (2000), as well as D. Duke, J. Carter, and C. Young at Wild Isle (Duke and Young 2005). Arkush and Pitblado's (2000) research on Paleoarchaic surface assemblages included the geochemical analysis of 22 'basalt' artifacts from eight sites located in the Wildcat Mountain area of northwestern Utah. These samples were submitted to R. Hughes (Geochemical Research Laboratory) for XRF analysis. Results, interpreted by Hughes, suggested two unknown source groups, which were presumed by the authors to be 'local'. They reported distinguishing element ratios for both unknown FGV source groups. Unknown source A produced strontium (Sr) values between 330 and 370 ppm and yttrium (Y) values between 30 and 35 ppm, while unknown source B produced increased levels of Sr (600 to 650 pm) and lower levels of Y (10 to 15 ppm) (Arkush and Pitblado 2000; Hughes 1997). Differences in toolstone use in this region of the Great Basin may be attributed to multiple factors, including varied resource availability and subsistence changes through time surrounding the transgression and regression of fluvial/lacustrine resource patches, preference for specific physical characteristics of the lithic raw materials themselves related to flakability and/or durability, as well as risk minimizing strategies employed by tethered foragers in a closed toolstone-poor but food-rich basin.

1.2 Research Objectives

The primary goal of this thesis began, somewhat simplistically and naively, as identification of the sources of 'basalt' toolstone used by prehistoric peoples in the

Bonneville basin; however, it has become more complex and grown to address this and other resultant questions including:

1.) Within the Bonneville basin, was there preferential use of FGV early in prehistory? Did Paleoindian and later Archaic groups use represented FGV geochemical groups (i.e., sources) differently through time?

2.) How did identified FGV materials move around the landscape? Does FGV use fit current models of “local vs. extra-local” toolstone use?

3.) Can varied source use be attributed to any physical properties of the raw materials themselves? Is choice related to mechanical qualities of represented rock types (e.g., andesite, dacite, etc.) and their flakability, durability, or general availability?

1.3 Structure of the Thesis

The thesis is presented in six chapters. Chapter 2 synthesizes the geologic and cultural context of the study area. Methods used in geologic sampling and in sampling of artifacts from existing archaeological collections are described in Chapter 3, as is an overview of site chronology, X-ray fluorescence spectroscopy, and a look into the use of geographic information systems in lithic sourcing studies. Chapter 4 contains results of geochemical analysis for geologic source groups and artifacts from select archaeological sites across the region. Also included in this chapter are geochemical results for sources not represented in cultural contexts (non-cultural raw materials) and for artifacts lacking geologic provenience ('unknown' FGV types). Discussion of source use in select surface and rockshelter/cave sites is provided in Chapter 5. The final chapter, Chapter 6, summarizes the results and discusses future research considerations.

Chapter 2

Context

When viewing a satellite image of the eastern Great Basin, several prominent physiographic features emerge, including a large alkali flat in western Utah and a series of north-south trending mountain ranges that extend westward across Nevada (Figure 2). This part of the larger Basin and Range Province is rich in geologic and cultural diversity. West of the Colorado Plateau and the Wasatch Range and generally east of the Nevada border, one finds the physical evidence of an enormous, mostly-extinct lake with many intact geomorphic features including multiple wave-cut shorelines, gravel bars and spits, extensive tufa drapes, broad/barren saline mud flats, as well as preserved deltaic features. This intriguing region of western Utah/eastern Nevada is situated at the southern end of the Great Salt Lake Desert, southwest of the modern Great Salt Lake. The landscape is varied with topography consisting of broad valley bottoms, sand dune fields, and mountain ranges reaching more than 3,600 m.

This chapter provides an overview of regional geologic and cultural context. Included is discussion of the general geologic setting, a brief history of eastern Great Basin volcanism, the late-Pleistocene/early Holocene hydrographic history of pluvial Lake Bonneville, and a description of the Old River Bed (ORB) delta and subsequent wetland. Paleoindian sites located at the proximal and distal delta/wetland resource patch and other miscellaneous lowland Archaic sites in the basin will generally be

Figure 2. Satellite image showing Great Basin topography; location of study area shown right of center and black line denotes limits of hydrographic Great Basin (base image source: ERSI MODIS from www.geographynetwork.com).

described, as will select cave and rockshelters located at the periphery of the basin, including Danger Cave, Bonneville Estates Rockshelter, and Camels Back Cave. Site chronology and lithic assemblages will be summarized.

2.1 Bonneville Basin Geologic Context

The project area lies in the eastern part of the Great Basin within the larger Basin and Range Province of the western U.S. It is primarily contained within the southern half of the Great Salt Lake Desert, but includes Dugway Valley in the southeast; both are in the central portion of the Bonneville Basin, southeast of the modern Great Salt Lake. Surrounding this internally draining basin are a number of generally north-south trending mountain ranges, including the Deep Creek Range, Antelope Range, and Goshute Mountains to the west; Fish Springs Range, Dugway Range, and Thomas Range to the south; and the Cedar Mountain Range and Simpson Mountains to the east. In addition, several isolated mountains/peaks protrude from the basin fill and lake deposits of the valley floor, including Granite Peak, Wildcat Mountain, and Camels Back Ridge (Figure 3).

The Cedar Mountain Range is composed of late Paleozoic sedimentary rocks (various formations composed of sandstone, limestone, shale, quartzite, and chert) overlain by a Tertiary cap of extruded igneous rocks (andesite, tuff, and rhyolite) (Hintze 1975). The Dugway Range, the oldest of the four ranges, has a base of Precambrian quartzite and shale that is overlain by a suite of Paleozoic sedimentary rocks (limestone, dolomite, shale, and quartzite). As with the Cedar Mountains, these are capped by extruded igneous rocks of Tertiary age (tuff and rhyolite) (Hintze 1975). Granite Peak, surrounded by an alkali playa, is an isolated peak that is a locally unique inselberg composed of igneous and metamorphic rocks (felsite, pegmatite, and schist) (Zier 1984). Camels Back Ridge is an isolated north-south trending limestone fault-block ridge. The Deep Creek Range is an isolated north-northeast trending limestone fault-block mountain range with a lithology that consists primarily of sedimentary and metamorphic rocks that have been repeatedly intruded or overlain by igneous rocks. Sedimentary units consist of various limestone, dolomite, and shale formations. Metamorphic units consist of various

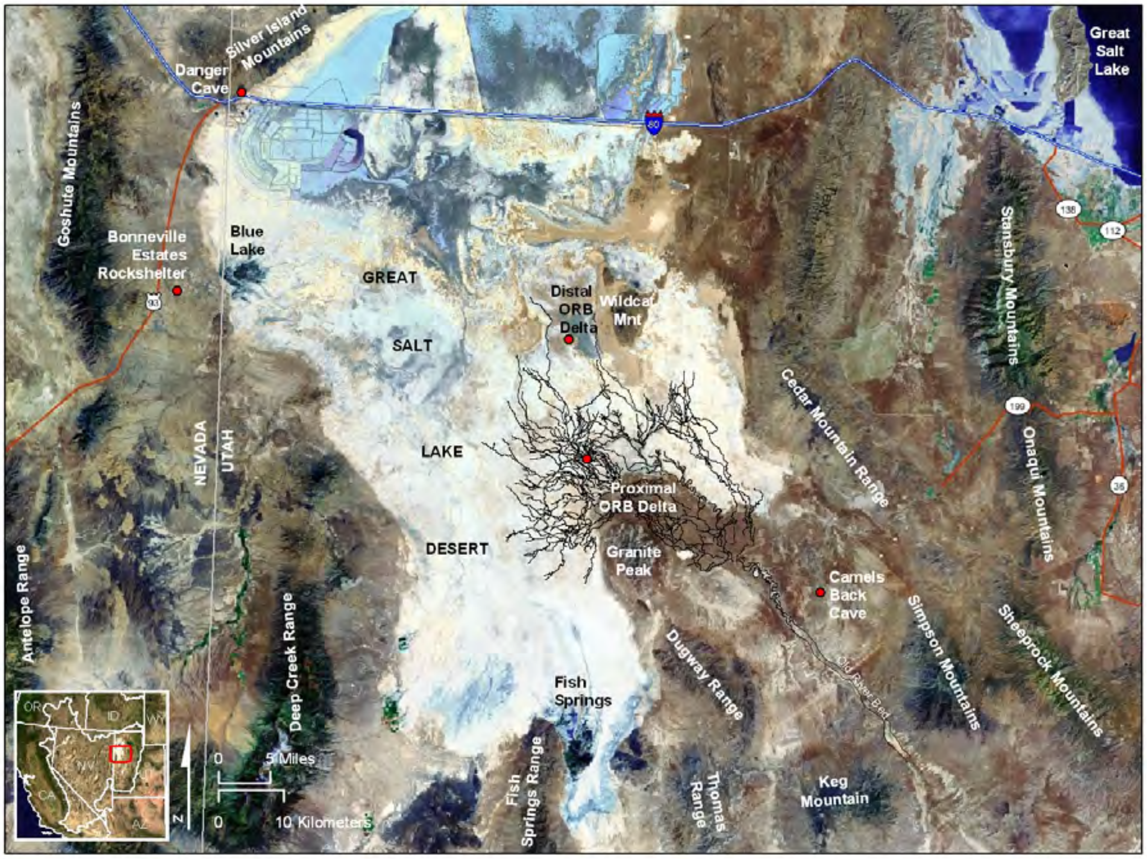

Figure 3. Overview of study area showing topography relative to discussed archaeological sites/assemblages (red dots) and ORB delta channels (black lines extending north of Granite Peak) (base image source: ERSI MODIS from www.geographynetwork.com).

quartzite formations, and the Ibapah stock makes up the igneous intrusive body (Hintze 1975).

2.11 Eastern Great Basin Geology and Volcanism

Although older rocks are present, most of the mountain ranges in the Great Basin are composed of late Paleozoic sedimentary rocks, specifically thick suites of carbonates laid down prior to 65 million years ago (Hintze 1975; Stokes 1987). As this project is focused on volcanic rocks and how these rocks were used by prehistoric peoples living on a modern or near modern geomorphic landscape, I will concentrate on the periods of geologic time that lead to this point. The last ca. 40 million years (Ma) of geologic time, roughly the last two-thirds of the Cenozoic Era (mid-Eocene though Pleistocene Epochs), has had direct implications on volcanic toolstone distribution and basin and range topography, thus will be my focus in this discussion (GSA 2007). Events during this time are generally punctuated (short-term events geologically) but are areally widespread within the region.

Cenozoic rocks (ca. 65 Ma-present) are abundant in the eastern Basin, of which about a third are of volcanic origin (Hintze 1975; Ludington et al. 1996; Stokes 1987) (Figure 4). These volcanic rocks correspond to two periods of Tertiary volcanism (ca. 40-25 Ma) and a later period of Pleistocene basaltic volcanism (Hintze 1975; Ludington et al. 1996; UGS 2006). Two episodes of major volcanic activity: one mid-Tertiary (Late Eocene to mid-Miocene) affected much of western North America which contributed to the extensive volcanism at this time in Utah; and a second, more recent episode in western Utah produced basalt flows and cones (Baer and Hintze 1987; Stokes 1987). During the early Cenozoic Era/Eocene Epoch, volcanism in eastern Basin and Range province is directly linked to increased faulting events. Increasing igneous activity at ca. 40 Ma resulted from subducted lithosphere at the contact zone beneath the North American plate. Magmatic activity was concentrated along pre-existing zones of structural weakness (Robinson 1987).

Within the eastern Basin, the first episodes of major volcanic activity can be further subdivided into stages. The first stage of Cenozoic volcanism (ca. 42-39 Ma) produced eruptions of calc-alkaline volcanics rocks of intermediate composition (FGV suite). The second stage (ca. 38-30 Ma) continued with extrusive/explosive eruptions but there was a shift to a more rhyolitic suite of rocks and ash-flow tuffs. The most recent episode of major volcanic activity (ca. 21-6 Ma) produced eruptions of rhyolite and basalt linked to extensional faulting in the region (Best and Christiansen 1991; Shubat 1987).

In western Utah, earliest tertiary rocks are rare but older Tertiary volcanoes/calderas are extensive, from several centers that produced intermediate composition volcanics (Baer and Hintze 1987). These calderas are now mostly destroyed and are all but visually indiscernible due to faulting, extension, erosion, and basin fill.

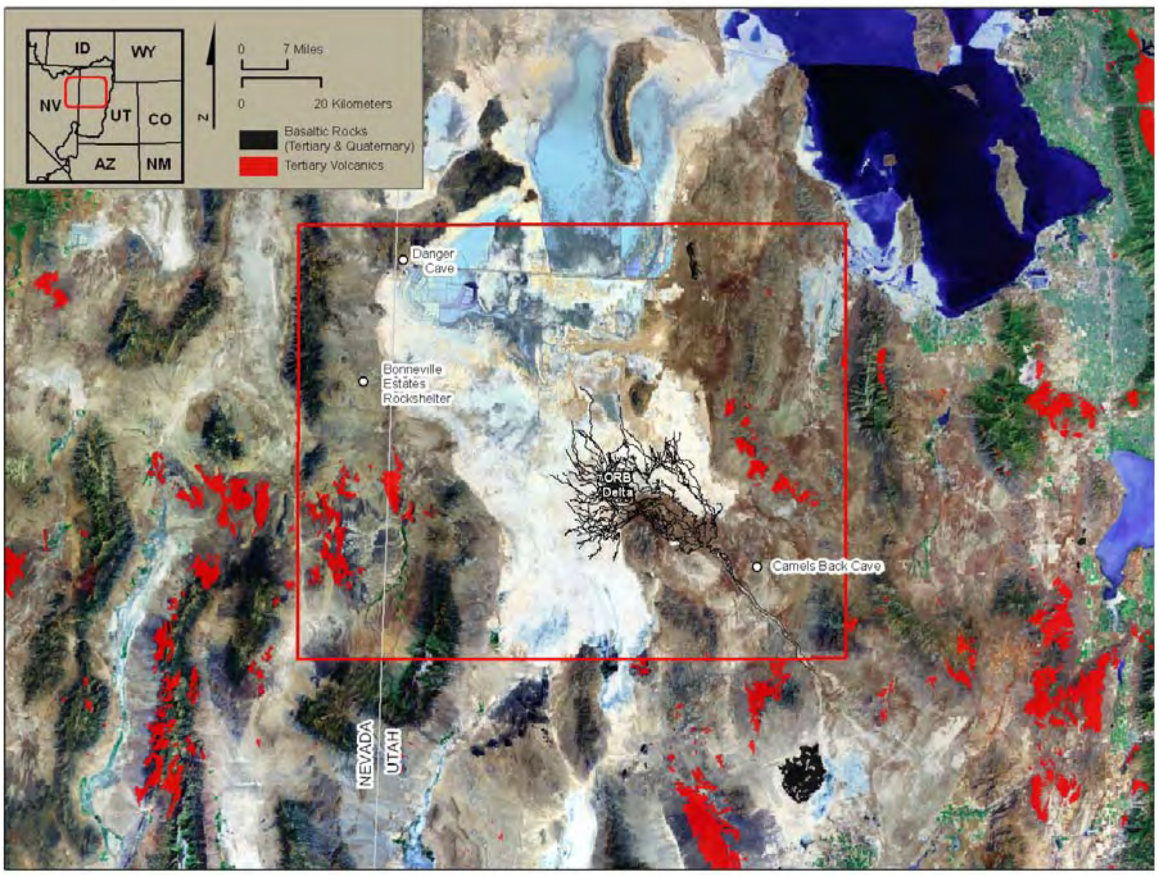

Figure 4. Distribution of Tertiary and Quaternary volcanic rocks in the eastern Great Basin with study area shown by red square (Kirby and Pohs 1997) (base image source: ERSI MODIS from www.geographynetwork.com).

Several small Pleistocene-age volcanoes (see Gilbert 1890:319-338) are located in and around the Sevier basin (e.g., Tabernacle Hill, Pavant Butte) (Hunt 1987).

Desert valleys make up two-thirds of the Great Basin portion of western Utah. Basin and Range block faulting began ca. 15 Ma with east-west extension, which was accompanied by small volume but widely distributed volcanism of rhyolite/basalt (Baer and Hintze 1987). With extension, mountains were uplifted and valleys were down-dropped. As mentioned above, an earlier more extensive episode of volcanism occurred in the eastern Great Basin, ca. 45-18 Ma. This was dominated by extensive/high volume ash-flow tuffs (Baer and Hintze 1987). Prior to basin-and-range extension ca. 15 Ma, regional topography was much different than today (Baer and Hintze 1987). Current topography of the Basin and Range, of which the Great Basin is a part, can be characterized by long, generally north-south trending mountain ranges with long valleys in between. This is related to tectonics and structural deformation via crustal extension of the Great Basin since the mid-Oligocene. This extension produced low angle normal faulting of older Paleozoic and Tertiary rocks in the eastern Basin (Robinson 1987). With extension, the composition of extrusive rocks shifts from a more andesitic suite of rocks to more basaltic rocks at ca. 17 Ma. Basic ‘Basin and Range’ topographic morphology with mountains bounded by normal faults was formed by east-southeast extension operating by 10 Ma (Robinson 1987). Through subsequent erosion of uplifted mountains, most basins (down-dropped valleys) were filled with mixed Quaternary alluvium and then topped with lacustrine deposits from Pleistocene pluvial lakes (Sharp 1987) (Figure 5).

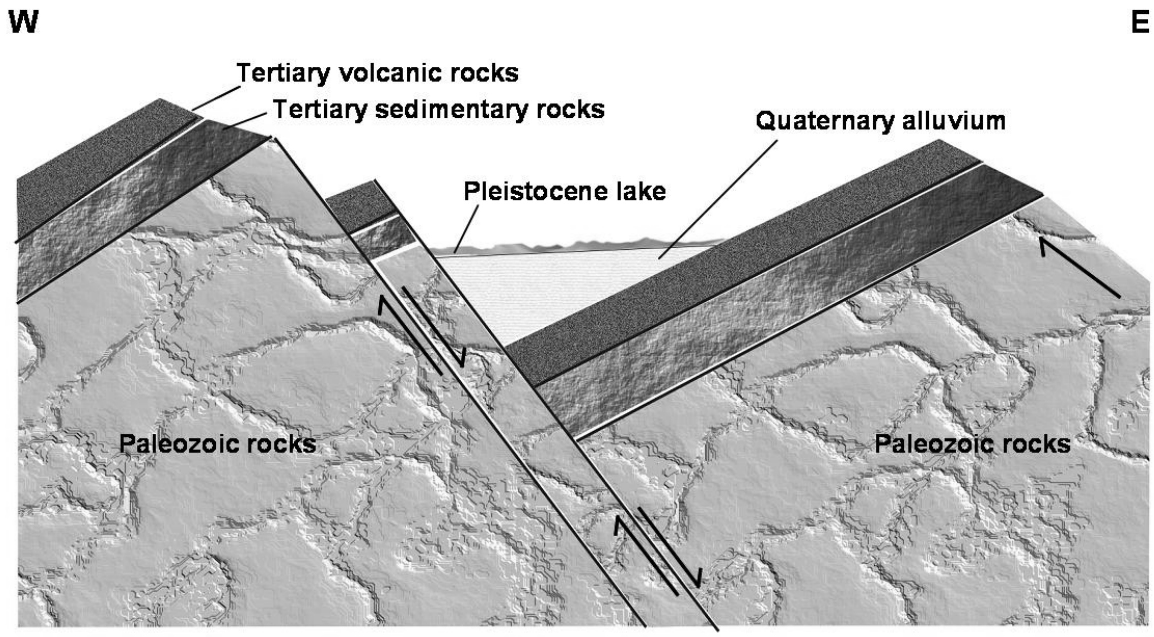

Figure 5. Illustrated cross-section of typical basin within the Great Basin; note relationship of Tertiary rocks to Pleistocene lake (modified from Sharp 1987).

2.12 Pleistocene Lake Bonneville and Old River Bed Delta

The project area occurs in the Great Salt Lake Desert, a sub-basin of the larger Bonneville Basin. During the Pleistocene, Lake Bonneville at its highstand covered three major sub-basins: the Great Salt Lake Desert, the Great Salt Lake, and the Sevier basin, and in total covered some 51,722 km^2 (Grayson 1993 and references therein). The Pleistocene lake developed four major shoreline stages during the transgressive and regressive lake cycles from 22,000 to 10,300 B.P. The most recent shoreline, Gilbert, formed between 10,500 and 10,000 B.P. when the lake rose to cover approximately 17,094 km^2 (Grayson 1993; Oviatt et al. 2005). Although subsequent geologic processes have resulted in shoreline features marking the Gilbert high stand to vary substantially in height and visibility at differing locations across the region, the high stand elevation ranges between 1,293 and 1,311 m (Currey et al 1984; Oviatt et al. 2005; Rhode et al. 2005). During the Gilbert high stand of Lake Bonneville the regional climate was generally moist and cool (Grayson 1993). This period of lake-level increase is likely related to the Younger Dryas global cooling chronozone, although how much of an effect this large scale climatic shift may have played in the Gilbert transgression is still unclear (Oviatt et al. 2005).

With the regression of Lake Bonneville from the elevation of the Provo shoreline, to levels approaching the modern Great Salt Lake prior to 12,000 B.P., a river connected the Great Salt Lake Desert basin with the Sevier basin to the south (Oviatt et al. 2003). This river, the Old River, flowed northwest by ca. 12,500 B.P., downcutting through soft lacustrine silts and clays to form a prominent incised river channel, the Old River Bed (ORB) (see Figure 3). As water continued to flow into the system, a delta with braided, digitate channels was formed at the river's terminus, east and north of Granite Peak. With the continuous input of sediment from ORB channel erosion and transport from the Sevier basin, the delta fan crowned at the point of input (pinching to the outside edges) causing the braided channel systems to shift east- west across the delta. As the energy levels of individual streams within the deltaic system increased and decreased, the amount and type of sediment load transported followed suit, producing a suite of channels with more or less sand and more or less gravel in their channel fill. Interactions between the valley slope, soft lacustrine sediment, and the water table through the early Holocene has resulted in severe erosion and deflation of these deltaic channels leaving them topographically inverted (raised in profile) above, or planed off and level with, the surrounding mudflat surface. Flow within the ORB continued until ca. 8,800 B.P. when the regional environment began to approach present conditions (Oviatt et al. 2003).

At least two types of channels have been described by Oviatt et al. (2003) and Madsen et al. (2006): raised gravel channels and sand channels. These differ both compositionally and, in a simplified view, temporally, as gravel channels likely formed during the period after the Provo regression but before the Gilbert transgression when the energy level of the fluvial system (accumulated Sevier overflow and groundwater discharge) was higher, with the ability to carry a sediment load of larger grain-size (gravel) a greater distance; while sand channels formed under reduced conditions (primarily after the Gilbert regression) with lower energy flow and sediment load of finer grain-size (sand and sparse pea gravel). These types as described are not mutually exclusive; ‘intermediate’ channels do exist with a mix of sand and gravel within the same channel fill. Older, pre-Gilbert phase sand channels and younger, post-Gilbert gravel channels also formed with changes in the energy level of individual channels with flux in the hydrologic system as controlled by regional environmental conditions.

The majority of braided sand and intermediate channels within the ORB delta formed after Gilbert (post-10,000 to ca. 8,500 B.P.). Likely some sand and intermediate channels also formed prior to the transgression of Gilbert, but to date evidence of these lower energy channels is limited. This may be due to erosion by wave action, sheet wash, and the extensive (estimated 2-6+ meters) deflation within the past 10,000+ years. The extensive system of channels and the continued input of water from south to north are thought to have promoted and supported an expansive wetland/ riparian environment that could have been in excess of 1,200 km^2. With the removal of several meters of sediment as previously described, much of the deposits showing the areal extent of the marsh have also been lost to erosion. Channels likely shifted course on a somewhat regular basis (every few hundred years? or less) and as they did they formed natural levees and other topographic features (points, bars, etc.) that provided conduits for human populations to access the supposed abundant marsh and riparian resources.

Today the ORB delta consists of a group of geomorphic features including uneroded and eroded deltaic deposits east and north of Granite Peak, an arc of silty sand dunes dividing these deposits, and an expanse of mudflats covering the valley/basin floor incised with various channel types (Figure 6). Extensive photogeologic mapping of a large number of deltaic channel distributaries within the ORB delta using ArcMap, the geographic information system (GIS) software package, in conjunction with high-resolution color satellite imagery and black and white digital orthophoto quadrangles has enabled a better understanding of the timing and extent of this vast hydrologic system (Page et al. 2008; Clark et al. 2007). This large convoluted, spaghetti-like network of eroded and exposed channels extends north and west from under the dunes marking the uneroded delta margin, north of Granite Peak more than 30 km to the west-side of Wildcat Mountain and beneath the TS-5 dune complex, while additional channels also extend west and southwest of Granite Peak more than 20 km. The majority of these linear channels are contained within U.S. Army Dugway Proving Ground (DPG), but some can be traced north where they enter the Utah Test and Training Range (UTTR).

A multiyear project investigating both paleoenvironmental conditions and the cultural occupation of the ORB delta is ongoing (Carter et al. 2004; Madsen et al. 2000; Oviatt 1999; Oviatt and Madsen 2000; Oviatt et al. 2003; Schmitt et al. 2002; Madsen et

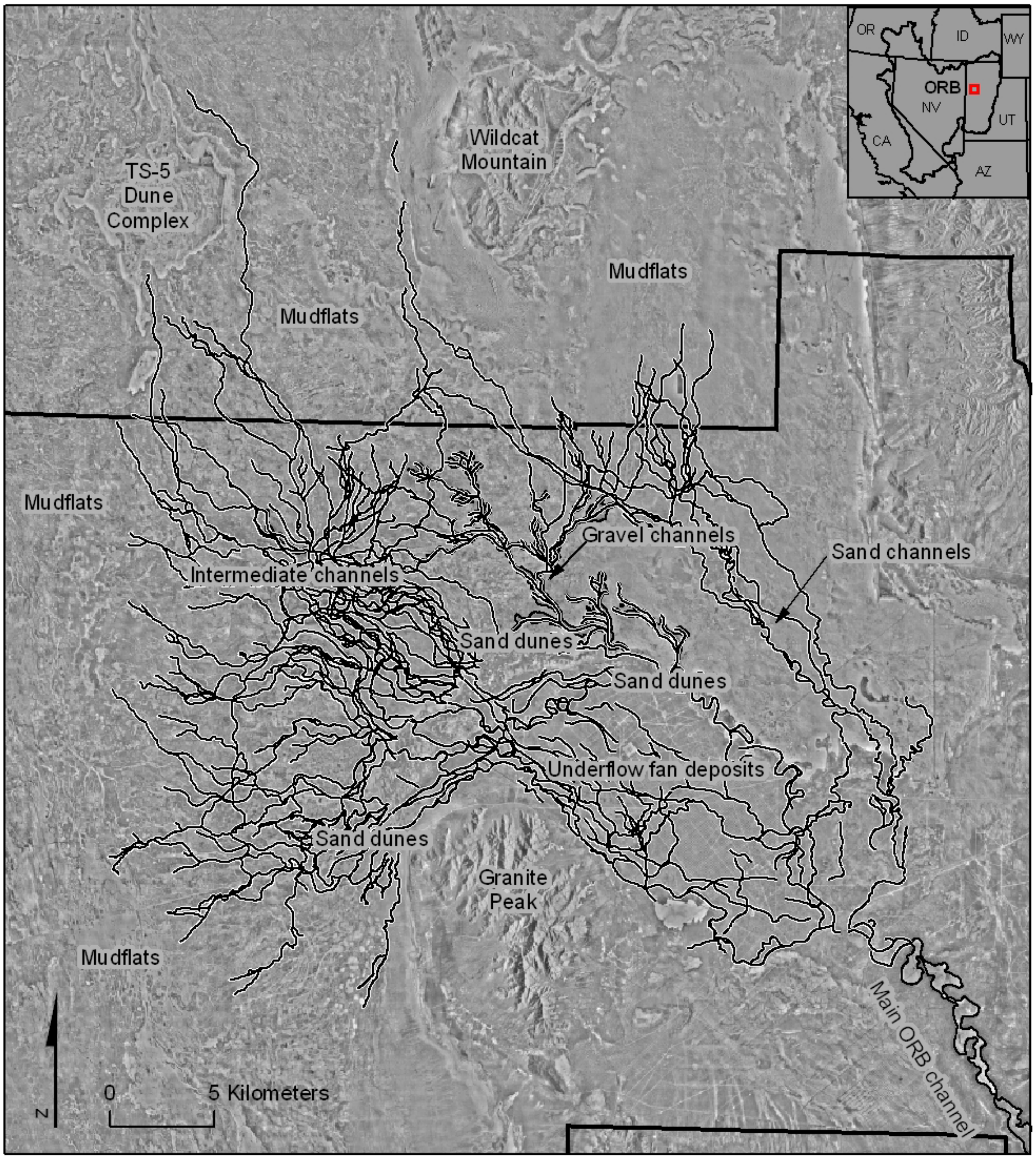

Figure 6. Overview of ORB delta system with distributary deltaic channels and other geomorphic features labeled for reference (modified from Schmitt et al. 2007).

al. 2006; Schmitt et al. 2007a; Young et al. 2006; see also Arkush and Pitblado 2000). A series of more than 20 radiocarbon dates on organic materials (charred material, organic sediment, plant material, shell, and peat) in channel fill, overbank deposits, or from marsh/wetland deposits associated with channels have been reported by Oviatt et al.

(2003). These dates place this period of fluvial system development from 11,000 to 8,800 B.P. (Oviatt et al. 2003).

Seven additional ^{14}C dates on plant material obtained within marsh deposits associated with four geographically-distinct channel distributary systems produced evidence of wetland formation in the proximal delta between 10,290 and 9,010 B.P. (Figure 7) (Madsen et al. 2006; Schmitt et al. 2007a; Page et al. 2008). The dated sediment samples contained identifiable plant materials that were identified to the generic level as bulrush (*Scirpus* sp.) suggesting that water in the channel(s) or in low energy ponds/lagoons adjacent abandoned channels was shallow/slow moving within a larger low energy marshy system (Schmitt et al. 2007a). Five additional unpublished dates on organic sediment by D. Duke from wetland deposits in the distal portion of the delta near Wildcat Peak (See Figure 6) fall between 9,210 and 8,880 B.P. (Duke, personal communication 2007). These other dates from the distal delta are consistent with dates presented by Oviatt et al. (2003) for wetland development.

In conjunction with distributary channel mapping via aerial photography and continued dating of marsh deposits throughout the delta, chronology of the ‘major’ channel systems (traceable on digital imagery from dune/mudflat interface to distal portion of delta) have been addressed using cross-cutting relationships (Madsen et al. 2006; Schmitt et al. 2007a; Page et al. 2008). Due to the number and complexity of these cross-cutting distributary systems, researchers (including me) have attempted to gain some understanding of their relative age by color-coding the main systems and identifying where they intersect each other. To date more than 25 principal intermediate and sand channel distributary systems have been identified on the southwestern and

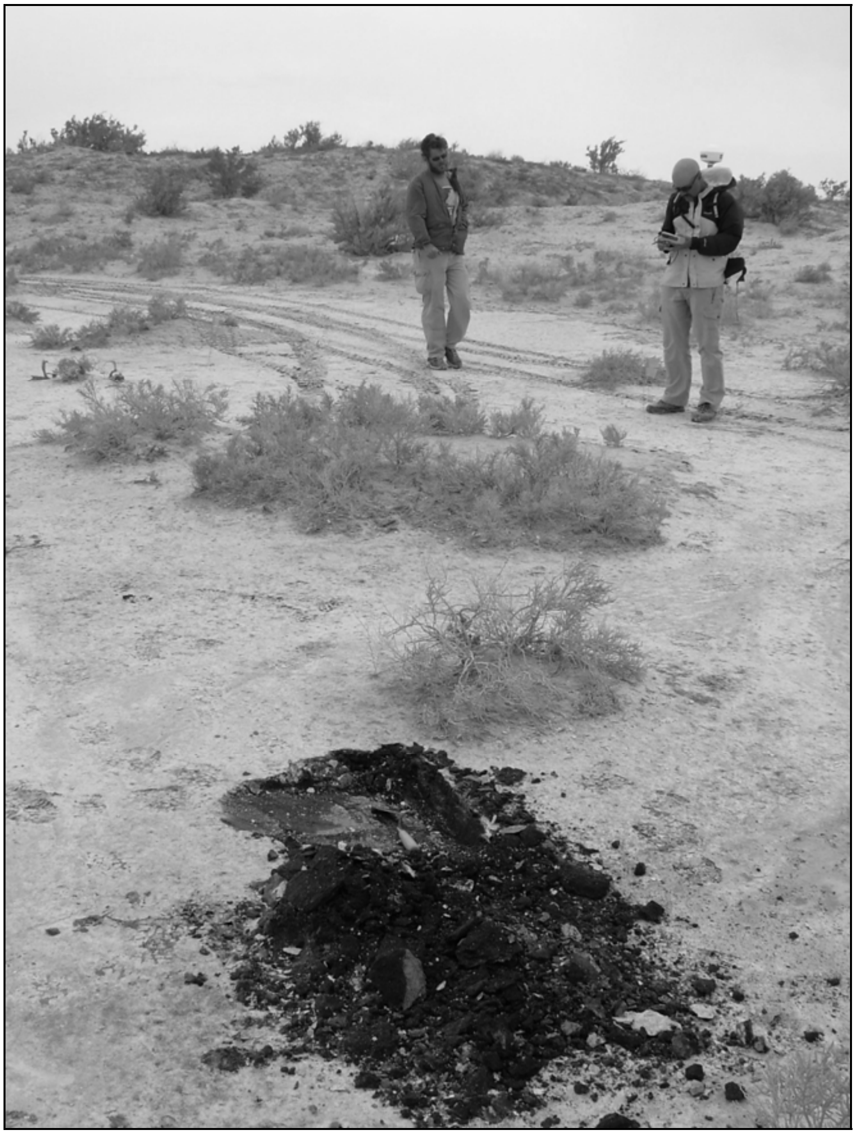

Figure 7. Example of organic black mat deposit with AMS radiocarbon date of 9,010 ± 40 B.P. (Beta-221778) (photo credit: D. Madsen).

southeastern margin of the ORB delta. This includes ca. 1,200 km of eroded channels spanning from Granite Peak to Wildcat Mountain and more than 368 km of uneroded and buried channels within the underflow fan deposits east of Granite Peak (Figure 6) (Schmitt et al. 2007a). Based on current observed site densities of one to 1.5 sites per linear km of channel, the previous estimate of 500 or more sites made by Rhode et al.

(2005), has recently been revised and increased to be an estimated 1,200-1,800 late Paleoindian sites.

2.2 Early Bonneville Basin Cultural Context

Two main temporal periods, the Paleoindian (or Paleoarchaic [another term for Paleoindian adaptations]) and the Archaic (with focus on the earliest portion of the Archaic), will be outlined here, as they relate to the occupation episodes in the Bonneville basin that were most reliant on FGV toolstone.

This brief culture history section will be followed by a summary of open sites associated with the ORB paleodelta/wetland resource patch and of several stratified caves and rockshelters at the periphery of the basin (Danger Cave, Bonneville Estates Rockshelter, and Camels Back Cave). The majority of open sites discussed here are the result of presumed single event (or multiple events within a single Period) occupations dating to the late Paleoindian period, while the stratified sites contain intermittent and/or episodic occupations spanning most of the Holocene. For the suite of sites mentioned above, I will discuss various contextual aspects such as location within region, topography and hydrology, generalized site type, site history and excavation status, content of reported assemblage, site integrity and occupation history, and a review of radiocarbon chronology.

The Paleoindian Period (~13,300 – 9,000 cal B.P.) began during the latest Pleistocene and extended into the early Holocene (Grayson 1993; Jones et al. 2003). This period encompasses more than 4,000 calendar years of dramatic change, including climatic change, hydrologic fluctuations, faunal and floral migrations, animal extinctions, and cultural emergence by the earliest peoples in the Basin (Beck and Jones 1997; Madsen 2007). It is a cultural period marked by adaptive flexibility and regional variability on the part of early forager populations in the eastern Great Basin. To characterize the period and distinguish it from what follows it in the Archaic, a simplified list of key points is discussed further below (Table 1).

Table 1. Characteristics of the Paleoindian Period

Temporal Period	Age (^{14}C)	Key Points
Paleoindian	>11,500-8,000 B.P.	- earliest known occupation of region - sparse record (open sites/few caves) - mostly water-centric site locations - variable mobility (toolstone/resources) - variable diet - no groundstone, ceramics, or long storage - few fluted/abundant stemmed points - Pinto points by 9,000 B.P. (perhaps earlier)

During this temporal period the eastern Great Basin archaeological record is typically sparse, mostly represented by open surface scatters and isolated finds of weathered lithic artifacts and by a handful of stratified caves and rockshelters with limited cultural signatures. Sites seem to be located in lowland settings in association primarily with pluvial lake basins, springs, marshes/wetlands, and other geomorphic features related to resource rich, water-centric localities, which fits the current view of Paleoindian lifeways in the Bonneville basin, although there may be some bias in this assessment, as certain low impact activities in mid-elevation or upland settings (e.g., upland hunting by small parties) would have left a less visible and less detectable footprint on the landscape. Evidence of such behaviors may have been obscured or erased by the many thousands of years of erosion and other taphonomic processes at play. Although these short forays likely were part of the suite of Paleoindian behaviors in the eastern Basin, they are underrepresented in the archaeological record.

As mentioned, archaeological data from this period are limited, making inferences about mobility, settlement patterns, and subsistence somewhat speculative. Given site locations that seem to be tied to resource-rich and mostly well-watered areas and the fixed points of toolstone sources and other resources on the landscape, we can make inferences regarding levels of mobility and resource acquisition and use. It is likely that these characteristics were highly variable according to season and location and quite dependent upon the quality of the environment at any given time.

Use of obsidian and other toolstone by these populations allows us to track movement of stone across the landscape. Based on these data, mobility is gauged to be relatively high, with sites often containing materials that originate from great distances (occasionally from >400 km away) (Jones et al. 2003). Again, as with other characteristics of the period, this source profile is often quite variable with some long range source use but once settled into an area it seems populations became more reliant upon closest materials sufficient for the task at hand.

Hafted lithic technology included both concave base (fluted and non-fluted points are rare in Bonneville basin) and lanceolate projectile points early on, as well as possible coeval use of stemmed projectile points, which seem to replace these earlier forms and remain in continued use until the terminal Paleoindian period (Beck and Jones 1988;

1997; Davis et al. 1996). The majority of eastern Basin projectile points from this period fit well into the Great Basin Stemmed Series or Western Stemmed Tradition as defined by Tuohy and Layton (1977) and Willig and Aikens (1988), respectively. There is also some evidence of later use of split-stem Pinto Series projectile points coeval with stemmed points (Duke et al. 2008a). Use of other technologies and subsistence strategies familiar to more recent temporal periods (e.g., groundstone, small seed use, ceramics, long term storage, portable art) is not apparent in the archaeological record from this period.

The temporal and behavioral transition from the Late Paleoindian Period to that of the Archaic Period ca. 8,000 B.P. occurred at a turbulent time of environmental change after the end of the Younger Dryas, during a period of early Holocene warming that resulted in pluvial lake drying and a shift of biotic communities: in essence a gradual but dramatic ecological shift to effectively modern conditions (Oviatt et al. 2005; Madsen 2007).

The Archaic Period (9,000 – 2,500 cal B.P. [Early and Middle Archaic]) spans a transitional period of cultural and middle-Holocene environmental change. This ca. 6000 calendar year period is bracketed by the Paleoindian and Fremont Periods and likely represents a continuation of the same populations that occupied the region and at least a partial carry-over of their lifeways, although modified to deal with volatility in environmental conditions and shifts in technology in the eastern Great Basin. To characterize the period and differentiate it from the preceding period, a simplified list of key points (Table 2) is discussed in more detail below.

Table 2. Characteristics of the Archaic Period

Temporal Period	Age (^{14}C)	Key Points
Archaic	8,000-2,400 B.P.	- continued occupation of region - changing environments - diverse site locations (lowland & upland) - richer record (open sites/caves) - variable mobility (toolstone/resources) - variable diet (groundstone and seed use) - notched projectile points (darts/arrows) - atlatl spear thrower; late shift to bow/arrows

As mentioned above, initial Archaic populations continued to occupy the region occupied by precursory, Paleoindian populations. Early on there was likely general continuity in subsistence and settlement patterns, but change was spurred by growing aridity and deterioration of marsh habitats. Shifts in lowland vegetation communities from mesic-adapted communities with sage and grasses to more xeric-adapted plant communities dominated by shadscale and greasewood caused a shift in floral and faunal resource availability and prompted changes in both subsistence and settlement patterns as marsh resources fell out of the regional picture. These changes in the available food resource base caused a broadening of pursued food resources, as well as a change in population numbers and overall land use patterns (Aikens and Madsen 1986; Madsen and Kirkman 1988; Madsen and Schmitt 1998; Simms and Jensen 1999). There was a focus shift from lowland settings to include midland and upland regions. The transition to the Archaic pattern seems to have been an additive process (Schmitt and Madsen 2005; Madsen 2007).

The eastern Basin Archaic record is quite rich with numerous open and sheltered sites in diverse locations including increased and extensive use of caves and rockshelters. The increase in the number of sites dating to this period is seen as an increase in regional population but may be a factor of increased group mobility (Schmitt and Madsen 2005). Changes in the subsistence focus during the middle Holocene also led to changes in technology with the addition of ground stone for seed processing (Grayson 1993). In addition to increased use of floral resources, there is increased use of artiodactyls and small game such as jackrabbits (Madsen and Rhode 1990; Madsen and Schmitt 2005; Schmitt and Madsen 2005).

Hafted lithic technology from the period includes diverse forms of notched and un-notched dart projectile points ranging from the transitional split-stemmed Pinto Series to shouldered (side and corner-notched varieties) and unshouldered types, including Humboldt Series, Large-side notched (also Sudden and Northern Side-notched), Gatecliff Series, and Elko Series projectile points (Heizer and Hester 1978; Thomas 1981). Shifts in mobility and settlement strategies and size reduction in projectile point technology also influenced the type of toolstone used and in turn produced a change in individual lithic source use through time (e.g., severe reduction in FGV use is paired with an increase in CCS use). This change is magnified during the Late Archaic and beyond with the abandonment of the atlatl and the introduction of the bow and arrow in the eastern Great Basin by 1,600 B.P. (Elston 2005).

2.21 Select Surface Assemblages

The following section contains background information about select Paleoindian surface assemblages from the Great Salt Lake Desert. This region contains a rich archaeological history, with numerous open-air sites in the basin interior associated with the proximal and distal ORB delta which have been largely preserved due to more than 50 years of public access restrictions by the US military (DPG and the UTTR) (see Arkush and Pitblado 2000; Duke and Young 2008; Duke et al. 2008b; Madsen 2001; Madsen et al. 2004; 2006; Page et al. 2008; Rhode et al. 2005; Schmitt et al. 2002; 2003; 2007a; 2007b; Young et al. 2006). These sites are abundant, are fairly well preserved (although highly deflated), and contain diverse lithic assemblages that include high amounts of FGV toolstone.

2.211 Old River Bed Delta Sites

Based on recent archaeological inventory conducted by Madsen et al. (2006), Schmitt et al. (2007a), and Page et al. (2008), an estimated 1,200-1,800 late Paleoindian sites are thought to exist on or adjacent distributary channels within the greater ORB delta (see Figure 6). Environmental conditions limited the productivity of the region and sometime after ~8,500 B.P., conditions deteriorated in the delta. As the marsh dried up, what was a mega resource patch became unattractive to foragers and site formation essentially ceased until the later development of mid-Holocene dunes in limited areas of the proximal and distal delta and a minor resurgence of occupation by Archaic foragers. Site reoccupations (assemblage palimpsests) are rare as site placement is based on different topographic and hydrological constraints; essentially there is little evidence of early site disturbance by later peoples.

While some potentially older sites have been recorded on the elevated, high energy gravel channel remnants (see Madsen 2001; Madsen et al. 2004; Schmitt et al. 2002; Schmitt et al. 2003), the majority of these sites are thought to date to the period of low to moderate energy channel formation when water was actively flowing in any given individual channel system or slightly after channel abandonment when residual water (seasonal water and groundwater input) remained in permeable channel fill, thus allowing marsh formation for a period of time after a horizontal shift in the active stream course.

Sites are found in a variety of settings related to topography and hydrology. They can be found along the channel margins or within the channel itself, and as such seem to indicate whether sites were occupied concurrently with periods of stream flow when foragers were occupying the natural levees of the channel banks or post-stream flow when foragers were able to occupy the channel bed. Additionally, sites are found flanking channel margins extending onto what is now barren alkali playa where there may have been enough water via ponding or overbank events to support wetland/marsh resources during periods of peak stream formation (Figure 8).

Site types consist of open lithic scatters with most being linear artifact clusters along channels or diffuse scatters outside channel margins on the mudflat surface. Assemblages are composed of varying tool to debitage ratios, with most having high numbers of tools and little debitage but some with more debitage and fewer tools. This is likely a functional difference in site type (e.g., campsite, tool maintenance or retooling station, foraging/collecting area, etc.) (see Oviatt et al. 2003; Rhode et al. 2005). Most sites contain diverse tool classes with high numbers of Great Basin Stemmed point variants, fragmentary bifaces, unifacial scrapers, simple modified flake tools, and the occasional graver, drill, and core. In general, most formal tools are small and often expediently made (often unifacial on flake blanks) and are made of two major toolstone types (primarily FGV and obsidian with the occasional CCS or quartzite tool or flake).

Figure 8. Overview from channel margin in ORB delta, looking south toward Granite Peak (photo credit: D. Page).

Toolstone source profiles are commonly diverse, often having many sources represented within the same site but are generally quite similar across sites in the delta. This is likely a function of a finite number of fixed sources on the landscape and the distance to nearby sources.

Little subsurface testing of Paleoindian sites has been conducted in the ORB delta (Madsen et al. 2004; Carter et al. 2004; Duke, personal communication 2007). The excavation history is limited, as most sites are primarily deflated open lithic scatters with little potential for intact buried deposits, although there is increased potential for intact buried deposits under aeolian silt/sand dunes armoring channels in some places. To date, only two pre-Archaic sites have been tested on DPG and findings were quite limited and provided little information about prehistoric lifeways in the delta (Madsen et al. 2004).

2.22 Select Rockshelter/Cave Assemblages

The following section contains background information about a few rockshelters/cave sites recorded within and adjacent the Great Salt Lake Desert that contain assemblages that are also FGV-rich. These sites, including Bonneville Estates Rockshelter, Danger Cave, and Camels Back Cave, contain well stratified deposits that have a high degree of organic preservation and are well dated. With the exception of Camels Back Cave, they contain evidence of cultural occupations spanning the terminal Pleistocene and most of the Holocene (the cultural record of Camels Back spans the mid-to-late Holocene). These sites have been excavated with modern methods, contain detailed excavation records, and have detailed and well-associated chronological control that is lacking with the surface assemblages of the ORB delta.

2.221 Bonneville Estates Rockshelter

Located in the Lead Mine Hills adjacent the Goshute Mountains, Bonneville Estates Rockshelter (CrNV-11-4893) lies in Elko County, Nevada, approximately 30 km south of the town of Wendover, Utah, and nearby Danger Cave, ca. 70 km northwest of the central ORB delta, and ca. 110 km northwest of Camels Back Cave. It sits at the western edge of the Bonneville basin, overlooking the vast Great Salt Lake Desert (see Figure 3). It is an open, east-facing, wave-cut carbonate erosional feature associated with the Lake Bonneville high shoreline at an elevation of ca 1580 m amsl (Figure 9). The mouth of the shelter measures approximately 25 m wide by 10 m high and is ~15 m deep from the dripline to the back wall; overall it provides some 250 sq m of inhabitable space (for detailed information refer to Goebel et al. 2004, 2007; Goebel 2007; Graf 2007; Hockett 2007; Rhode et al. 2005).

The site was recorded in 1986 by Department of Interior Bureau of Land Management (BLM) employees after a period of illegal site excavation by looters. The site was later tested by P-III Associates in 1988 and the site was found to contain a sequence of deposits dating to at least 6,000 B.P. In the year 2000, site testing and excavation efforts resumed through a joint project with the BLM and the University of Nevada, Reno. This project under the direction of T. Goebel is still underway after eight years (2000-2008) and has recovered extensive amount of data about prehistoric ways of life in this part of the eastern Great Basin.

Occupations occurred repeatedly but intermittently from ca. 11,000 B.P. until historic times as evident in more than 3 m of generally-horizontal, well stratified and highly preserved cultural and sterile (natural) deposits. This sheltered environment has allowed excellent preservation of hearths and lithic materials, as well as perishable organic items including vegetal materials, wood, bone, textiles, charcoal, etc., and has provided essential materials for producing quality radiocarbon assays and the

Figure 9. Overview of Bonneville Estates rockshelter, looking southwest (summer 2006) (photo credit: D. Page).

establishment of excellent chronological control throughout the site. To date, some 50 radiocarbon dates have been obtained and show periods of site occupation spanning the late Pleistocene and entire Holocene.

The Paleoindian assemblage is diverse and contains not only abundant lithic materials but rich faunal and paleobotanical components (e.g., worked bone and antler, cordage, feathers, worked wood, fragmentary textiles, etc.). The Paleoindian-age lithic assemblage is mostly lithic debitage (~97 %) but does contain a number of Great Basin Stemmed point variants, bifaces, modified flake tools, scrapers, and the occasional graver and core. Tools are made of three major toolstone types (CCS, obsidian, and FGV) although counts and frequencies vary through the stratigraphic sequence. On average the pre-9,000 B.P. lithics (including debitage) are ca. 44 % CCS, ca. 32 % FGV, and ca. 23 % obsidian. Compare this pattern of toolstone use with the Early Archaic assemblage that is even more diverse and extensive (four times as many tools including Large Side-notched projectile points and more than twice the debitage) but is also mostly lithic debitage (ca. 96 %). On average the ca. 6,000-9,000 B.P. lithics (including debitage) are ca. 63 % CCS, ca. 19 % obsidian, and ca. 17 % FGV (Goebel 2007). Toolstone source profiles are also diverse but are varied through time, with many of the same sources represented in both aged assemblages but in differing frequencies.

2.222 Danger Cave

Also located at the western edge of the Bonneville basin, Danger Cave (42To0013) falls within Tooele County, Utah, just northeast of the town of Wendover, Utah. It is situated approximately 32 km northeast of Bonneville Estates Rockshelter, ca. 83 km northwest of the central ORB delta, and ca. 118 km northwest of Camels Back Cave. It is found on the southwestern toe of the Silver Island Range, just above the Gilbert shoreline of Lake Bonneville (see Figure 3). At the time of occupation it would have been neighboring a small spring-fed wetland at the edge of the nearby playa. It is a southeast-facing cavern, most likely created by carbonate dissolution, roof spalls, and perhaps wave-action through the many cycles of Lake Bonneville (Figure 10). The mouth of the cave is sheltered and provided some protection from the elements while the inner chamber measures about 20 m wide by 40 m long and is some 9 m tall (to the basal gravels); overall it provides some 600 m^2 of mostly inhabitable space (for detailed

Figure 10. Overview of Danger Cave, looking southwest with fieldtrip participants in foreground (spring 2005) (photo credit: D. Page).

information refer to Aikens 1970; Fry 1976; Goebel 2007; Grayson 1988; Jennings 1957; Rhode and Madsen 1998; Rhode et al. 2005, 2006).

The site has a long history of excavation and has contributed greatly to our understanding of the region's cultural history and paleoenvironments. Original test excavations began with E. Smith in the early 1940s, followed by four years of systematic and intensive excavations led by J. Jennings and the University of Utah from 1949 to 1953. This period of methodical excavation, analysis, and the resulting interpretation has played a key role in the last 50 years of Great Basin archaeology. In 1968, others including D. Madsen and G. Fry continued excavations deeper within the cave seeking information about subsistence and environmental change. In 1986, D. Madsen with the Utah State History Antiquities Section led a team of researchers investigating resource use and trying to refine the site chronology. From 2001 through 2004, efforts by D. Madsen and D. Rhode continued to refine the site chronology by reexposing previously established profiles and sampling of known features to obtain additional and better radiocarbon dates.

To date, some 50 radiocarbon dates have been obtained from the more than 3 m of undulating but generally horizontal, well stratified and well preserved cultural deposits and show periods of site occupation spanning the late Pleistocene and most of the Holocene. As indicated by the most recently obtained dates, initial site occupation occurred at ca. 10,300 B.P. and continued repeatedly but intermittently late into the Archaic period. The major strata are broken up into six distinct levels and are described here from earliest to latest: DI dates to ca. 10,300 – 10,100 B.P., DII dates to ca. 10,100 – 7,500 B.P., strata DIII through DIV dates to ca. 7,500 – 4,800 B.P., DV dates to ca. 2,800 – 900 B.P., and DVI dates to the period post-ca. 900 B.P. (Goebel et al. 2007; Jennings 1957; Madsen and Rhode 1990; Rhode et al. 2005; Rhode, personal communication 2008). The bulk of the radiocarbon dates are from the lower strata (DI and DII) and there are only four marginal dates directly obtained from upper strata (DIII-DV), although a number of later, coeval dates were obtained from coprolites derived from lower stratigraphic levels (apparently out of stratigraphic context) (Rhode et al. 2006).

As in Bonneville Estates, the cultural assemblage is extensive and the mostly dry environment of the cave has afforded excellent preservation of perishable organic items including vegetal materials, wood, bone, textiles, charcoal, etc. The Paleoindian assemblage of DI is diverse and contains not only lithic materials and hearth remnants but also faunal and paleobotanical components (e.g., worked bone, cordage, worked wood, etc.). Later periods of occupation within the upper stratum (DII) include at least three main pulses at 10,100-9,800 B.P., 8,600-8,400 B.P., and 8,200-7,500 B.P. (Rhode et al. 2005). These occupations, including those stratigraphically above DII (DIII-DVI), are richer and contain abundant lithic materials, as well as perishable materials. The Paleoindian/Early Archaic and Middle Archaic lithic assemblages contain the full sequence of Great Basin projectile points (including some GBS variants), bifaces, modified flake tools, scrapers, gravers, drills, and cores. As is typical, tools are made of three major toolstone types (obsidian, FGV, and CCS) although counts and frequencies also vary throughout the stratigraphic sequence.

2.223 Camels Back Cave

Located in the central Bonneville basin, Camels Back Cave (42To0392) falls within Tooele County, Utah. It is on the eastern edge of the Great Salt Lake Desert, ca. 38 km southeast of the central ORB delta, ca. 110 km southeast of Bonneville Estates Rockshelter, and ca. 118 km southeast of Danger Cave. It is found ca. 6 km east of the main ORB river channel and is situated at the north end of the southern-most hump of Camels Back Ridge at an elevation of ca. 1380 m (~30 km east of the Gilbert shoreline) (see Figure 3). The mouth of this small and narrow wave-cut shelter/shallow cave measures approximately 6 m wide by ~2 m high and is less than 6 m deep from the dripline to the back wall; overall it provides some 30 sq m of inhabitable space, although this varied through time with wall slope and habitation beyond the dripline (Figure 11) (for detailed information refer to Schmitt and Madsen 2001; 2005; Schmitt et al. 1994).

The site was initially recorded by C. Zier in 1984 and primary test excavations were conducted by State of Utah archeologists (Madsen and Schmitt) in 1993 who found some 3 m of cultural deposits. Additional excavation took place during the period of 1996-1998 under the direction of K. Callister (US Army DPG Cultural Resource Management Officer) and D. Madsen (Utah Geological Survey). These seasons of excavations produced extensive data not only about paleoenvironmental conditions with abundant faunal remains but evidence of repeated and intermittent cultural occupations

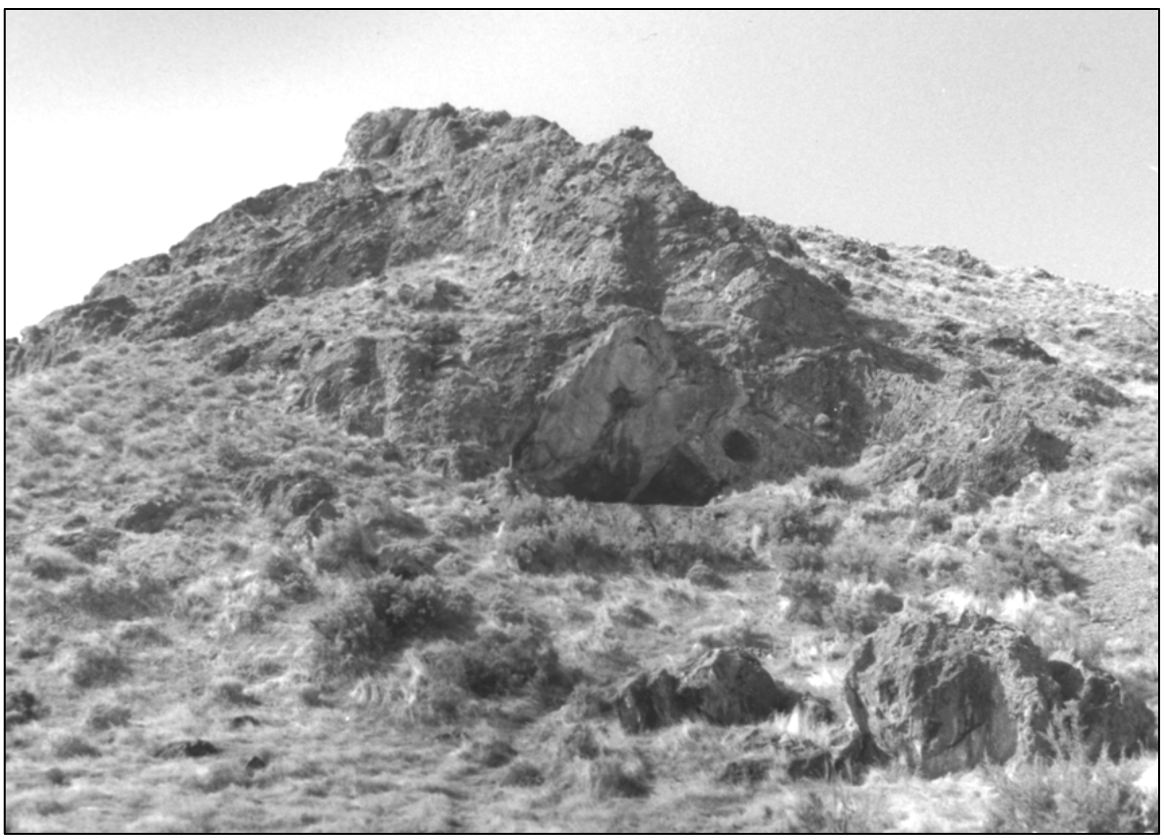

Figure 11. View of Camels Back Cave, looking south (from Schmitt and Madsen 2005).

spanning most of the Holocene from the Early Archaic through the Fremont period (Schmitt and Madsen 2005).

Initial occupations occurred by 7,530 B.P. and extend to the Shoshone and historic period, as evident by 30 radiocarbon dates and more than 90 hearths throughout some 18 cultural strata/levels. As the cave is small and the rock overhang is sloped, the deposits within the sheltered area were wetted repeatedly causing limited and poor preservation of vegetal materials, although bone and charcoal preservation was not as adversely affected. The cultural assemblage is extensive and includes abundant and diverse lithic materials, worked bone, ground stone, and in later strata, ceramics. Lithic materials included more than 9,000 pieces of debitage, 144 flake tools, 117 bifaces, and 193 projectile points and were composed of a variety of toolstone types including obsidian, CCS, FGV, and quartzite. The counts and frequencies of raw material use vary throughout the stratigraphic sequence with a sharp contrast between early and later use of certain lithic materials.

2.3 Summary

With the goal of gaining a better regional understanding of prehistoric FGV use, it is critical to understand the relationship between potential geologic sources of FGV rock and cultural use of selected toolstone sources. To get to this understanding in a reasonable length of time, thus minimizing frustrations and the many fruitless miles of dirt road reconnaissance, knowledge of the regional geology, geomorphology, hydrology, and archaeology becomes increasingly important. This chapter presented an overview of these contexts and included discussion of a suite of archaeology sites that will be further examined through geochemical analyses (see results in Chapter 4 and discussion in Chapter 5). In so doing, we move closer to identifying the host of unknown sources of FGV toolstone within archaeological sites of the Bonneville basin and perhaps other adjacent regions.

Chapter 3

Materials and Methods of Investigation

As addressed in Chapter 1, toolstone sourcing studies follow a basic stream of events that lead the researcher from the unknown to the known. To identify sources of FGV in this region a similar stream of events was followed including fieldwork and sampling of geologic materials, sampling of existing archaeological collections, geochemical analysis for trace elements and limited oxide analysis, data analysis, spatial analysis, and interpretation of results. The remainder of this chapter provides a description of materials and an overview of methods involved in this investigation.

3.1 Fieldwork and Geologic Sampling

The intent of geologic sampling was to identify the source locations of toolstone-quality FGV lithic material used by prehistoric peoples in tool-making activities. To get to this information it was critical to get a better understanding of the regional geology, geomorphology, hydrology, and archaeology. This being said, the investigation started in a somewhat backwards fashion – working "from the known to the unknown"; essentially using the locations of FGV artifacts in the study area to aid in identifying the locations of 'unknown' FGV geologic sources.

First, prior to starting any fieldwork, there was a period of research where records and reports were consulted for any mention of 'basalt' in the lithic assemblage with attention to increased basalt use within specific sites or across larger survey areas. Existing geologic maps and geologic reports (including investigation of digital data via GIS) were also scoured for any reference to ‘basalt’ or other tertiary volcanic rocks that may be lithic sources.

Initial sampling began with a preliminary shotgun sampling of a diverse range of artifacts from across the study area (at this stage all samples were from DPG collections) to try and identify areas of increased source use or areas of increased source density and thus perhaps closer distance to a given primary geologic source. This first sourcing group included a wide variety of temporally diagnostic projectile points as well as bifaces, scrapers, cores, and flake tools from Paleoindian and Archaic sites.

Primary geologic sampling was limited and was done concurrent with ongoing contract field projects. During these few chance encounters on pedestrian survey when cobbles or pebbles appeared to be toolstone quality, dark colored, fine-grained volcanic rocks, their locations were recorded and they were sent off to a laboratory for XRF assay. The second phase of geologic source investigation began after initial sourcing results on the broad sampling of artifacts came back with a specific number of identifiable ‘unknown’ types and the few geologic samples submitted did little to address the problem. This took the study from a point of abstract intentions and allowed for the formation of tangible goals of discovery (e.g., identify the sources of Unknown 1, Unknown A, and Unknown B). This escalation of ‘unknowns’ warranted several cross-state road trips to specific locations on the landscape that showed promise based on information gleaned from the first phases of sourcing, geologic maps, and initial spatial analysis.

The sampling procedure was to some extent standardized for geologic materials and all attempts were made to follow this set procedure. To establish a geologic dataset that could be compared to cultural data in a meaningful way, multiple samples were collected from any locations where potential source materials were encountered. When multiple cobbles from the same source area were tested it broadened the chance of sampling one of the 'unknown' sources from a single location on the landscape and it tested not only source homogeneity but it aided in the establishment of geochemically similar but distinct sources variants within a single source area.

Samples were typically limited to two or three rock hammer-struck flakes from cobbles or bedrock where encountered (one flake for XRF sourcing [later given to the laboratory for their source type collection], one for my source type collection and subsequent 'data storage and backup', and occasionally a spare or two). Ideal sample 'flakes' were ca. 5 cm diameter and had a fairly smooth, flat face for geochemical analysis. Although in many instances where transport allowed (driving to the study area and the sampling location was fairly close to a road) larger samples, including cobbles and some boulders, were collected. Samples were bagged in appropriately sized zippered polyethylene bags and a paper label including the following information: sample identification number, date, collector name, context, and GPS coordinates (recorded in UTM NAD27 Zone 11 or 12, where appropriate).

Upon arriving back at the lab, samples were split and sample locations were added to a GIS database and active map document. Potentially viable samples were submitted to the Northwest Research Obsidian Studies Laboratory (NWROSL) under the direction of C. Skinner in Corvallis, OR, for XRF trace element analysis. Once trace element analysis results were back from the laboratory, sample locations were compared against known sites rich in FGV and other data layers including topography, elevation, hydrology, and geology; this was done to track down primary sources and extent of distribution of secondary sources. These processes continued over the period of two field seasons when the majority of regional sources had been adequately characterized.

3.2 Sampling of Previous Archaeological Collections

The Bonneville basin has been host to decades of archaeological inventories and excavations. As a result, there are literally hundreds of recorded sites and many thousands of collected artifacts housed in museums and curation facilities in Utah and Nevada (and across the US). To date only a small fraction of a percent of these materials have been investigated geochemically and, with the exception of obsidian, the majority of the lithic sources from which these thousands of flaked stone tools originate remain unknown and essentially uninvestigated. Archaeological materials from 86 open Paleoindian sites and 32 Paleoindian-age isolated finds in the ORB delta, 25 Archaic sites and 4 Archaic-age isolated finds from across DPG, and materials from Danger Cave, Bonneville Estates Rockshelter and Camels Back Cave were sampled for chemical analysis. In total, 587 FGV artifacts from existing archaeological collections are included in this study.

ORB Delta Sites

Materials originating from both DPG lands and UTTR lands are included in this sample. Fifty-one Paleoindian sites (and 13 isolates) from the proximal ORB delta were sampled from DPG-housed collections with the approval of the DPG Cultural Resource Management Officer (CRMO). The bulk of these materials was collected during investigations made by Schmitt et al. (2003) and includes samples of site assemblages from various deltaic channel settings (mix of raised gravel channel sites and sand/intermediate channel sites). A total of 297 Paleoindian-age flaked stone artifacts were selected for non-destructive geochemical trace element analysis using an energy dispersive X-ray fluorescence (XRF) spectrometer (Figure 12). Sample selection was based on the basic criteria of visual distinction of rock type and artifact class. Only flaked stone tools made on fine-grained, dark colored, non-glassy volcanic artifacts were sampled for analysis. Tool selection within sites was based on obtaining a wide view of toolstone use across tool classes, and as such samples included not only temporally diagnostic projectile points (stemmed point variants and Pinto points) (Figure 13), but also bifaces in various stages of refinement, unifaces/scrapers, gravers, cores, and flake tools.

Also included in this study are previously sampled/sourced materials from 35 Paleoindian-age sites and 19 isolated finds from the distal portion of the ORB delta on Hill Air Force UTTR administered lands, north of DPG. The sourcing results for 131 artifacts were provided by D. Duke (personal communication 2007), while sourcing results for 22 artifacts from the UTTR as presented by Arkush and Pitblado (2000) are also included in this study (Appendix B).

In addition to the Paleoindian materials referred to above, an initial sampling of 25 Archaic sites from across DPG, including 39 artifacts (mix of diagnostic projectile

Figure 12. Example of FGV tools sampled from ORB delta Paleoindian sites (select artifacts from site 42To1872 are shown) (photo credit: D. Page).

Figure 13. Example of FGV diagnostic projectile points (stemmed point variants and Pinto point) from ORB delta Paleoindian sites (photo credit: D. Page).

points, bifaces, scrapers, cores, flake tools, and a drill), provided preliminary sourcing information and will allow coarse-grained comparison of source use through time.

Bonneville Estates Rockshelter

With consent from T. Goebel, 22 flaked stone artifacts were selected for non-destructive geochemical trace element analysis using XRF (Figure 14). Sample selection took place in the spring of 2006 and was limited by the amount of FGV materials in the assemblage at the time of sampling. Since the sampling was done, more FGV materials have been recovered from the lower strata. Actual sample selection was based on several criteria including visual distinction of rock type, stratigraphic provenience within the

Figure 14. Example of FGV tools sampled from Bonneville Estates Rockshelter (photo credit: T. Goebel).

shelter's cultural deposits, and artifact class. Only flaked stone tools made on fine-grained, dark colored, non-glassy volcanic toolstone were sampled. Due to research focus and budgetary constraints, no debitage was sampled at this time for XRF analysis. Six tools (mix of stemmed projectile points, a biface, a scraper, and a flake tool) were selected for sourcing from the lowest Paleoindian-age strata (stratum 17b, 17b', 18a, and 10 [from the east block]) and 16 tools (mix of projectile points, bifaces, scrapers, and flake tools) were selected from the middle strata dating to the Early and Middle Archaic (stratum 14a, 14b/c) (Graf 2007). All artifacts sampled were from Goebel's excavations from the years 2000-2006 and included materials originating throughout the middle to lower portion of the strata with the bulk of the materials originating from the mid-depth portion of the shelter.

Danger Cave

Upon approval of an outgoing museum loan from the Utah Museum of Natural History in Salt lake City, Utah, 47 flaked stone artifacts were selected for non-destructive geochemical trace element analysis using an energy dispersive XRF spectrometer (Figure 15). Sample selection was based on several criteria including visual distinction of rock type, stratigraphic provenience within the cave's cultural deposits, and artifact class. Only flaked stone tools made on fine-grained, dark colored, non-glassy volcanic toolstone were sampled from the lowest strata (I-IV). No FGV artifacts were recovered from the lowest stratum within the cave (DI) and therefore none were sampled. All samples were from Jennings' excavations of the late 1940s- early 1950s and included the majority of artifacts within class W78. According to Jennings, this class was separated from the lot as it was:

> "…completely inconsistent with other groups. The segregation was based entirely on the material – basalt. These are the fragmentary blades, points and scrapers which, if whole, would perhaps have fallen into other types. The material was segregated on the basis of stone used when it was noted that most of the specimens occurred in the earlier layers of the site" (Jennings 1957: 160).

Thirty-four artifacts (mix of projectile points, bifaces, and flake tools) were selected for analysis from the level DII, Paleoindian- age strata (ca. 10,100-7,500 B.P.). Debitage was not sampled and due to research focus and budget constraints, sampling of artifacts from more recent strata (III and IV) was biased toward selection of temporally diagnostic projectile points. From these later layers only 13 artifacts (all projectile points) were selected from the Early-Middle Archaic-age strata DIII/DIV (ca. 7,500-4,800 B.P.) (Jennings 1957; Madsen and Rhode 1990).

Camels Back Cave

With approval from the DPG CRMO, 30 flaked stone artifacts were selected for non-destructive geochemical trace element analysis using an energy dispersive XRF spectrometer (Figure 16). Sample selection was inclusive and included all flaked stone tools in the collection that were classified as 'basalt' in the artifact catalog and were made on fine-grained, dark colored, non-glassy volcanic lithic materials. All samples were

Figure 15. Example of FGV tools sampled from Danger Cave (photo credit: D. Page).

Figure 16. Example of FGV tools sampled from Camels Back Cave (photo credit: D. Page).

from the D. Madsen and D. Schmitt excavations of the late 1990s and included materials from throughout the strata with the bulk of the materials originating from the lower portion of the cave.

Thirty artifacts (mix of projectile points, bifaces, scrapers, and flake tools) were selected for analysis, although one returned a 'not basalt' result and is not included in this study. Due to research focus and budgetary constraints no debitage was sampled for XRF analysis. Twenty-four flaked stone artifacts were selected from the levels III-IX which are composed of Early-to-Middle Archaic age strata (ca. 7,500-5,600 B.P.), while the FGV assemblage from the upper layers (strata XI-XVIII [ca. 5,500-500 B.P.]) included only five tools from the last ~6,200 calendar years of occupation.

3.3 XRF and Trace Element Analysis

All artifacts and geologic samples were sent out to a well established and independent laboratory for trace element analysis via energy dispersive X-ray fluorescence spectrometer (ED-XRF) (Appendix A). As referenced on their laboratory website, FGV may be more geochemically variable than obsidian, but basalt, andesite, rhyolite, and other similar volcanic rocks can be characterized successfully via XRF analysis if samples are dense, fine-grained, and free of phenocrysts or inclusions. The lab cautions that FGV is more common and more geographically widespread than obsidian and in most geographic areas it may not be possible to assign specific geologic sources to artifacts (Northwest Research Obsidian Laboratories 2007). Source assignments were based on a comparison of trace element ratios across samples using both tabular data and simple bivariate plots (XY scatter plots) in Microsoft Excel showing the ratios of diagnostic trace element values, including the ratio of strontium to zirconium (Sr/Zr) and rubidium to zirconium (Rb/Zr).

In addition to trace element assays, a subset of the geologic samples was selected (once source groups were identified) to undergo whole rock XRF analysis at a separate laboratory, ALS Chemex. This was done to identify the rock type and determine if sources contained materials of the same type and if specific sources were targeted because of their physical properties (e.g., the amount of silica within the material). The process varies from the previous method of trace element analysis in that it quantifies the amounts of major and minor elements in a sample. This technique is a standard method for differentiating between various extrusive igneous rock types and can also be used in differentiating between geologic source groups. Although possible, it is not a good method of artifact sourcing, as it is destructive requiring the sample to be ground into a powder and fused into a glass disc prior to testing. Note, only nondestructive testing was conducted on cultural samples used in this study, but this major element analysis was performed on a selection of geologic source samples enabling distinction of volcanic rock types present in the sample. Identified geologic sources were plotted on a Total Alkali Silica (TAS) diagram, which plots the weight percent of silica against sodium and potassium oxides to determine the specific volcanic rock type of the sample (e.g., andesite, trachyandesite, dacite, trachydacite, etc.; e.g., see Figure 17).

3.4 GIS and Spatial Analysis

Geographic Information System (GIS) software was used for data storage and retrieval, visualization, and spatial analysis. GIS was also used in initial research to analyze digital geologic datasets and maps and identify areas of increased data potential including those areas containing Tertiary volcanic rocks. It also proved useful in extrapolating material transport and distribution in reference to the primary source locality (see Figure 18).

Spatial analysis at this stage was minimal but generally consisted of basic mapping and visualization, distance calculations, and investigation of patterns of material

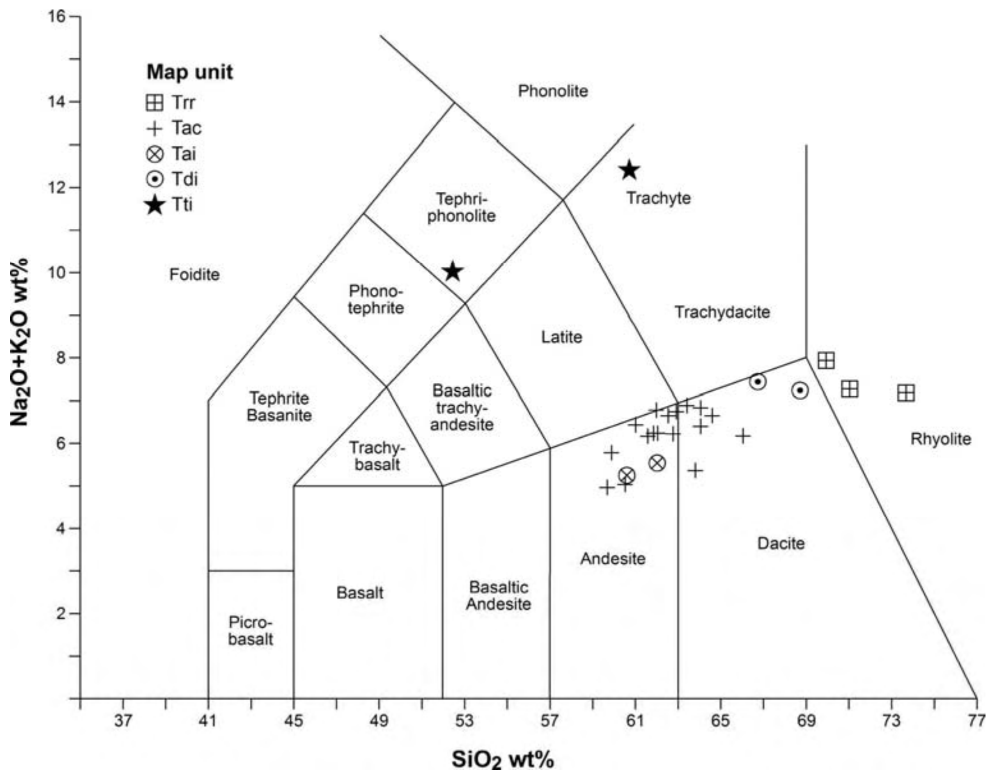

Figure 17. Sample TAS diagram (from Clark et al. 2007).

distribution within the region. Sample locations were plotted as points on the landscape and source locations as either points or polygons when their geographical extent could be determined. Sample and source locations were overlaid onto various data layers including, but not limited to, topographic maps, aerial photographs, pluvial lake shorelines, drainages, watersheds, elevation, slope, known archaeological sites, etc. This was followed by simple calculations of distance and direction to represented sources within sites, as well as between sites and a general analysis of source material distribution across the study area.

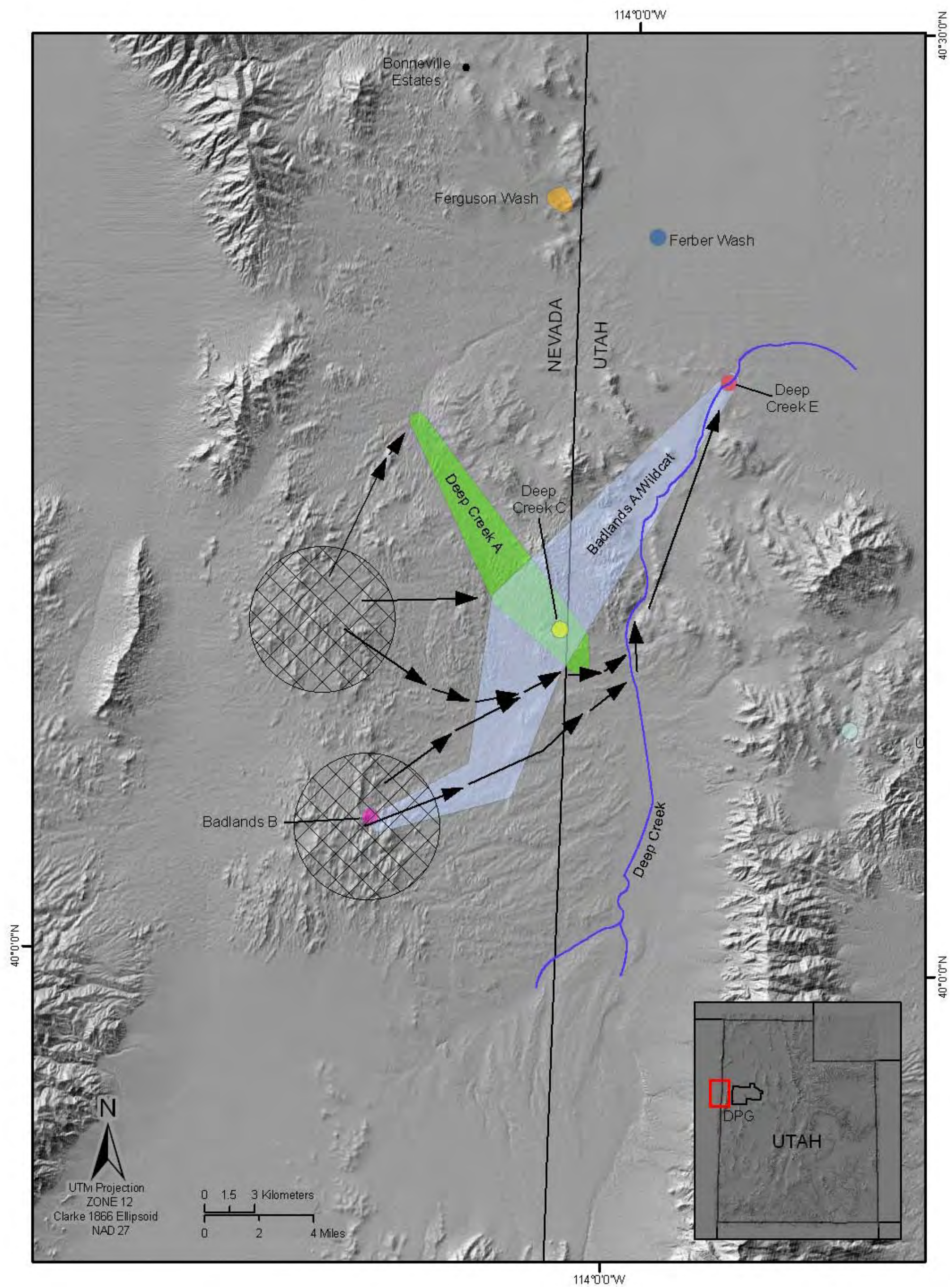

Figure 18. Example GIS map showing spatial analysis of source distribution with extrapolation of probable primary source locations (cross-hatched circles) and paths of secondary distribution (arrows) based on topography, geology, and hydrology (base image source: USGS National Elevation Dataset).

3.5 Summary

This chapter presented an overview of the materials and methods employed in this toolstone sourcing study. Employing these methods, we move one step closer to identifying the host of unknown sources of FGV toolstone within the Bonneville basin. Briefly addressed here were the methods used in fieldwork efforts and sampling procedures used for both geologic materials and archaeological specimens. Also discussed were the techniques used in geochemical analysis via XRF spectroscopy and the role GIS played in the study. These methods and procedures were discussed to introduce the materials prior to the presentation and discussion of sourcing results and as an aid in future sourcing studies. Following the basic stream of events for a sourcing study, as discussed in previous chapters, and employing sound methods, one should be able to successfully conduct a toolstone sourcing project and provide the ability for replicable results by future researchers. Results of geologic and archaeological sourcing efforts are presented in Chapter 4.

Chapter 4

Sourcing Results

One of the principal goals of this study is to identify the sources of FGV toolstone used by prehistoric peoples in the Bonneville basin; another is to investigate how these sources were used by prehistoric peoples living in the region. This chapter provides an overview of newly identified/characterized geologic sources and a discussion of geochemical variants identified within those source groups. Also presented are geochemical sourcing data for 587 FGV artifacts from 85 open Paleoindian sites and 33 Paleoindian-age isolated finds in the ORB delta, 25 Archaic sites and 4 Archaic-age isolated finds from the central basin, as well as Paleoindian and Archaic materials from well dated contexts within Danger Cave (DC), Bonneville Estates Rockshelter (BER), and Camels Back Cave (CBC).

4.1 Geologic Sources of FGV Toolstone

Fieldwork and geologic sampling around the Bonneville basin resulted in the collection and geochemical analysis of more than 100 geologic samples of mostly toolstone quality FGV rocks. Some of these samples were of lesser quality and thus not likely to show up in the archaeological record but were sampled anyway to expand the regional geochemical database and possibly rule out unknowns in the cultural sample (see section 4.2 for discussion of these other sources). Once sampled, geologic materials were submitted for XRF trace elements analysis (Appendix B) and after analyses of these data, geologic source groups were established (Figure 19). Samples from the most culturally important geologic sources were then submitted to whole-rock XRF analysis of major elements to determine igneous rock type (Appendix C; Figure 20).

In the section below, identified sources of FGV toolstone (andesite, trachyandesite, dacite, and trachydacite based on chemical composition) are discussed separately by geographic locations providing detailed investigation of both eastern and western basin source areas. Scatter plots delineating samples by trace element ratios, photos of source areas, digital scans of select hand samples, and summary statistics for trace element composition of the geologic samples are provided for each newly identified and characterized geologic source (Appendix D). The source determinations presented here are preliminary (based on XY scatter plots of a few trace-element ratios) and are not statistically based. Additional statistical verification may be needed to solidify source assignments. Information is also presented about the physical characteristics of the material, such as package size, and other diagnostic qualities, and there is discussion of geologic context, setting, areal extent, and secondary source distribution.

4.11 Eastern Bonneville Basin Sources

Two main source groups were identified on the eastern edge of the study area and include two geographically distinct sources composed of a variety of geochemical variants. The eastern sources of Cedar Mountain FGV and Flat Hills FGV materials are located in the southern edge of the Cedar Mountain Range and on the northern and eastern flanks of the Flat Hills, respectively (See Figure 19). Two other sources of non-

Figure 19. Location of geologic sources identified (secondary extent of some Deep Creek, Badlands, and Cedar Mountain variants shown as dashed lines) (base image source: ESRI MODIS from www.geographynetwork.com).

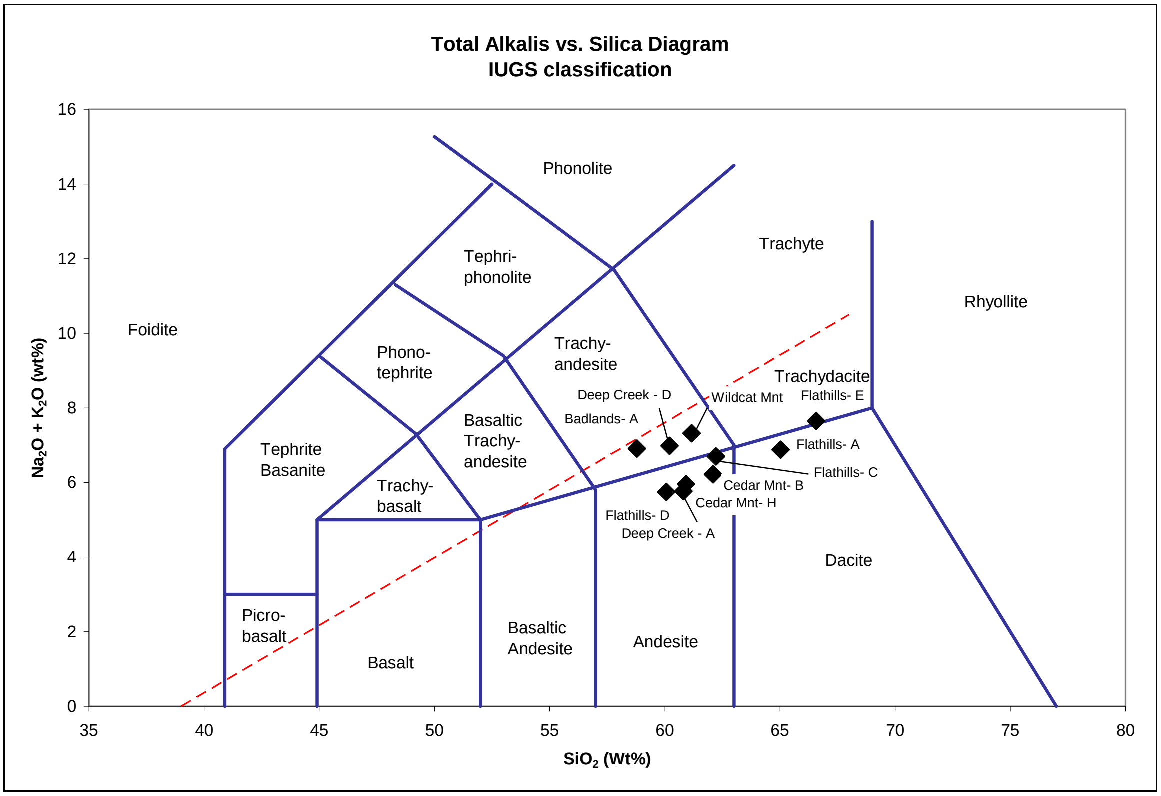

Figure 20. Total Alkali Silica (TAS) diagram showing select geologic sources with weight percent of silica plotted against sodium and potassium oxides to determine igneous rock type (red line shows alkaline - subalkaline dividing line) (after Le Bas et al. 1986).

toolstone quality material were also investigated in this eastern area and include a source of trachyandesite found on the western toe of Wildcat Mountain and a source of andesite found in Rydalch Canyon of the Cedar Mountain Range (see Figure 19 and discussion below).

Fifteen sources and source variants were identified and geochemically characterized in the eastern area. These sources/variants were established using scatter plots of strontium (Sr) and zirconium (Zr) compared visually against scatter plots of rubidium (Rb) and Zr (Figure 21). Wildcat Mountain FGV was previously identified by

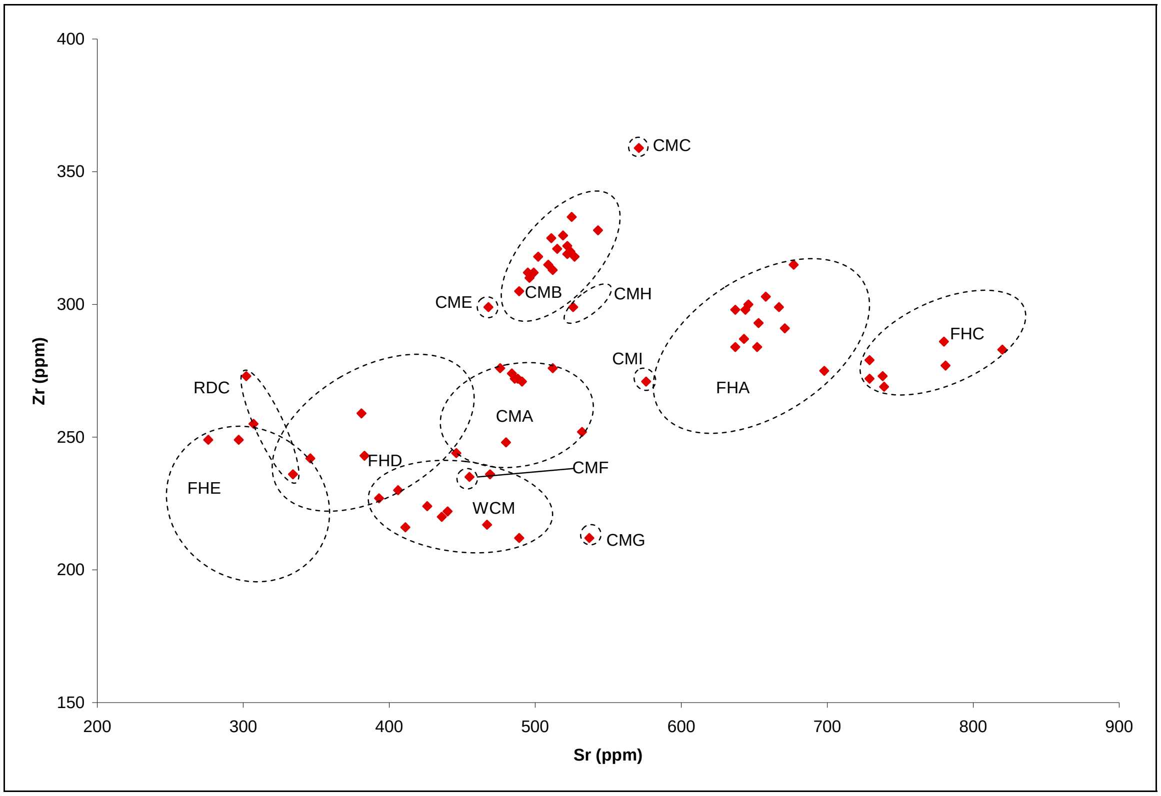

Figure 21. Scatter plot of strontium (Sr) plotted against zirconium (Zr) for eastern geologic samples (red dots); note CMD not shown as values fall outside plotted area.

D. Duke in 2003 (Carter et al. 2004) but was misidentified as a major contributor to local archaeological assemblages due to an overlap in geochemical signatures.

4.111 Flat Hills Variants

The Flat Hills source is a newly identified/characterized source with several geochemical variants (designated A, C, D, and E) composed of a number of different igneous rock types, including andesite, dacite, and trachydacite. Cobbles of high quality FGV were first identified at the southern end of the Cedar Mountain Range on the gentle alluvial plain between the southern toe of the Cedars and the Flat Hills (near the east gate of DPG) (Figure 22). At first, the materials were thought to originate from the low-lying, wave-eroded hills south of the DPG boundary fence that give the source its name. This was later refuted when the hills were established to be of sedimentary and not igneous composition and found to contain only carbonate rocks.

Figure 22. View of the Flat Hills source area looking northeast from atop the Flat Hills (photo credit: D. Page).

Cobbles of varying size and shape are scattered diffusely across the surface of the alluvial plain between the Cedar Mountains and the Flat Hills (within an area about 5 km in diameter) and either occur as float or were entrained within the lacustrine gravels making up the tombolo (area where the Provo waters would have shallowed between the islands of the Cedar Mountains and the Flat Hills). The latter is likely true but buried deposits cannot be ruled out at this time. To date no primary source has been located and it is likely that the primary source no longer exists. Cobbles are rounded to sub-rounded and have generally smooth, lighter colored, and at times, calcified cortex (Figure 23). They are found as round or tabular shaped cobbles and can currently be found in the

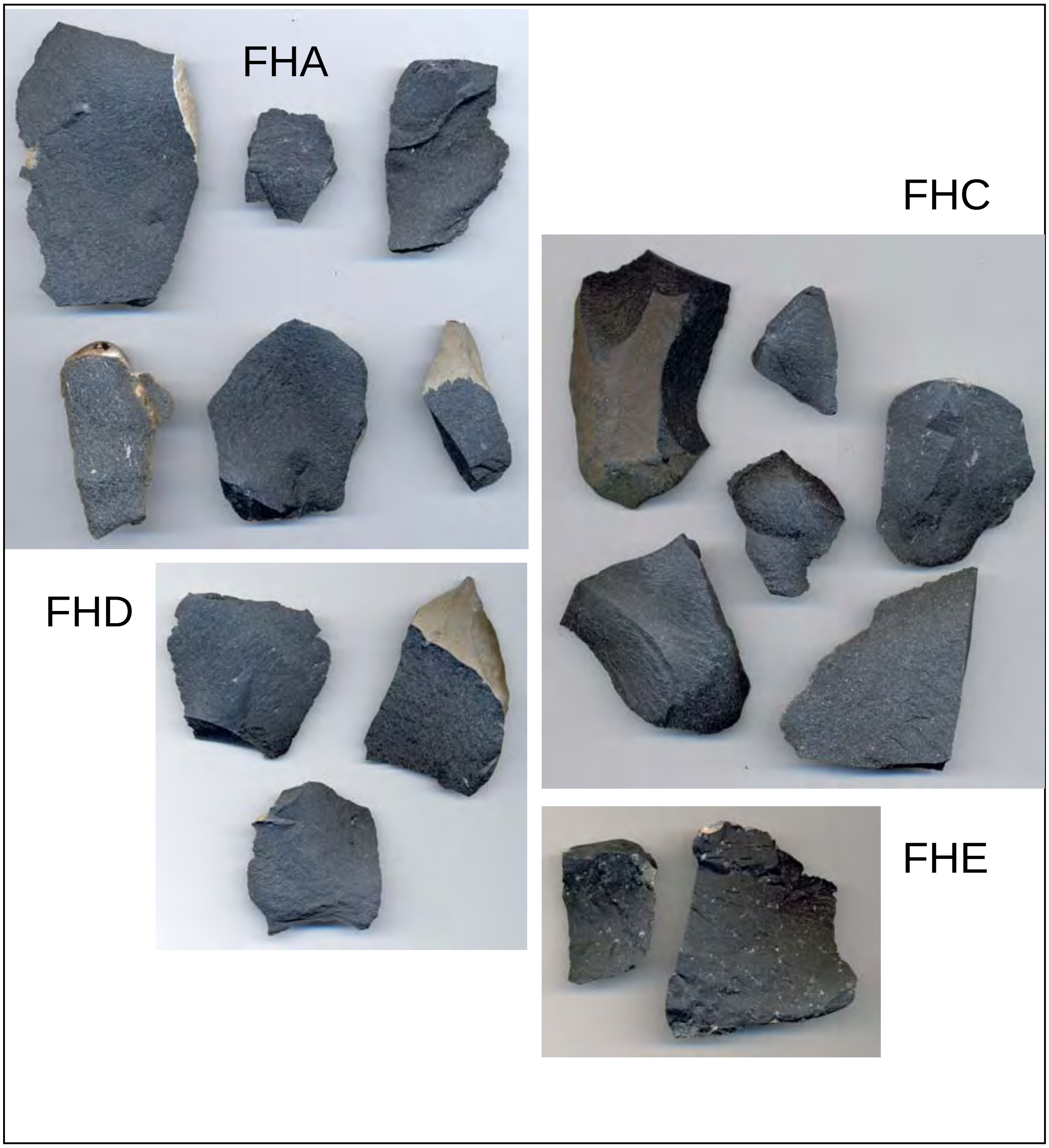

Figure 23. Select geologic samples showing macroscopic variation within Flat Hills variants (shown at half scale) (photo credit: D. Page).

range of 10-30 cm in diameter. These materials are of high quality with few inclusions and phenocrysts and available in package sizes that are sufficient to produce bifaces and flake blanks of adequate size. The attractiveness of these materials to the early inhabitants of the region is evident by the more than 60 primary reduction sites that have been recorded in this area.

Four variants within the larger source group are based on trace element ratios of the 24 geologic samples analyzed (See Figure 21; Table 3). Flat Hills A (FHA) is a cobble source of dacite in secondary context. It produced Sr values between 637 and 698 ppm, Rb values between 73 and 111 ppm, and Zr value between 275 and 315 ppm. Flat Hills C (FHC) is a cobble source of andesite in secondary context. It produced Sr values between 729 and 820 ppm, Rb values between 91 and 122 ppm, and Zr value between 269 and 286 ppm. Flat Hills D (FHD) is a cobble source of andesite in secondary context. It produced Sr values between 346 and 383 ppm, Rb values between 96 and 108 ppm, and Zr value between 242 and 259 ppm. Flat Hills E (FHE) is a cobble source of trachydacite in secondary context. It produced Sr values between 276 and 297 ppm, Rb values between 216 and 218 ppm, and Zr values of 249 ppm.

Table 3. Summary statistics for trace element composition of geologic samples from the Flat Hills geochemical group (n = 24).

Flat Hills A (n=12)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
Maximum	108	40	111	698	22	315	18	5834	597	1965	5	103	29
Minimum	79	22	73	637	15	275	13	3234	265	1374	3	59	26
Range	29	18	38	61	7	40	5	2600	332	591	2	44	3
Mean	91	29	99	657	18	294	15	4399	394	1548	4	79	27
Median	88	27	101	653	18	296	15	4376	359	1528	4	79	28
SD	9	5	9	18	2	11	2	650	105	150	1	16	1
CV%	10	18	9	3	13	4	10	15	27	10	14	21	3

Flat Hills C (n=7)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	$Fe^{2}O^{3T}$	Fe:Mn	Fe:Ti
Maximum	112	29	122	820	21	286	16	4802	613	1648	4	96	30
Minimum	74	18	91	729	16	269	12	3851	327	1461	3	51	27
Range	38	11	31	91	5	17	4	951	286	187	1	45	2
Mean	89	24	100	759	18	277	14	4338	388	1542	4	81	28
Median	88	23	99	739	18	277	15	4349	359	1536	4	85	28
SD	14	4	11	35	2	6	1	311	101	65	0	14	1
CV%	16	18	11	5	11	2	10	7	26	4	6	17	3

Flat Hills D (n=3)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	$Fe^{2}O^{3T}$	Fe:Mn	Fe:Ti
Maximum	103	30	108	383	37	259	23	4332	913	879	5	63	42
Minimum	61	23	96	346	35	242	21	3585	583	777	4	40	41
Range	42	7	12	37	2	17	2	747	330	102	1	23	1
Mean	83	26	102	370	36	248	22	3857	767	828	5	53	41
Median	85	24	102	381	37	243	23	3653	805	829	4	55	42
SD	21	4	6	21	1	10	1	413	168	51	1	12	1
CV%	25	15	6	6	3	4	5	11	22	6	12	22	1

Flat Hills E (n=2)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	$Fe^{2}O^{3T}$	Fe:Mn	Fe:Ti
Maximum	59	33	218	297	31	249	24	2696	638	1107	3	52	43
Minimum	47	28	216	276	31	249	22	1549	316	976	2	43	41
Range	12	5	2	21	0	0	2	1147	322	131	1	10	2
Mean	53	31	217	287	31	249	23	2123	477	1042	3	48	42
Median	53	31	217	287	31	249	23	2123	477	1042	3	48	42
SD	8	4	1	15	0	0	1	811	228	93	1	7	1
CV%	16	12	1	5	0	0	6	38	48	9	36	14	3

4.112 Cedar Mountains Variants

The Cedar Mountain source is a newly identified/characterized source with numerous geochemical variants (designated A- I) composed of andesite and other, unknown igneous rock types. Initial investigations by D. Duke in 2003 identified cobbles of poor quality FGV in a gravel pit along the edge of the Cedar Mountains (established as geochemical variants CMA and CMD). Recent investigations identified additional FGV cobbles of varying degrees of quality in a major drainage system along the southwestern flanks of the Tertiary volcanic-rich Cedar Mountain Range (Figure 24). After several attempts to find primary outcrops of toolstone quality material around this specific drainage and throughout the Cedar Mountain Range, little more is known about the primary sources of many of these source materials. Several bedrock outcrops were located and sampled and have been identified as the primary source locations for several of the minor variants including CMA, CMF, CMG, CMH, and CMI. Additionally, cobbles identified as CMB were found in Provo beach gravels ca. 8 km southeast along the edge of the Cedars and likely were conveyed via ice rafting or longshore transport (Oviatt and Madsen, personal communication 2006).

Cobbles of varying size and shape are scattered diffusely across alluvial fan slopes and within drainages in this portion of the Cedar Mountains (within an area of about 5 km in diameter as well as 8-10 km southeast along the mountain front). Where material in cobble form was found, it occurred as float or was entrained within the drainage alluvium. When bedrock was encountered materials were available as thickly bedded, blocky packages of mostly poor-grade (non-toolstone quality) material.

Cobbles are rounded to sub-rounded and have generally smooth, lighter colored cortex (e.g., see Figure 25). They are found as round or oblong shaped cobbles and can currently be found in fist to basketball-sized pieces. These materials are of varying quality, ranging from high to low, and generally degrade with increased inclusions and phenocrysts. Many of the toolstone quality materials are available in package sizes that are sufficient to produce bifaces and flake blanks of adequate size. The attractiveness of some of these materials to the early inhabitants of the region is evident by a number of upland primary reduction sites that have yet to be formally recorded or analyzed.

Nine variants within the larger source group are based on trace element ratios of the 32 geologic samples analyzed (See Figure 21; Table 4). <u>Cedar Mountain A</u> (CMA) is

Figure 24. View of the Cedar Mountains source area looking north (photo credit: D. Page).

a cobble/bedrock source of unknown FGV rock (not submitted for whole rock XRF analysis) found in primary and secondary context. It produced Sr values between 446 and 532 ppm, Rb values between 143 and 160 ppm, and Zr value between 244 and 276 ppm. Cedar Mountain B (CMB) is a cobble source of andesite in secondary context. It produced Sr values between 489 and 543 ppm, Rb values between 126 and 143 ppm, and Zr value between 305 and 333 ppm. Cedar Mountain C (CMC) is a cobble source of

Figure 25. Select geologic samples showing macroscopic variation within Cedar Mountain B source variant (shown at half scale) (photo credit: D. Page).

unknown FGV rock (not submitted for whole rock XRF analysis) found in secondary context. It produced a Sr value of 571 ppm, Rb value of 160 ppm, and a Zr value of 359ppm. Cedar Mountain D (CMJ) is a cobble source of unknown FGV rock (not submitted for whole rock XRF analysis) found in secondary context. It produced a Sr value of 48 ppm, Rb value of 6 ppm, and a Zr value of 45 ppm; all well below the other values within the Cedar Mountain source group. Cedar Mountain E (CME) is a cobble source of unknown FGV rock (not submitted for whole rock XRF analysis) found in secondary context. It produced a Sr value of 468 ppm, Rb value of 112 ppm, and a Zr value of 299 ppm. Cedar Mountain F (CMF) is a bedrock source of unknown FGV rock (not submitted for whole rock XRF analysis) found in primary context. It produced a Sr value of 455 ppm, Rb value of 233 ppm, and a Zr value of 235 ppm. Cedar Mountain G (CMG) is a bedrock source of unknown FGV rock (not submitted for whole rock XRF analysis) found in primary context. It produced a Sr value of 537 ppm, Rb value of 152 ppm, and a Zr value of 212 ppm. Cedar Mountain H (CMH) is a bedrock source of andesite found in primary context. It produced a Sr value of 526 ppm, Rb value of 169 ppm, and a Zr value of 299 ppm. Cedar Mountain I (CMI) is a bedrock source of unknown FGV rock (not submitted for whole rock XRF analysis) found in primary context. It produced a Sr value of 576 ppm, Rb value of 163 ppm, and a Zr value of 271 ppm.

Table 4. Summary statistics for trace element composition of geologic samples from the Cedar Mountain geochemical group (n = 32).

Cedar Mountain A (n=9)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
Maximum	79	53	160	532	33	276	21	3971	648	1631	4	77	37
Minimum	50	22	143	446	25	244	15	2687	382	1345	3	41	29
Range	29	31	17	86	8	32	6	1284	266	286	1	37	7
Mean	60	31	151	488	29	265	19	3249	494	1488	3	54	32
Median	56	28	150	486	28	272	19	3217	491	1486	3	50	32
SD	11	9	5	24	3	13	2	382	100	91	0	13	2
CV%	18	29	3	5	9	5	9	12	20	6	13	24	7

Cedar Mountain B (n=16)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
Maximum	117	85	143	543	41	333	22	5070	3016	1456	4	66	32
Minimum	63	22	126	489	34	305	13	3636	433	1222	3	12	28
Range	54	63	17	54	7	28	9	1434	2583	234	1	54	3
Mean	82	31	131	513	36	319	19	4199	730	1377	4	52	30
Median	81	27	131	514	37	319	20	4175	573	1376	4	57	30
SD	13	15	4	14	2	7	2	382	619	53	0	14	1
CV%	16	48	3	3	6	2	12	9	85	4	8	27	3

Cedar Mountain C (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
Maximum	105	22	160	571	41	359	21	4543	636	1470	4	51	29
Minimum	105	22	160	571	41	359	21	4543	636	1470	4	51	29
Range	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	105	22	160	571	41	359	21	4543	636	1470	4	51	29
Median	105	22	160	571	41	359	21	4543	636	1470	4	51	29
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Cedar Mountain D (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
Maximum	0	7	6	48	8	45	1	656	62	249	0	66	23
Minimum	0	7	6	48	8	45	1	656	62	249	0	66	23
Range	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	ND	7	6	48	8	45	1	656	62	249	0	66	23
Median	ND	7	6	48	8	45	1	656	62	249	0	66	23
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Cedar Mountain E (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
Maximum	73	35	112	468	36	299	17	4177	486	1406	4	63	30
Minimum	73	35	112	468	36	299	17	4177	486	1406	4	63	30
Range	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	73	35	112	468	36	299	17	4177	486	1406	4	63	30
Median	73	35	112	468	36	299	17	4177	486	1406	4	63	30
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Cedar Mountain F (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
Maximum	60	29	233	455	27	235	14	3539	500	1457	3	56	32
Minimum	60	29	233	455	27	235	14	3539	500	1457	3	56	32
Range	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	60	29	233	455	27	235	14	3539	500	1457	3	56	32
Median	60	29	233	455	27	235	14	3539	500	1457	3	56	32
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Cedar Mountain G (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
Maximum	78	31	152	537	28	212	16	2958	568	1373	3	38	30
Minimum	78	31	152	537	28	212	16	2958	568	1373	3	38	30
Range	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	78	31	152	537	28	212	16	2958	568	1373	3	38	30
Median	78	31	152	537	28	212	16	2958	568	1373	3	38	30
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Cedar Mountain H (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
Maximum	76	25	169	526	35	299	19	3844	458	1480	3	57	28
Minimum	76	25	169	526	35	299	19	3844	458	1480	3	57	28
Range	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	76	25	169	526	35	299	19	3844	458	1480	3	57	28
Median	76	25	169	526	35	299	19	3844	458	1480	3	57	28
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Cedar Mountain I (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
Maximum	77	32	163	576	32	271	16	3523	503	1440	3	55	32
Minimum	77	32	163	576	32	271	16	3523	503	1440	3	55	32
Range	0	0	0	0	0	0	0	0	0	0	0	0	0

CMI; continued.

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
Mean	77	32	163	576	32	271	16	3523	503	1440	3	55	32
Median	77	32	163	576	32	271	16	3523	503	1440	3	55	32
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

4.12 Western Bonneville Basin Sources

Two main source groups were identified on the western edge of the study area and include two geographically overlapping but geochemically distinct sources containing a number of geochemical variants. The western sources of Deep Creek FGV and Badlands FGV materials are located in the Little Antelope Hills, across the heavily dissected piedmont surface between the Antelope Range and the Deep Creek Range, and entrained with the fluvial gravels/cobbles of Deep Creek (See Figure 19). Three other sources of FGV material were also identified in this western area and include Ferber Wash, Gold Hill Wash, and Little White Horse Badlands FGV sources (see Figure 19 and discussion below).

Nine sources and source variants were identified and geochemically characterized in the western area. These sources/variants were established using both scatter plots of strontium (Sr) and zirconium (Zr) compared visually against scatter plots of rubidium (Rb) and zirconium (Zr) (Figure 26). One of these sources, Deep Creek A, was previously identified by D. Duke in 2003 (Carter et al. 2004) but was further explored and characterized by this investigation.

4.121 Deep Creek Variants

The Deep Creek source was previously identified in part but was not very well

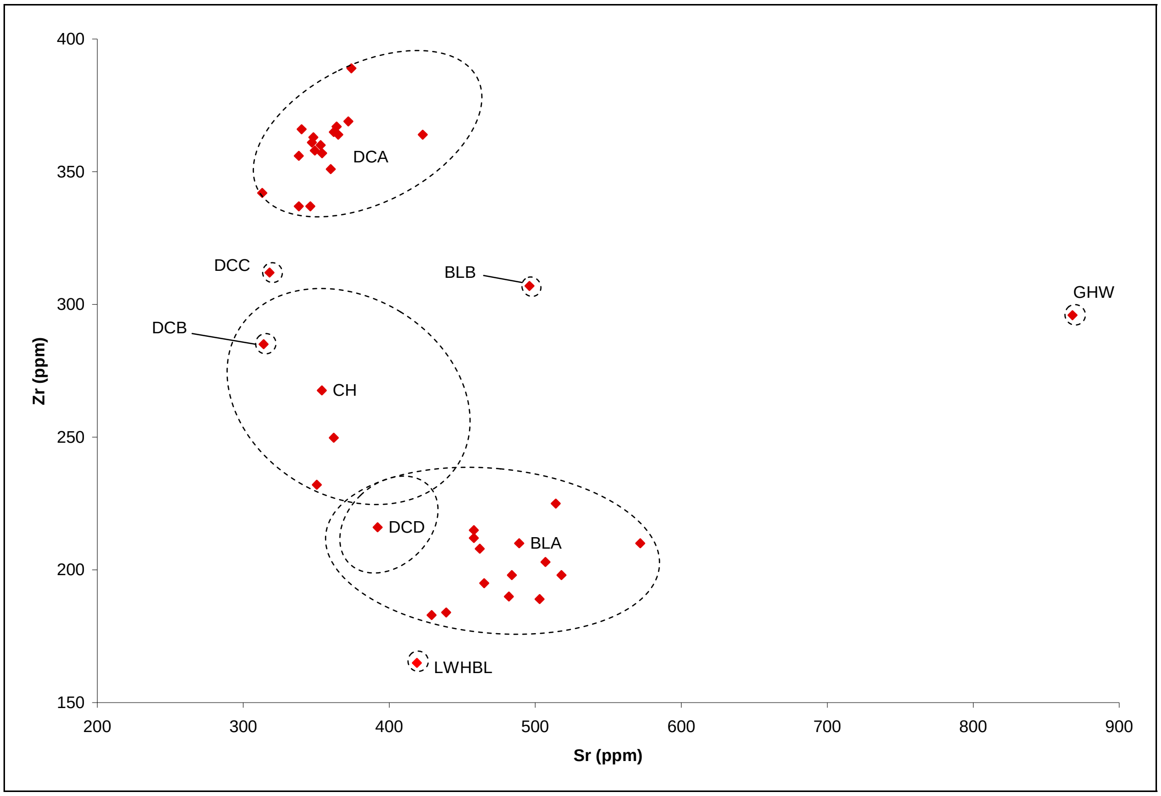

Figure 26. Scatter plot of strontium (Sr) plotted against zirconium (Zr) for western geologic samples (red dots).

characterized. It now contains several geochemical variants (designated A-D) composed of a number of different igneous rock types, including andesite, trachyandesite and possibly others. As mentioned, Deep Creek A was previously identified by D. Duke in2003 from a cobble retrieved from the road crossing at Deep Creek on the western side of the Deep Creek Range (Duke, personal communication 2006). As part of current research, the primary source of DCA was located and further characterized geochemically and four additional source variants were identified and characterized (see Figures 26 and 27). The primary source area for DCA is located in the Little Antelope Hills. Samples were collected at two primary outcrops located 2 km apart (north-south) and additional cobbles of DCA and other variants were sampled from across the surface

Figure 27. View of the Deep Creek A primary source area looking northwest (photo credit: D. Page).

of the dissected alluvial plain/piedmont between the Antelope Range and the Deep Creek Range where it is associated with badlands topography. Secondary distribution of these materials cover an area about 15 km in diameter, but cobbles are also incorporated into fluvial gravels in Deep Creek where they have been transported ca. 28 km to the point where the creek debouches near the playa interface.

These materials are found generally as cobbles and can currently be found in the range of 5-15 cm diameter, with rounded to sub-rounded shapes, and a smooth, darkly colored cortex (Figure 28). These materials are of high quality with few inclusions and phenocrysts and available in package sizes that are sufficient to produce bifaces and flake blanks of adequate size. These materials are not visually distinguishable from other sources such as Flat Hills variants, especially when in the form of a weathered artifact. The attractiveness of these materials to the early inhabitants of the region is evident by a number of extensive primary reduction sites that have yet to be recorded in detail.

Four variants within the larger source group are based on trace element ratios of the 20 geologic samples analyzed (See Figure 26; Table 5). Deep Creek A (DCA) is a cobble/bedrock source of andesite found in primary and secondary context. It produced Sr values between 313 and 423 ppm, Rb values between 78 and 98 ppm, and Zr value between 337 and 389 ppm. Deep Creek B (DCB) is a cobble source of unknown FGV rock (not submitted for whole rock XRF analysis) found in secondary context. It produced a Sr value of 314 ppm, Rb value of 83 ppm, and a Zr value of 285 ppm. Deep Creek C (DCC) is a cobble source of unknown FGV rock (not submitted for whole rock XRF analysis) found in secondary context. It produced a Sr value of 318 ppm, Rb value of 95 ppm, and a Zr value of 312 ppm. Deep Creek D (DCD) is a cobble source of trachyandesite found in secondary context. It produced a Sr value of 392 ppm, Rb value of 188 ppm, and a Zr value of 216 ppm.

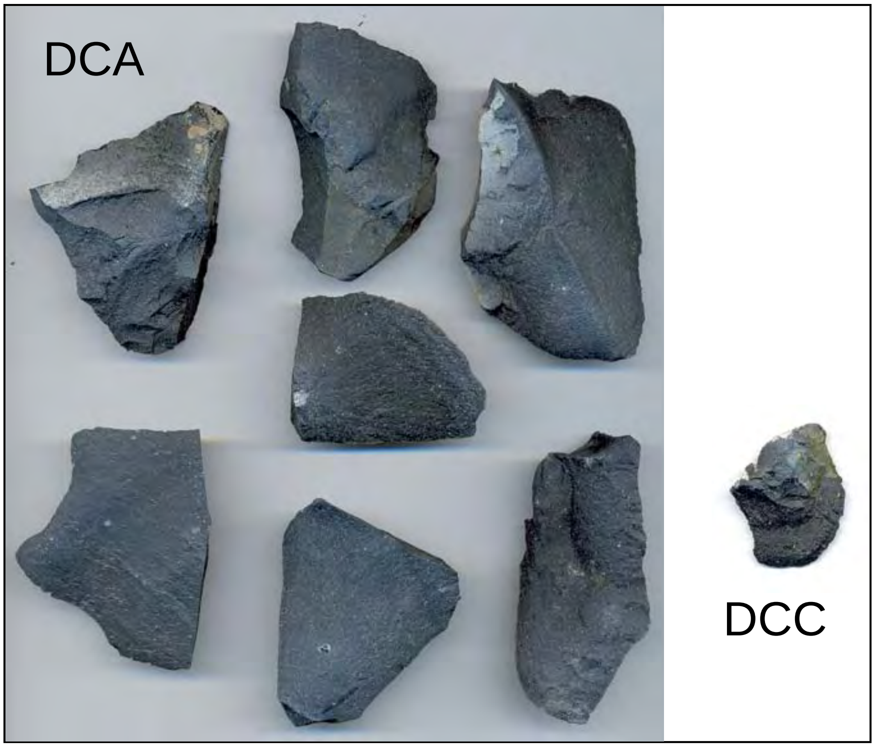

Figure 28. Select geologic samples showing macroscopic variation within Deep Creek variants (shown at half scale) (photo credit: D. Page).

Table 5. Summary statistics for trace element composition of geologic samples from the Deep Creek geochemical group (n = 20).

Deep Creek A (n=17)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
Maximum	118	30	98	423	56	389	24	5128	800	1933	5	77	37
Minimum	62	12	78	313	45	312	17	3048	401	783	3	45	33
Range	56	18	20	110	11	77	7	2080	399	1150	2	32	4
Mean	86	21	91	354	50	357	20	4156	606	1170	4	60	35
Median	84	21	92	351	50	361	20	4138	581	1130	4	63	35
SD	15	4	5	24	3	17	2	475	108	223	0	9	1
CV%	18	20	6	7	6	5	10	11	18	19	11	15	4

Deep Creek B (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
Maximum	69	27	83	314	41	285	19	4306	489	890	5	78	36
Minimum	69	27	83	314	41	285	19	4306	489	890	5	78	36
Range	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	69	27	83	314	41	285	19	4306	489	890	5	78	36
Median	69	27	83	314	41	285	19	4306	489	890	5	78	36
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Deep Creek C (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
Maximum	74	16	95	318	47	312	20	3996	531	783	4	67	36
Minimum	74	16	95	318	47	312	20	3996	531	783	4	67	36
Range	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	74	16	95	318	47	312	20	3996	531	783	4	67	36
Median	74	16	95	318	47	312	20	3996	531	783	4	67	36
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Deep Creek D (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
Maximum	84	26	188	392	31	216	12	3888	535	1065	4	69	38
Minimum	84	26	188	392	31	216	12	3888	535	1065	4	69	38
Range	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	84	26	188	392	31	216	12	3888	535	1065	4	69	38
Median	84	26	188	392	31	216	12	3888	535	1065	4	69	38
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

4.122 Badlands Variants

The Badlands source is a newly identified/characterized source with two geochemical variants (designated A and B) composed of trachyandesite and possibly another igneous rock types. Cobbles and boulders of BLA and the other variants were sampled as diffuse cobbles from across the surface of the dissected alluvial plain/piedmont between the Antelope Range and the Deep Creek Range where it is associated with secondary deposits of Deep Creek materials (Figure 29). Secondary distribution of these materials cover an area about 20 km in diameter, and, as with Deep Creek FGV, cobbles are also incorporated into fluvial gravels in Deep Creek where they have been transported ca. 28 km to the point where the creek debouches near the playa interface.

These materials are found as cobbles/boulders and can currently be found in the range of 10-30 cm diameter with rounded to sub-rounded shapes, and a smooth, darkly colored cortex. When found as exposed materials on the fan surface they are often

Figure 29. View of the Badlands source area looking west towards Antelope Range (photo credit: D. Page).

heavily patinated. These materials are of high quality but contain small phenocrysts and the occasional vesicle and are available in package sizes that are sufficient to produce bifaces and flake blanks of adequate size (Figure 30). They are visually distinguishable from other sources by cortex and evidence of horizontal flow banding and the occasional small vug. The attractiveness of these materials to the early inhabitants of the region is evident by a number of extensive primary reduction sites that have yet to be recorded in detail in eastern Elko and White Pine Counties, NV.

. Two variants within the larger source group are based on trace element ratios of the 15 geologic samples analyzed (See Figure 26; Table 6). Badlands A (BLA) is a cobble source of trachyandesite found in secondary context. It produced Sr values between 429 and 572 ppm, Rb values between 144 and 194 ppm, and Zr value between 183 and 225 ppm. Badlands B (BLB) is a cobble source of unknown FGV rock (not submitted for whole rock XRF analysis) found in secondary context. It produced a Sr value of 496 ppm, Rb value of 163 ppm, and a Zr value of 307 ppm.

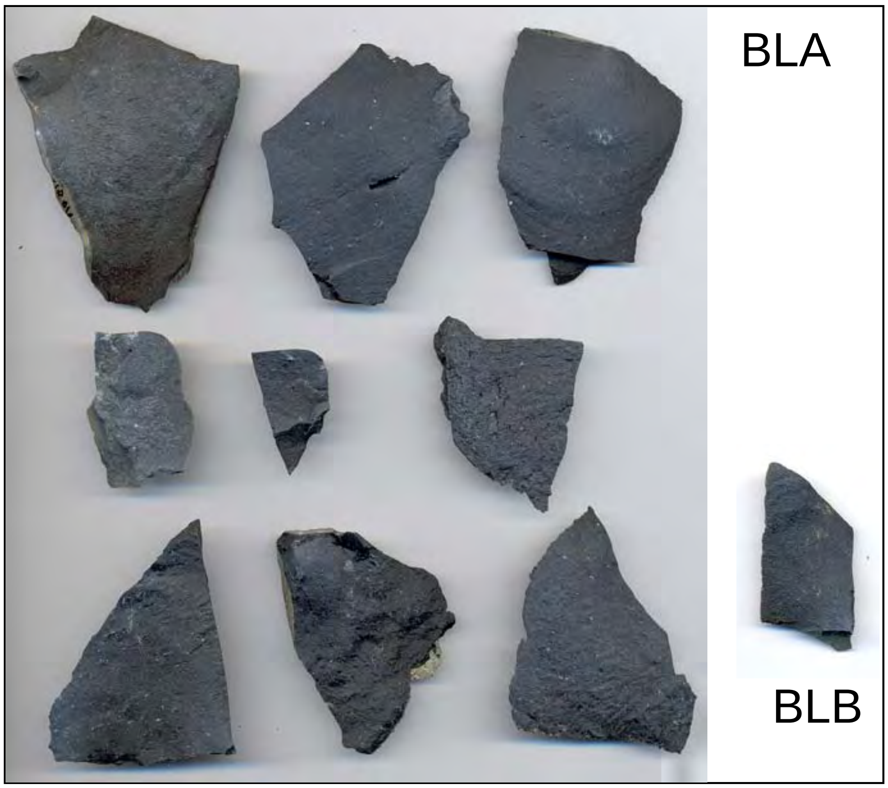

Figure 30. Select geologic samples showing macroscopic variation within Badlands variants (shown at half scale) (photo credit: D. Page).

Table 6. Summary statistics for trace element composition of geologic samples from the Badlands geochemical group (n = 15).

Badlands A (n=14)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
Maximum	106	31	194	572	33	225	20	4751	907	2496	6	71	45
Minimum	58	7	144	429	24	183	14	3461	554	1039	4	49	34
Range	48	24	50	143	9	42	6	1290	353	1457	1	22	10

BLA; continued.

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
Mean	90	23	178	484	27	201	17	3992	646	1355	5	62	40
Median	93	23	182	483	26	201	17	3933	596	1268	5	64	40
SD	13	7	15	37	3	13	2	375	103	355	0	8	3
CV%	14	30	8	8	10	6	11	9	16	26	7	12	8

Badlands B (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
Maximum	95	20	163	496	42	307	21	4978	780	1310	5	47	30
Minimum	95	20	163	496	42	307	21	4978	780	1310	5	47	30
Range	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	95	20	163	496	42	307	21	4978	780	1310	5	47	30
Median	95	20	163	496	42	307	21	4978	780	1310	5	47	30
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

4.123 Currie Hills Variants

The Currie Hills source is a previously identified/characterized source with several geochemical variants (undesignated at this time) composed of dacite, trachydacite, and trachyandesite and possibly another igneous rock types. This source of FGV was identified by T. Jones in 2003 (Jones, personal communication, 2007). At present, not much is known about the CH source beyond its general source location and quite varied geochemical signatures. Like the others, it is a cobble source in secondary context (primary source is unknown but presumed to be in the Currie Hills). It was identified and sampled north of the intersection of NV US 93 and NV US 93A around the Currie Hills (See Figure 19). Additional work recently conducted by Jones in 2007 may improve understanding of this source and its other various geochemical variants.

At this time, one variant has been separated from the larger source group (as seen in the archaeological record) and is based on trace element ratios of three of the geologic samples analyzed by Jones (See Figure 26; limited geochemical data in Table 7). Currie

Hills (CH) is a cobble source of FGV found in secondary context. It produced Sr values between 350 and 362 ppm, Rb values between 163 and 199 ppm, and Zr value between 232 and 268 ppm.

Table 7. Summary statistics for trace element composition of geologic samples from the Currie Hills geochemical group (n = 3).

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
Maximum	-	-	199	362	-	268	-	-	-	-	-	-	-
Minimum	-	-	163	350	-	232	-	-	-	-	-	-	-
Range	-	-	36	12	-	36	-	-	-	-	-	-	-
Mean	-	-	182	355	-	250	-	-	-	-	-	-	-
Median	-	-	183	354	-	250	-	-	-	-	-	-	-
SD	-	-	18	6	-	18	-	-	-	-	-	-	-
CV%	-	-	10	2	-	7	-	-	-	-	-	-	-

4.2 Other FGV Sources

Four other sources of FGV were identified and characterized in addition to the sources already discussed. These sources include, Wildcat Mountain trachyandesite, Rydalch Canyon FGV, Gold Hill Wash FGV, and Little White Horse Badlands FGV (see Figure 19).

Wildcat Mountain FGV

As mentioned above, Wildcat Mountain (WCM) FGV was previously identified by D. Duke in 2003 from cobbles retrieved from a gravel pit on the western side of Wildcat Mountain (Carter et al. 2004; Duke, personal communication 2006). As part of current research, this location was revisited and resampled for geochemical analysis. These materials are found generally as small cobbles and can currently be found in the range of 5-15 cm diameter, with rounded to sub-rounded shapes, and a smooth, light gray colored cortex. These materials are of low quality with abundant inclusions and phenocrysts.

The WCM source group is based on trace element ratios of the nine geologic samples analyzed (See Figure 21; Table 8). Wildcat Mountain (WCM) is a cobble source of trachyandesite found in secondary context with a presumed primary source located somewhere on the western flank of Wildcat Mountain. It produced Sr values between 393 and 489 ppm, Rb values between 194 and 217 ppm, and Zr value between 212 and 236 ppm (Table 8).

Table 8. Summary statistics for trace element composition of geologic samples from the Wildcat Mountain geochemical group (n = 9).

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
Maximum	91	31	217	489	28	236	21	3491	711	1457	4	65	48
Minimum	66	17	194	393	23	212	13	2311	490	1171	3	40	40
Range	25	14	23	96	5	24	8	1180	221	286	1	25	8
Mean	75	25	200	437	25	223	16	2756	566	1314	4	55	45
Median	74	24	197	436	26	222	16	2731	531	1317	4	56	47
SD	8	5	7	32	2	8	3	338	71	75	0	7	3
CV%	11	20	4	7	7	3	16	12	13	6	9	13	6

Prior to identification and characterization of Badlands A source, artifacts with this chemical fingerprint were attributed to the Wildcat Mountain FGV source and thus the source was misinterpreted as a major contributor to local archaeological assemblages. This mistaken identity was due to an overlap in geochemical signatures especially in those generally diagnostic elements commonly used in source assignment (see Figures 21 and 26). Both are trachyandesite sharing common values for Sr, Rb, and Zr, but they may be separable using other trace elements such as titanium (Ti) values (Figure 31). Although geochemically quite similar, they are visually distinct and may be separable by this distinction in material quality alone (Figure 32).

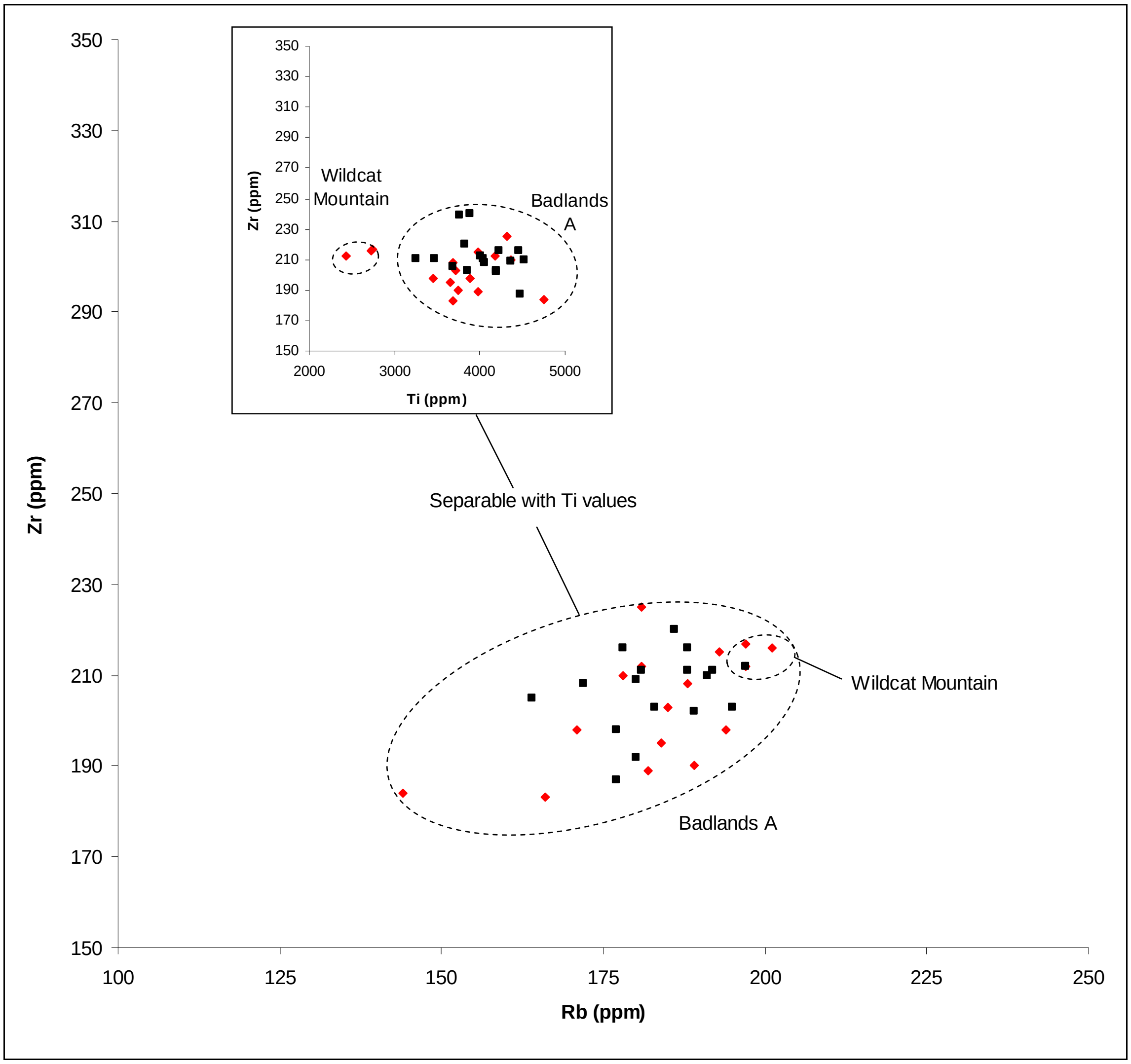

Figure 31. Scatter plot of rubidium (Rb) plotted against zirconium (Zr) for Badlands A and Wildcat Mountain sources – note overlapping signature; inset plot shows separation with titanium (Ti) values plotted against zirconium (Zr) (red symbols are geologic samples and black symbols are artifacts).

<u>Rydalch Canyon FGV</u>

This source of FGV was located and sampled during investigations of the Cedar Mountain Range. Additional samples collected from this source area by the Utah Geological Survey (UGS) were submitted for whole rock XRF analysis and determined to be andesite (Clark et al. 2007). This source group is based on trace element ratios of the two geologic samples analyzed (See Figure 21; Table 9). Rydalch Canyon (RDC) is a bedrock and colluvial source of andesite found in primary context. The primary source is Tabbys Peak located on the north slope of Rydalch Canyon in the Cedar Mountain Range. It produced Sr values between 302 and 307 ppm, Rb values between 88 and 89 ppm, and Zr value between 255 and 273 ppm (Table 9).

These materials are of low quality with some inclusions and phenocrysts and are found generally as angular colluvial cobbles and boulders in the range of 15 cm to more than 1 m in diameter (Figure 33).

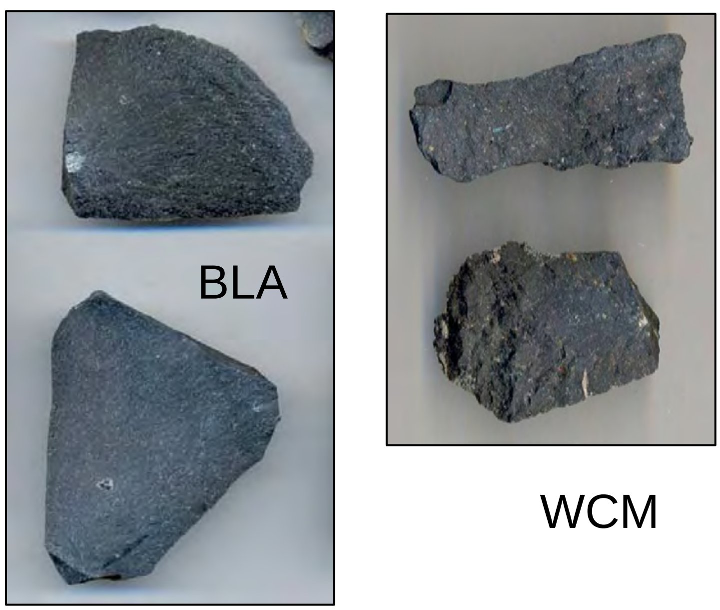

Figure 32. Select geologic samples showing macroscopic variation between Badlands A and Wildcat Mountain source materials (photo credit: D. Page).

Table 9. Summary statistics for trace element composition of geologic samples from the Rydalch Canyon geochemical group (n = 2).

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
Maximum	102	25	89	307	43	273	18	4152	699	878	4	67	37
Minimum	64	20	88	302	39	255	15	3979	507	868	4	52	33
Range	38	5	1	5	4	18	3	173	192	10	0	15	4
Mean	83	23	89	305	41	264	17	4066	603	873	4	60	35
Median	83	23	89	305	41	264	17	4066	603	873	4	60	35
SD	27	4	1	4	3	13	2	122	136	7	0	11	3
CV%	32	16	1	1	7	5	13	3	23	1	5	18	8

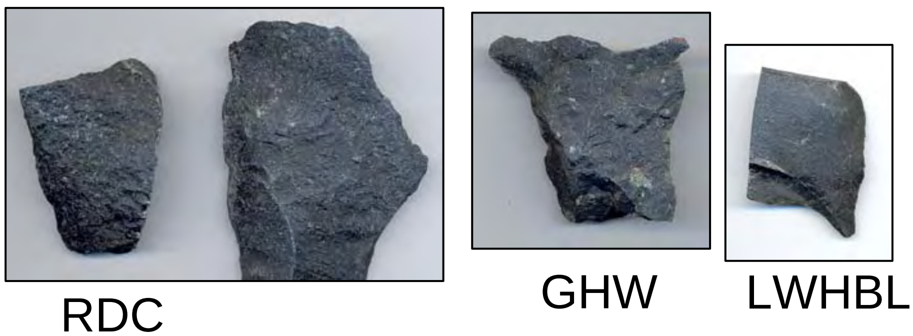

Figure 33. Select geologic samples showing macroscopic variation within Rydalch Canyon, Ferber Wash, Gold Hill Wash, and Little White Horse Badlands sources (shown at half scale) (photo credit: D. Page).

<u>Gold Hill Wash FGV</u>

This source of FGV was located and sampled during investigations of the western source area, ca. 4 km south of the small town of Gold Hill, UT. This source group is based on trace element ratios of a single geologic sample analyzed (See Figure 26; Table 11). <u>Gold Hill Wash</u> (GHW) is a bedrock source of unknown FGV rock (not submitted for whole rock XRF analysis) in primary context. It produced a Sr value of 868 ppm, Rb value of 32 ppm, and a Zr value of 296 ppm (Table 10). This material is of low quality with many inclusions and phenocrysts and was found as thickly bedded, blocky packages of mostly poor-grade (non-toolstone quality) material (see Figure 33).

Table 10. Summary statistics for trace element composition of geologic samples from the Gold Hill Wash geochemical group (n = 1).

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	$Fe^{2}O^{3T}$	Fe:Mn	Fe:Ti
Maximum	106	0	32	868	38	296	54	11951	705	1273	6	72	17
Minimum	106	0	32	868	38	296	54	11951	705	1273	6	72	17
Range	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	106	ND	32	868	38	296	54	11951	705	1273	6	72	17
Median	106	ND	32	868	38	296	54	11951	705	1273	6	72	17
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Little White Horse Badlands FGV

This source of FGV was located and sampled during investigations of the Deep Creek and Badlands source area. This source group is based on trace element ratios of a single geologic sample analyzed (See Figure 26; Table 11). Little White Horse Badlands (LWHBL) is a cobble source of unknown FGV rock (not submitted for whole rock XRF analysis) in secondary context. It produced a Sr value of 419 ppm, Rb value of 181 ppm, and a Zr value of 165 ppm (Table 12). This material is of good quality with few inclusions and phenocrysts and was found as a rounded cobble in the range of ca.15 cm in diameter (see Figure 33).

Table 11. Summary statistics for trace element composition of geologic samples from the Little White Horse Badlands geochemical group (n = 1).

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	$Fe^{2}O^{3T}$	Fe:Mn	Fe:Ti
Maximum	87	25	181	419	22	165	12	4423	799	1005	5	54	40
Minimum	87	25	181	419	22	165	12	4423	799	1005	5	54	40
Range	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	87	25	181	419	22	165	12	4423	799	1005	5	54	40
Median	87	25	181	419	22	165	12	4423	799	1005	5	54	40
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

4.3 Cultural Use of FGV Toolstone

Geologic sources of toolstone are fixed points on the landscape, but not all will be used equally, as many factors play into a source's overall usefulness at any given time (e.g., distance to source, proximity to other resources, material quality, package size, etc.). The distance from a site to a geologic source may play into the choice to use one source over another. The proximity of a source relative to other resources that may be pursued, such as upland game species or seasonally available plant resources, may affect source selection. The general quality of raw material may play into source selection or rejection, as will the size of available material at the time of retrieval. This being said, there are many sources of toolstone quality FGV in and around the Bonneville basin that have been recently discovered and characterized. Many of these are minor sources of low quality material that show limited use by prehistoric peoples, but a number of these sources are major contributors to the regional toolstone assemblage. In addition, there are still a number of unknown sources that show up in low frequencies in multiple sites across the regional landscape.

Sampling of existing archaeological collections from around the Bonneville basin resulted in the geochemical analysis of 489 FGV artifacts from a suite of open Paleoindian sites associated with the ORB delta and a number of Archaic sites from across DPG (also includes isolated finds), as well as 98 FGV artifacts from well dated Paleoindian and Archaic contexts within the sheltered sites of DC, BER, and CBC (Appendix E). Geochemical sourcing data was processed and artifacts were correlated to various sources; as hoped, most were represented in the geologic source universe.

Sampled sites/groups of sites will be discussed separately by geographic location providing detailed investigation of sources represented in both open and sheltered assemblages. Tables of summary statistics for sources identified and charts showing FGV source profiles by temporal period will be provided for each site/group of sites discussed.

4.31 Surface Assemblages

Geochemical sourcing results for 489 Paleoindian artifacts and 39 Archaic artifacts from 85 open Paleoindian sites and 33 Paleoindian-age isolated finds in the ORB delta, as wells as 25 Archaic sites and four Archaic-age isolated finds from the central basin are presented below (Figure 34). Results are outlined in reference to temporal period to allow comparisons of FGV use not only across space but through time. Tables present the sources, counts, and frequency of sources represented at each group of sites and charts delineate source profiles within the areas discussed.

4.311 Old River Bed Delta Assemblage; DPG

Two hundred-ninety-seven artifacts were submitted for geochemical sourcing from 51 sites and 13 isolates (Appendix E and F) on DPG lands within the proximal ORB delta (Madsen 2001; Madsen et al. 2004; 2006; Page et al. 2008; Rhode et al. 2005b; Schmitt et al. 2002; 2003; 2007a; 2007b). Eight known sources/source variants are represented in the sample analyzed, as are five unknown sources (Table 12; Appendix E). Included is abundant dacite and andesite from the FHA and FHD respectively, and limited amounts of trachyandesite from the BLA source, andesite from the DCA source,

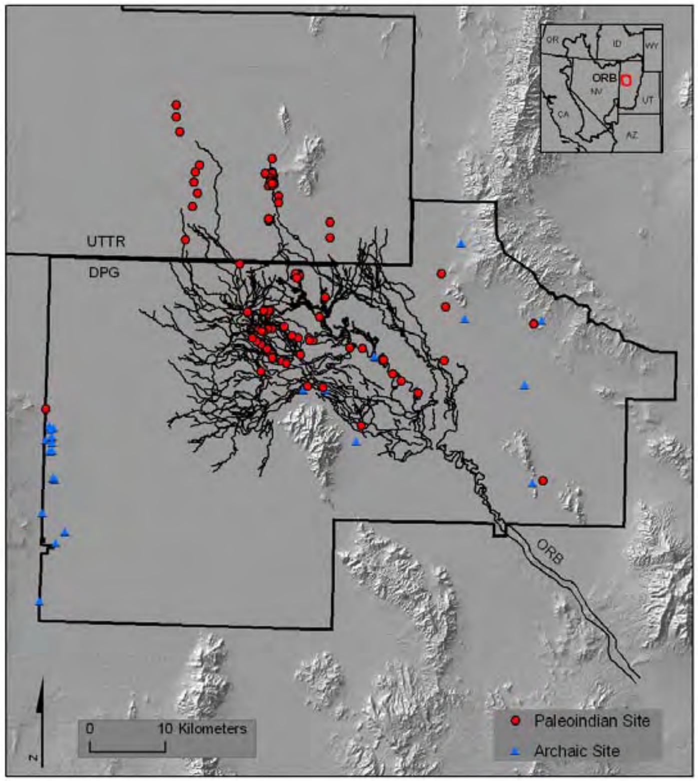

Figure 34. Location of select Paleoindian and Archaic surface sites included in this sourcing study (isolates not shown); fine lines show ORB channels and bold lines show military installation boundaries (base image source: USGS National Elevation Dataset).

trachydacite from the FHE source, andesite from the CMB source, and mixed FGV from the CH source.

Paleoindian artifacts (11,500-7,500 B.P.)

All 297 artifacts were sourced from surface sites/isolates dating to the Paleoindian period (Figure 35). Most originate from two major eastern sources located east of the delta, FHA at ca. 38 % (n=114) and FHD at ca. 37 % (n=111). There was also limited use of a few western sources, BLA at ca. 8 % (n=23), DCA at ca. 5 % (n=16), and CH at ca. 1 % (n=4), as well as a few eastern sources with FHE at ca. 3 % (n=10), CMB at ca. 3 % (n=9), and FHC at ca. 1 % (n=4). There are also ca. 2 % of the sample attributed to unknown sources (n=6).

Table 12. Summary statistics for sources identified in the proximal ORB delta sample group (n = 297).

Geochemical source	Count	Frequency
Flat Hills A	114	38.38%
Flat Hills D	111	37.37%
Badlands A	23	7.74%
Deep Creek A	16	5.39%
Flat Hills E	10	3.37%
Cedar Mountain B	9	3.03%
Currie Hills	4	1.35%
Flat Hills C	4	1.35%
Unknown 1	1	0.34%
Unknown 11	1	0.34%
Unknown A	1	0.34%
Unknown B	1	0.34%
Unknown C	2	0.67%
All Unknowns	**6**	**2.02%**

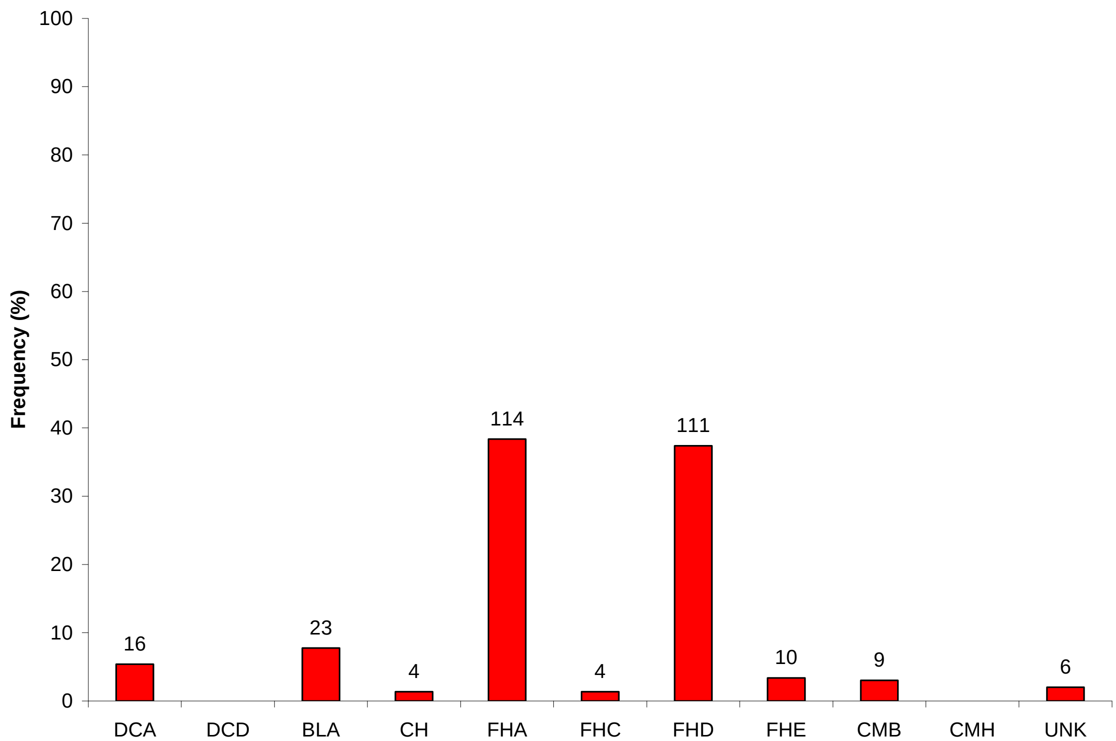

Figure 35. Paleoindian FGV source profile for proximal ORB delta sample group (n = 297) (frequencies shown on Y-axis and counts shown above bars).

4.312 DPG Archaic Assemblage

Thirty-nine artifacts were submitted for geochemical sourcing from 24 Archaic sites and four isolates (Appendix E and F) on DPG lands. Eight known sources/source variants are represented in the sample analyzed, as are two unknown sources (Table 13; Appendix E). Included is abundant andesite from the DCA source, trachyandesite from the BLA source, and limited amounts of dacite and andesite from the FHA, andesite from the FHD source, mixed FGV from the CH source, andesite from the CMB source, andesite from the FHC source, and trachydacite from the FHE source.

Archaic artifacts (7,500- 500 B.P.)

All 39 artifacts were sourced from surface sites/isolates dating to the Archaic period (Figure 36). Most originate from two major western sources located west of DPG, including DCA at ca. 36 % (n=14) and BLA at ca. 18 % (n=7). There was also limited use of a several eastern sources, FHA at ca. 10 % (n=4), FHD at ca. 10 % (n=4), FHC at ca. 5 % (n=2),CMB at ca. 3 % (n=1), and FHE at ca. 3 % (n=1), as well as limited use of another western source, CH at ca. 10 % (n=4).

Table 13. Summary statistics for sources identified in the DPG Archaic sample group (n = 39).

Geochemical source	Count	Frequency
Deep Creek A	14	35.90%
Badlands A	7	17.95%
Flat Hills A	4	10.26%
Flat Hills D	4	10.26%
Currie Hills	4	10.26%
Flat Hills C	2	5.13%
Cedar Mnt B	1	2.56%
Flat Hills E	1	2.56%
Unknown A	1	2.56%
Unknown 3	1	2.56%
All Unknowns	**2**	**5.13%**

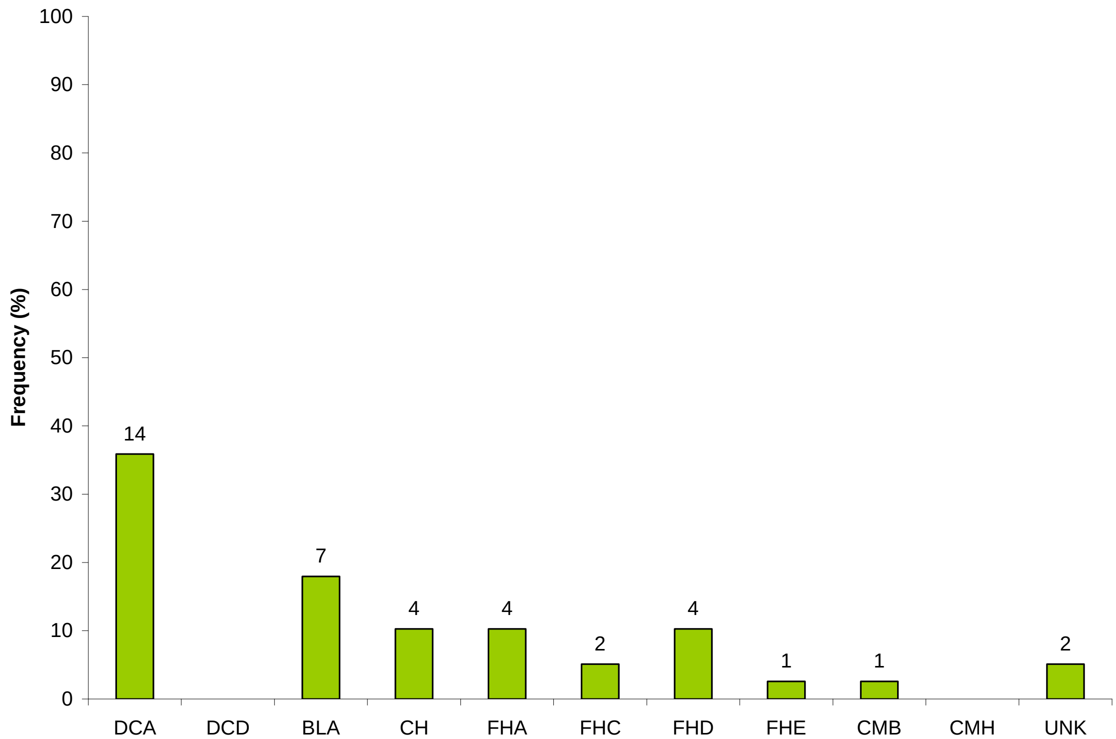

Figure 36. Archaic FGV source profile for DPG sample group (n = 39) (frequencies shown on Y-axis and counts shown above bars).

4.313 Distal Old River Bed Delta Assemblage; UTTR

One hundred-fifty-three artifacts were submitted for geochemical sourcing from 34 sites and 19 isolates (Appendix E and F) on UTTR lands from the distal ORB delta (Arkush and Pitblado 2000; Young et al. 2006). Nine known sources/source variants are represented in the sample analyzed, as are seven unknown sources (Table 14; Appendix E). Included is abundant andesite from the FHD source, and limited amounts of dacite from the FHA source, trachyandesite from the BLA source, andesite from the DCA source, trachydacite from the FHE source, andesite from the FHC source, mixed FGV from the CH source, andesite from the CMH source, and trachyandesite from the DCD source.

Paleoindian artifacts (11,500-7,500 B.P.)

All 153 artifacts were sourced from surface sites/isolates dating to the Paleoindian period (Figure 37). Most originate from the major eastern source located southeast of the distal delta, FHD at ca. 48 % (n=73). There was also limited use of a few other eastern sources with FHA at ca. 14 % (n=21), FHE at ca. 5 % (n=7), FHC at ca. 2 % (n=3), and CMH at ca. 1 % (n=2). Other western sources represented in limited quantities are BLA at ca. 12 % (n=18), DCA at ca. 11 % (n=16), and CH at ca. 2 % (n=3). There are also ca. 5 % of the sample attributed to unknown sources (n=8).

Table 14. Summary statistics for sources identified in the distal ORB delta sample group (UTTR) (n = 153).

Geochemical source	Count	Frequency
Flat Hills D	73	47.71%
Flat Hills A	21	13.73%
Badlands A	18	11.76%
Deep Creek A	16	10.46%
Flat Hills E	7	4.58%
Flat Hills C	3	1.96%
Currie Hills	3	1.96%
Cedar Mnt H	2	1.31%
Deep Creek D	2	1.31%
Unknown A	2	1.31%
Unknown 2	1	0.65%
Unknown 6	1	0.65%
Unknown 7	1	0.65%
Unknown 8	1	0.65%
Unknown 9	1	0.65%
Unknown 10	1	0.65%
All Unknowns	**8**	**5.23%**

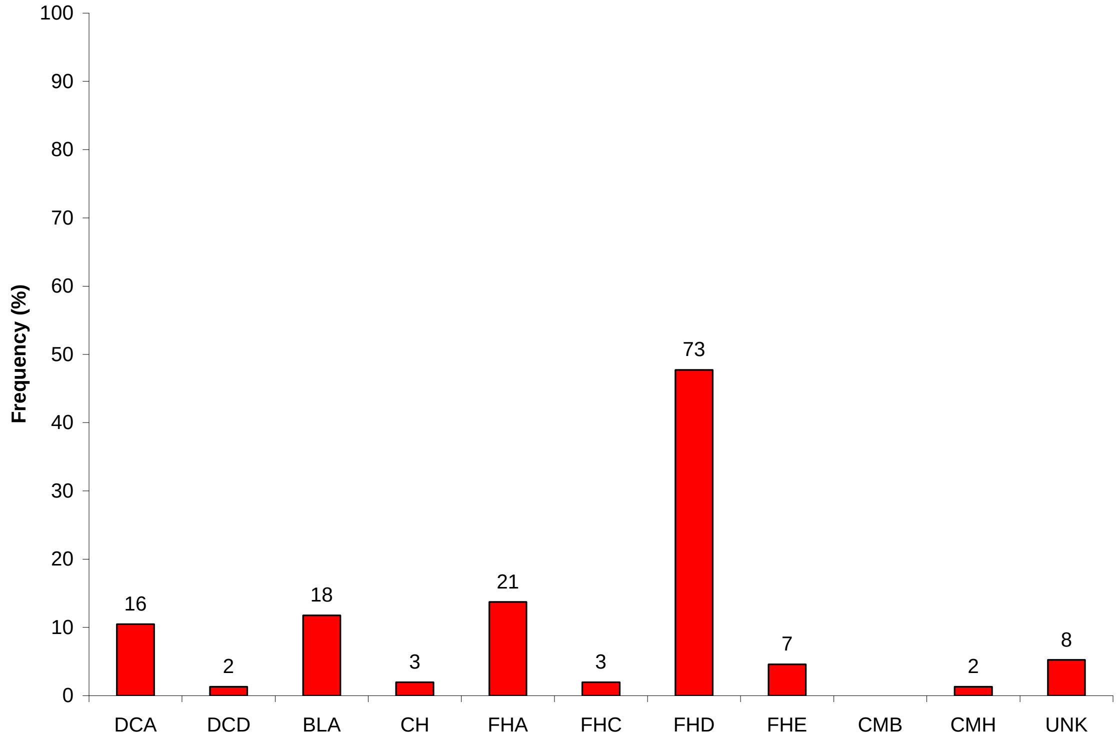

Figure 37. Paleoindian FGV source profile for distal ORB delta sample group (n = 153) (frequencies shown on Y-axis and counts shown above bars).

4.32 Rockshelter/Cave Assemblages

Geochemical sourcing results for 98 artifacts (Paleoindian and Archaic materials) from well dated contexts within Danger Cave, Bonneville Estates Rockshelter, and Camels Back Cave are presented below. Results are outlined in reference to temporal period to allow comparisons of FGV use not only across space but through time. Tables present the sources, counts, and frequency of sources represented at each site and charts delineate source profiles within each site discussed.

4.321 Bonneville Estates Rockshelter

Twenty-two artifacts were submitted for geochemical sourcing from BER. Geochemical sourcing results of FGV artifacts from the rockshelter are discussed below, relative to age, thus enabling a comparison of early Paleoindian use to later Early/Middle Archaic use (Figure 38). Four known sources are represented in the sample analyzed, as is one unknown source (Table 15). Included is abundant andesite from the DCA source, and limited amounts of FGV from CH source, trachyandesite from BLA source, and andesite from FHD source.

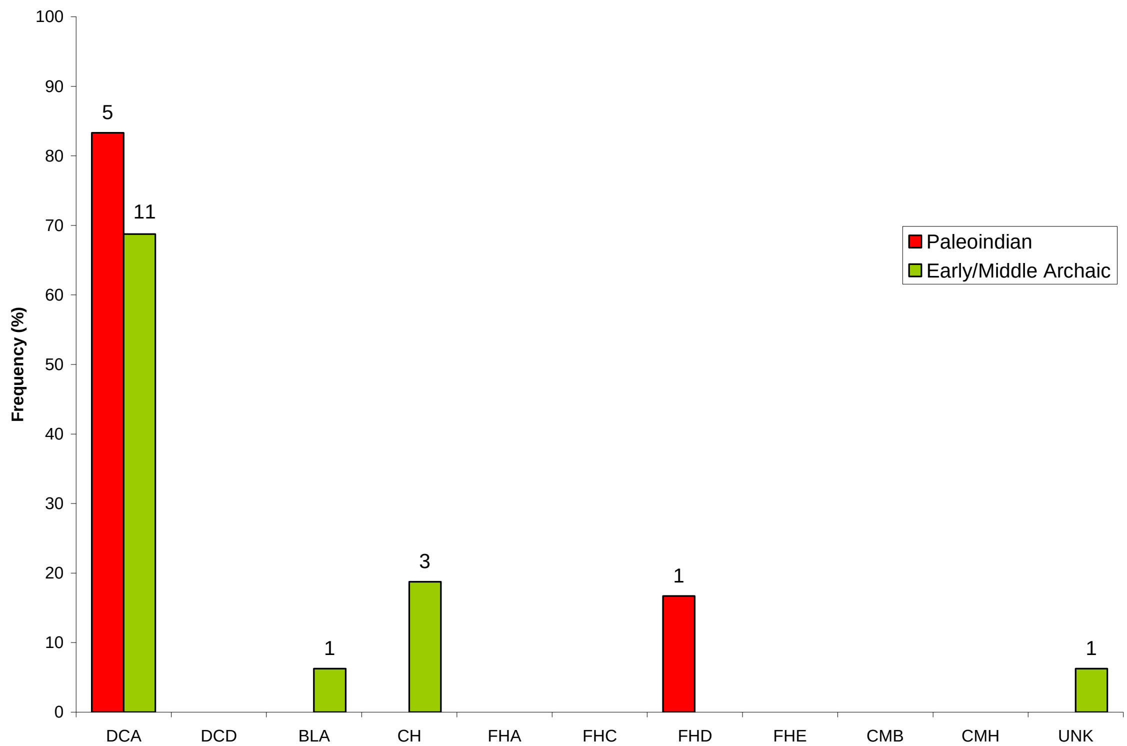

Figure 38. Paleoindian and Early/Middle Archaic FGV source profile for Bonneville Estates Rockshelter sample group (n = 22) (frequencies shown on Y-axis and counts shown above bars).

Early use (10,100-9,400 B.P.)

Six artifacts were sourced from the lower strata within the rockshelter (strata 17b, 17b', 18a, and 10 [east block]). Most originate from a major western source located south of the rockshelter: DCA at ca. 83 % (n=5). There was also limited use of a major eastern source, FHD at ca. 17 % (n=1). Sample size is small but there is no evidence of unknown source use during this time period of occupation.

Later use (6,300-6,000 B.P.)

Sixteen artifacts were sourced from the middle strata within the rockshelter (strata 14a and 14b/c). These show a similar pattern of source use with continued use of western sources, DCA at ca. 69 % (n=11) but an expansion of sources represented including, BLA at ca. 6 % (n=1), CH at ca. 19 % (n=3), and Unknown 5 at ca. 6 % (n=1). This unknown is unique to BER and has not been identified in any of the other sourced materials from the region.

Table 15. Summary statistics for sources identified in the Bonneville Estates Rockshelter sample group (n = 22).

Geochemical source	**Count**	**Frequency**
Deep Creek A	16	72.70%
Currie Hills	3	13.60%
Badlands A	1	4.50%
Flat Hills D	1	4.50%
Unknown 5	1	4.50%
Paleoindian artifacts	**6**	**27.27%**
Deep Creek A	5	83.30%
Flat Hills D	1	16.70%
Early/Middle Archaic artifacts	**16**	**72.73%**
Deep Creek A	11	68.75%
Currie Hills	3	18.75%
Badlands A	1	6.25%
Unknown 5	1	6.25%

4.322 Danger Cave

Forty-seven artifacts were submitted for geochemical sourcing from DC. Geochemical sourcing results of FGV artifacts from the rockshelter are discussed below, relative to age, thus enabling a comparison of early Paleoindian use to later Early/Middle Archaic use (Figure 39). Five sources are represented in the sample analyzed from Danger Cave (Table 16). Some of these are major regional sources represented in other caves/rockshelters across the region and from numerous open sites across the Bonneville basin. Included is trachyandesite from the Badlands source area; andesite and trachyandesite from the Deep Creek source area; dacite, trachydacite, and trachyandesite from the Currie Hills source area; and trachydacite from the Flat Hills source area.

Early use (10,100-7,500 B.P.)

Thirty-four artifacts were sourced from stratum DII. These primarily originate from several major western Bonneville basin sources located south of Danger Cave: BLA at ca. 44 %, DCA at ca. 18 %, DCD at ca. 12 %, and CH at ca. 15 % (totaling ca. 88 %). There was also limited use of a minor eastern Bonneville basin source, FHE (totaling ca. 6 %). In addition, there were two unknown sources represented (totaling ca. 6 %) (further discussed below).

Later use (7,500-4,800 B.P.)

Thirteen artifacts were sourced from strata DIII and DIV. These show a similar pattern of source use with continued use of western sources, DCA at ca. 62 %, BLA at ca. 15 %, and CH at ca. 15 % (totaling ca. 92 %) and limited use of the eastern source FHE (totaling ca. 8 %), but no use of unknown sources. Strata DIII and DIV may show some

Table 16. Summary statistics for sources identified in the Danger Cave sample group (n = 47).

Geochemical source	Count	Frequency
Badlands A	17	36.17%
Deep Creek A	14	29.79%
Currie Hills	7	14.89%
Unknowns (B, 4)	2	4.26%
Deep Creek D	4	8.51%
Flat Hills E	3	6.38%
Paleoindian artifacts	**34**	**72.34%**
Badlands A	15	44.12%
Deep Creek A	6	17.65%
Currie Hills	5	14.71%
Unknown B, 4	2	5.88%
Deep Creek D	4	11.76%
Flat Hills E	2	5.88%
Early/Middle Archaic artifacts	**13**	**27.66%**
Deep Creek A	8	61.54%
Currie Hills	2	15.38%
Badlands A	2	15.38%
Flat Hills E	1	7.69%

changes in source use, but this may be related to smaller sample size and the artifact types selected for sourcing.

Only two artifacts are made of unknown source materials (Unknown 4 and B). Of interest, Unknown B also shows up in another Paleoindian assemblage from the Old River Bed delta. The remaining unknown (UNK4) is unique to Danger Cave and has not been identified in any of the other sourced materials from the region.

4.323 Camels Back Cave

Twenty-nine artifacts were submitted for geochemical sourcing from CBC. Geochemical sourcing results of FGV artifacts from the rockshelter are discussed below,

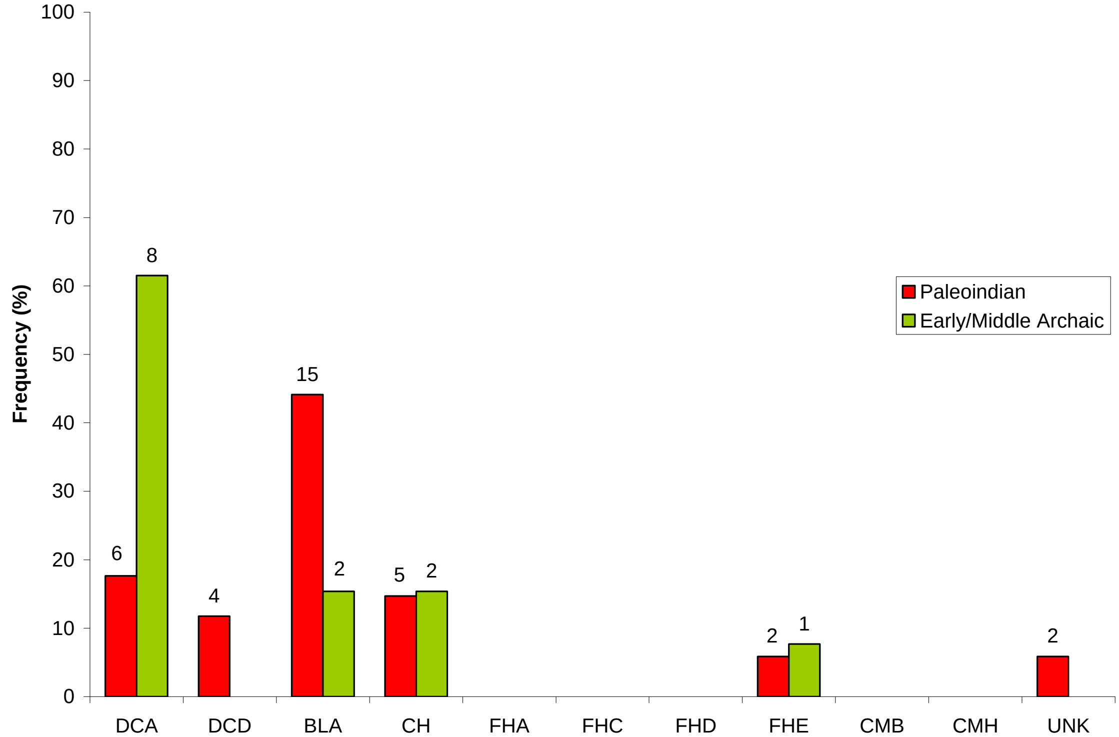

Figure 39. Paleoindian and Early/Middle Archaic FGV source profile for Danger Cave sample group (n = 47) (frequencies shown on Y-axis and counts shown above bars).

relative to age, thus enabling a comparison of Early Archaic to Middle Archaic through Late Prehistoric use (Figure 40). Six known sources are represented in the sample analyzed (Table 17). Included is abundant dacite from the FHA source, moderate amounts of andesite from FHC and trachyandesite from BLA, and limited amounts of andesite from DCA and FHD, and trachydacite from FHE. There is no evidence of unknown source use in CBC.

Early use (7,500-5,600 B.P.)

Twenty-four artifacts were sourced from the lower strata within the rockshelter (strata III-IX). Most originate from a major eastern source, FHA at ca. 67 % (n=16). There was also moderate use of two sources; the minor source, FHC at ca. 13 % (n=3) and a major western source, BLA at ca. 8 % (n=2). The remaining samples show limited use of several other sources; a major western source, DCA at ca. 4 % (n=1), and two other Flat Hills variant, FHD and FHE, both with ca. 3 % (n=1 each). There is no evidence of unknown source use during this time of occupation.

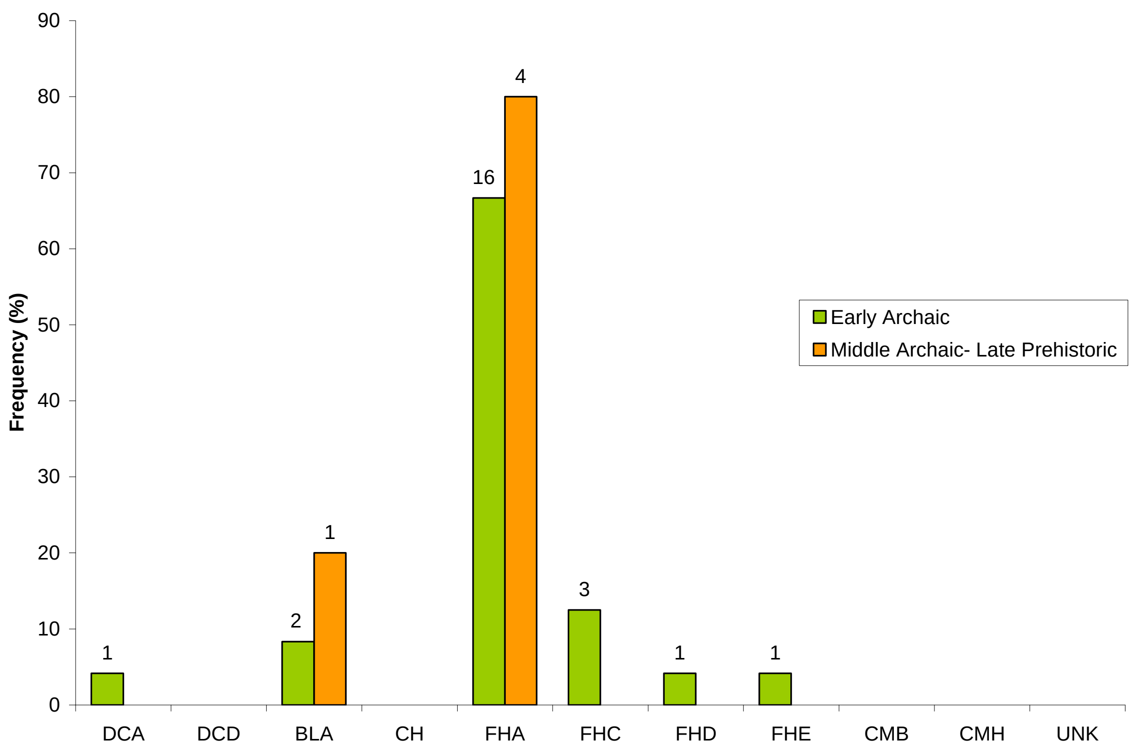

Figure 40. Early Archaic and Middle Archaic-Late Prehistoric FGV source profile for Camels Back Cave sample group (n = 29) (frequencies shown on Y-axis and counts shown above bars).

Later use (5,600-500 B.P.)

Five artifacts were sourced from the middle and upper strata within the rockshelter (strata XI-XVIII). These artifacts are the only FGV artifacts recovered from the last 5000 radiocarbon years of site occupation. Although the sample size is small, there is a reduction in source diversity with only two sources represented. This being said, these show a similar pattern of source use with continued use of eastern sources, with FHA at 80 % (n=4) and limited use of western sources, with BLA at 20 % (n=1). Sample size is small but there is no evidence of unknown source use during this period of occupation.

Table 17. Summary statistics for sources identified in the Camels Back Cave sample group (n = 29).

Geochemical source	Count	Frequency
Flat Hills A	20	68.97%
Badlands A	3	10.34%
Flat Hills C	3	10.34%
Deep Creek A	1	3.45%
Flat Hills D	1	3.45%
Flat Hills E	1	3.45%
Early Archaic artifacts	**24**	**82.76%**
Flat Hills A	16	66.67%
Flat Hills C	3	12.50%
Badlands A	2	8.33%
Deep Creek A	1	4.17%
Flat Hills D	1	4.17%
Flat Hills E	1	4.17%
Middle Archaic-Late Prehistoric artifacts	**5**	**17.24%**
Flat Hills A	4	80.00%
Badlands A	1	20.00%

4.33 Unknown Sources of FGV

In addition to the FGV sources identified in this study there are 14 ‘unknown sources’ where the location of the FGV geologic source material has not been identified or characterized. This equates to 19 artifacts out of 587 artifacts sourced or 3.24 % of the cultural sample analyzed (Appendix E). These unknowns are represented by a letter or number designation; ‘lettered’ unknowns (e.g., Unknown A) have been identified by multiple artifacts, often in different sites, while 'numbered' unknowns (e.g., Unknown 1) have only been identified by a single artifact thus far. As more fieldwork and geochemical sourcing is done within the region, it is likely that these 'numbered' sources will be changed to 'lettered' sources and will eventually make the move from 'unknown' to 'known' as their geologic sources are discovered.

To date, unknown materials have been divided in the following groups: Unknowns 1-11 (n=1 each); Unknown A (n=4), Unknown B (n=2), Unknown C (n=2). A discussion of the use of these unknown sources will be provided in Chapter 5. Results of geochemical sourcing are presented in Table 18.

Table 18. Summary statistics for trace element composition of archaeological samples from unknown sources (n=14 sources; 19 artifacts).

Unknown 1 (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe2O3T	Fe:Mn	Fe:Ti
Maximum	79	34	116	526	36	268	28	3520	692	948	4.72	55.6	44.4
Minimum	79	34	116	526	36	268	28	3520	692	948	4.72	55.6	44.4
Range	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	79	34	116	526	36	268	28	3520	692	948	4.72	55.6	44.4
Median	79	34	116	526	36	268	28	3520	692	948	4.72	55.6	44.4
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Unknown 2 (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe2O3T	Fe:Mn	Fe:Ti
Maximum	84	28	111	592	34	257	26	3172	669	916	4.25	51.9	44.4
Minimum	84	28	111	592	34	257	26	3172	669	916	4.25	51.9	44.4
Range	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	84	28	111	592	34	257	26	3172	669	916	4.25	51.9	44.4
Median	84	28	111	592	34	257	26	3172	669	916	4.25	51.9	44.4
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Unknown 3 (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe2O3T	Fe:Mn	Fe:Ti
Maximum	28	21	120	235	39	229	18	4231	122	234	2	156	18
Minimum	28	21	120	235	39	229	18	4231	122	234	2	156	18
Range	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	28	21	120	235	39	229	18	4231	122	234	2	156	18
Median	28	21	120	235	39	229	18	4231	122	234	2	156	18
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Unknown 4 (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe2O3T	Fe:Mn	Fe:Ti
Maximum	59	24	101	333	21	108	9	2832	508	885	4	59	42
Minimum	59	24	101	333	21	108	9	2832	508	885	4	59	42
Range	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	59	24	101	333	21	108	9	2832	508	885	4	59	42
Median	59	24	101	333	21	108	9	2832	508	885	4	59	42
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Unknown 5 (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe2O3T	Fe:Mn	Fe:Ti
Maximum	23	8	39	30	13	60	4	1560	148	172	NM	30	11
Minimum	23	8	39	30	13	60	4	1560	148	172	NM	30	11
Range	0	0	0	0	0	0	0	0	0	0	NM	0	0
Mean	23	8	39	30	13	60	4	1560	148	172	NM	30	11
Median	23	8	39	30	13	60	4	1560	148	172	NM	30	11
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Unknown 6 (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe2O3T	Fe:Mn	Fe:Ti
Maximum	82	23	207	631	33	272	19	3214	554	NM	4	59	41
Minimum	82	23	207	631	33	272	19	3214	554	NM	4	59	41
Range	0	0	0	0	0	0	0	0	0	NM	0	0	0
Mean	82	23	207	631	33	272	19	3214	554	NM	4	59	41
Median	82	23	207	631	33	272	19	3214	554	NM	4	59	41
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Unknown 7 (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe2O3T	Fe:Mn	Fe:Ti
Maximum	90	23	183	870	33	226	16	4002	581	1149	5	68	40
Minimum	90	23	183	870	33	226	16	4002	581	1149	5	68	40
Range	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	90	23	183	870	33	226	16	4002	581	1149	5	68	40
Median	90	23	183	870	33	226	16	4002	581	1149	5	68	40
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Unknown 8 (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe2O3T	Fe:Mn	Fe:Ti
Maximum	149	29	155	342	28	138	14	3337	3598	472	4	10	42
Minimum	149	29	155	342	28	138	14	3337	3598	472	4	10	42
Range	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	149	29	155	342	28	138	14	3337	3598	472	4	10	42
Median	149	29	155	342	28	138	14	3337	3598	472	4	10	42
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Unknown 9 (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe2O3T	Fe:Mn	Fe:Ti
Maximum	102	37	134	648	35	337	19	4040	546	1375	4	56	31
Minimum	102	37	134	648	35	337	19	4040	546	1375	4	56	31
Range	0	0	0	0	0	0	0	0	0	0	0	0	0

UNK 9; continued.

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe2O3T	Fe:Mn	Fe:Ti
Mean	102	37	134	648	35	337	19	4040	546	1375	4	56	31
Median	102	37	134	648	35	337	19	4040	546	1375	4	56	31
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Unknown 10 (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe2O3T	Fe:Mn	Fe:Ti
Maximum	101	46	175	793	26	192	13	3623	901	1363	3	32	32
Minimum	101	46	175	793	26	192	13	3623	901	1363	3	32	32
Range	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	101	46	175	793	26	192	13	3623	901	1363	3	32	32
Median	101	46	175	793	26	192	13	3623	901	1363	3	32	32
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Unknown 11 (n=1)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	$Fe^{2}O^{3T}$	Fe:Mn	Fe:Ti
Maximum	71	33	200	541	41	289	18	5340	839	1473	4.93	47.8	30.7
Minimum	71	33	200	541	41	289	18	5340	839	1473	4.93	47.8	30.7
Range	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean	71	33	200	541	41	289	18	5340	839	1473	4.93	47.8	30.7
Median	71	33	200	541	41	289	18	5340	839	1473	4.93	47.8	30.7
SD	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CV%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Unknown A (n=4)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	$Fe^{2}O^{3T}$	Fe:Mn	Fe:Ti
Maximum	109	27	172	702	35	254	25	5721	921	1445	6	74	39
Minimum	75	18	153	626	28	235	19	4555	662	1092	5	47	35
Range	34	9	19	76	7	19	6	1166	259	353	1	27	4
Mean	95	24	162	671	30	248	22	5010	843	1231	6	54	37
Median	98	25	161	678	30	251	22	4881	895	1194	5	48	36
SD	15	4	8	33	3	9	2	527	122	154	0	13	2
CV%	15	16	5	5	10	4	10	11	14	13	7	24	5

Unknown B (n=2)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	$Fe^{2}O^{3T}$	Fe:Mn	Fe:Ti
Maximum	106	31	193	598	38	247	22	5605	657	1661	6	70	37
Minimum	94	28	177	575	32	230	18	3912	611	1137	4	59	33
Range	12	3	16	23	6	17	4	1693	46	524	1	11	4
Mean	100	30	185	587	35	238	20	4759	634	1399	5	64	35
Median	100	30	185	587	35	238	20	4759	634	1399	5	64	35
SD	8	2	11	16	4	12	3	1197	32	370	1	8	3
CV%	8	8	6	3	12	5	15	25	5	26	18	12	8

Unknown C (n=2)

	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	$Fe^{2}O^{3T}$	Fe:Mn	Fe:Ti
Maximum	84	30	107	757	37	350	20	4513	556	1255	4	66	33
Minimum	71	18	103	746	34	326	15	4513	556	1255	4	66	33
Range	13	12	4	11	3	24	5	0	0	0	0	0	0
Mean	77	24	105	752	36	338	18	4513	556	1255	4	66	33
Median	77	24	105	752	36	338	18	4513	556	1255	4	66	33
SD	9	8	3	8	2	17	4	NA	NA	NA	NA	NA	NA
CV%	12	35	3	1	7	5	21	NA	NA	NA	NA	NA	NA

4.4 Summary

This study seeks to identify the sources of FGV toolstone used by prehistoric peoples in the Bonneville basin and to investigate how these sources were used by prehistoric peoples living in the region. This chapter presented an overview of the geochemical sourcing results for geologic sources of FGV identified/characterized by this toolstone sourcing study and results of geochemical sourcing for 587 FGV artifacts from a number of open and sheltered sites in the Bonneville basin.

There are 24 known geologic sources of FGV, including minor variants, within the known Bonneville Basin FGV source universe (see Figures 21 and 26). Many of these minor sources are of low quality and had limited use by prehistoric peoples. A number of these sources are major contributors to the region's toolstone assemblage as seen by the sourcing results for the sites discussed above. In addition, there are 14 unknown sources, some of which show up in multiple sites across the regional landscape. This sector of unknown source material equates to just 3.2 % of the overall cultural material sourced -- a far lower number than the nearly 100 % unknown sources when the study commenced. The following chapter, Chapter 5, will provide a discussion of FGV toolstone source use in open and sheltered sites across the region.

Chapter 5

Discussion of FGV Source Use

The following are some potential questions of interest that may be posed along the stream of events in a toolstone sourcing project, especially with the creation of a large dataset of sourcing information from a given geographic area.

- What sources are represented in sites/groups of sites across the region?
- In what proportions are various sources represented?
- How much source diversity occurs within sites?
- Do these source profiles change in sites of different ages within the same geographic region? What causes are spurring these changes?
- What characteristics are important in source selection or rejection?
- Are different sources used differently in specific functional tasks or for specific tool classes?
- Are there physical characteristics of individual sources that make them more or less selectable? What qualities seem important?

Toolstone sources are limited resources. The choice to use one source locality over another is a conscious decision made by regional hunter-gatherers. There are many complex factors that play into a source’s overall usefulness, i.e., whether it is selected or rejected for tool making. Toolstone sources are distributed as haphazard points on the landscape tied to the geology, but their use is not random. Although their locations are generally fixed, raw material sources are used differently through time, when they are used at all (e.g., Figure 41).

At this time there are 24 known geologic sources of FGV within the Bonneville basin source universe. A small number of these sources are major contributors to the regional toolstone assemblage, while many of these are minor sources of low quality material with little to no use by prehistoric peoples. Additionally, there are 14 sources of FGV represented in the regional assemblage with unknown provenience as the geologic source has not yet been determined. Within the regional archaeological record there are three main eastern sources represented including FHA, FHD, and FHC (with limited use of CMB and CMH, and FHE), and three main western sources represented including DCA, BLA, and CH (with limited use of DCD).

Having been successful in the source-finding portion of this toolstone sourcing project, it is possible to examine the use of these FGV sources within the various assemblages sampled. Looking for patterns of change through time and across space can lead to a better understanding of regional prehistoric hunter-gatherer behavior. This is a work in progress and not all aspects or causes of change are understood at this juncture, but within the assemblages sampled there is potential for more in-depth look at toolstone use by looking to transport distance and toolstone utility.

Beck et al. (2002) outlines toolstone utility by usable amount of stone in a core. This measure of utility is complex with several dependent factors, such as amount of waste produced in relation to morphology of final product; toolstone package size;

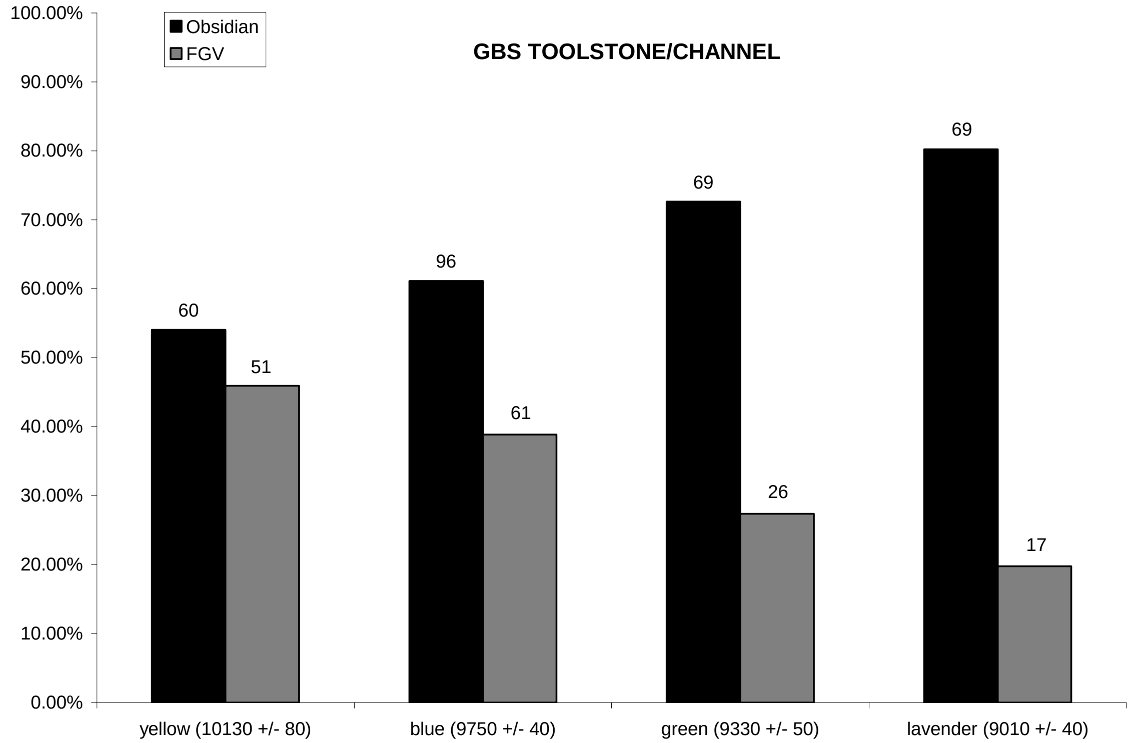

Figure 41. FGV and obsidian GBS projectile points within recorded sites on four dated ORB deltaic channels; ordered (left to right) from oldest to youngest showing increasing obsidian use through time as FGV use declines- even within the Paleoindian period (frequencies shown on Y-axis and counts shown above bars).

functional requirements of manufactured tool relative to toolstone type; and quality of the raw material. As no work was done to analyze quarry locations or primary reduction sites and research was not focused on the analysis of technological organization within the assemblages sampled, this measure of utility is beyond the scope of this investigation.

Transport distance from source to site may be considered a very basic proxy measure of toolstone utility and provides the observer with a snapshot of this utility at the time of discard. If a piece of stone is chosen over another for a given task and transported away from the quarry location, it must have fit the specific criteria desired by its user. The fact that a piece of lithic material was selected, fashioned into either a tool that was eventually discarded or was a byproduct of a tool-making activity and discarded as a waste flake, and at some point along this continuum transported a given distance away from a source location is evidence of this usefulness. This measurable distance is an indicator of a material's utility in terms of cost of procurement and user value (Elston 1990a, b). A simple calculation of average transport distance within a lithic assemblage is produced by multiplying the number of artifacts sourced by the distance to the geochemical sources and then averaging the results (e.g., 2 artifacts from FHA at 47 km, 3 artifacts from BLA at 67 km, and an artifacts from CMB at 34 km produce an average transport distance of 54.8 km). This figure can be calculated for assemblages of different ages within a given area and general comparisons can be made between sites/clusters of sites. It should be noted that this measure is very basic and excludes the factors of re-use and scavenging, as evidence of these activities is difficult to identify in heavily weathered artifacts. Both re-use and scavenging were likely strategies of toolstone procurement especially in remote areas such as the distal ORB delta.

5.1 Use in Surface Assemblages

Analysis of toolstone use in these open sites allows for comparison between sites of similar ages in the proximal and distal ORB delta and later sites within the DPG Archaic sample. FGV use will be discussed in reference to the use of other toolstone types, the frequencies of sources represented, and the distance to sources represented.

5.11 Old River Bed Delta Assemblage; Dugway Proving Ground

FGV accounts for about 45 % (on average) of the proximal ORB delta Paleoindian lithic assemblage (all tools and debitage), but this figure ranges from about a quarter to three-quarters in individual assemblages. Looking to just stemmed points, roughly 30 % are made of FGV, while the remaining ca. 70 % are made of obsidian (on average; although this is highly variable within individual sites). The average transport distance from known sources of FGV to Paleoindian sites in the proximal ORB delta sample at the time of tool discard is about 50.8 km. Sites are quite distant to viable toolstone sources and materials had to be transported in from the surrounding area (Figure 42).

Most of the FGV in these Paleoindian sites are from two eastern sources located ca. 47 km to the southeast of the proximal delta (ca. 75 % from FHA and FHD). The remaining material derives from five other sources in smaller frequencies. Three more eastern source variants are represented in low frequencies (ca. 3 % from FHE, ca. 3 % from CMB, and ca. 1 % from FHC). There are also small amounts of material from three western sources (BLA, DCA, and CH) occurring 67 km, 77 km, and 117 km to the west, respectively (ca. 8 % from BLA, ca. 5 % from DCA, and ca. 5 % from CH). During this time, there is extensive use of the eastern sources (totaling ca. 84 %) with limited use of western sources (totaling ca. 14 %) but also limited use of five unknown sources in very low frequencies (totaling ca. 2 %). The general trend appears clear with the majority of toolstone originating from a couple of the nearest available sources of toolstone quality FGV. Material in the Cedar Mountains is closer in distance (ca. 13 km closer) but was not used in significant quantities.

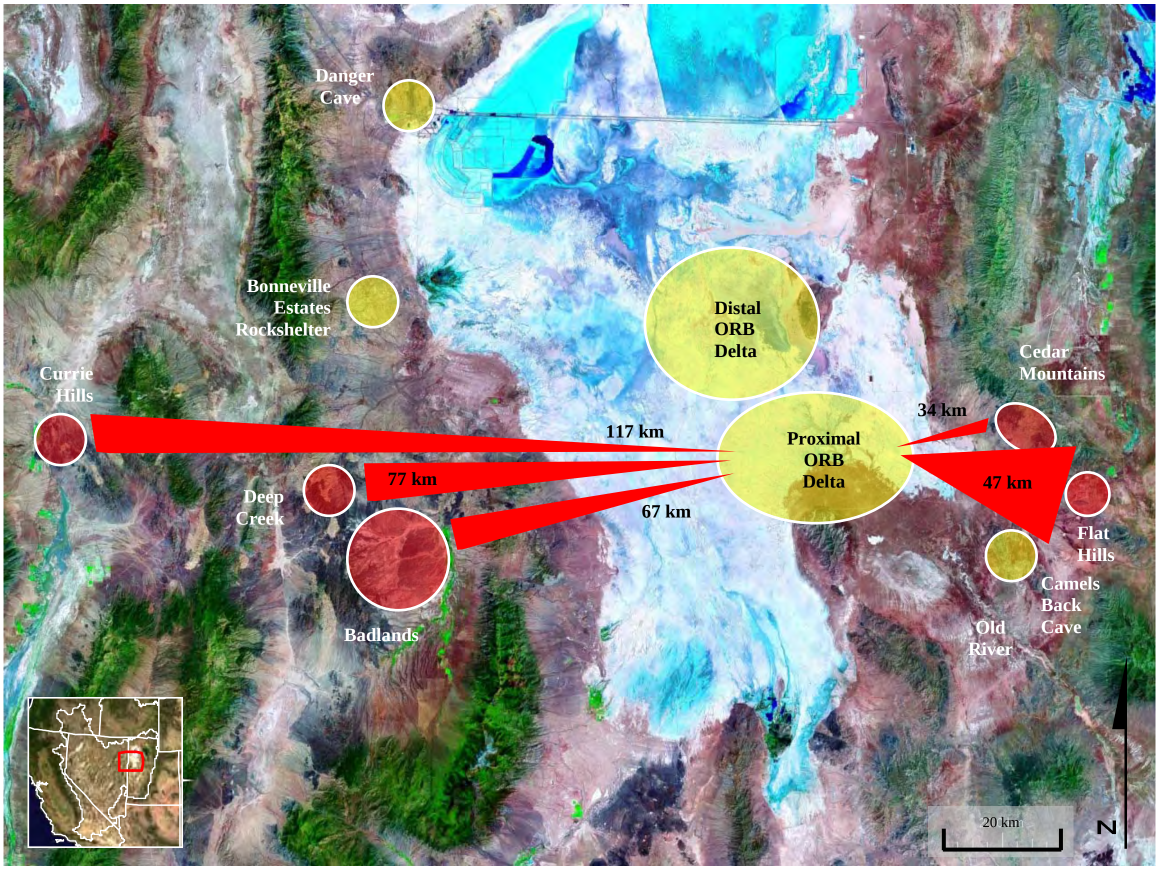

Figure 42. Distance and direction to known FGV sources represented in the proximal ORB delta sample. Arrow size indicates frequency: (large) > 15%; (intermediate) 5-15%; (small) < 5% (base image source: http://worldwind.arc.nasa.gov).

5.12 Distal Old River Bed Delta Assemblage; Utah Test and Training Range

FGV accounts for about 60 % (on average) of the distal ORB delta Paleoindian lithic assemblage (all tools and debitage), but this figure is variable within individual assemblages (Young et al. 2006). Looking to just stemmed points, roughly 35 % are made of FGV, ca. 60 % are made of obsidian, while the remaining ca. 5 % are made of CCS and quartzite (on average; although this is highly variable within individual sites) (Duke and Young 2007). Pinto points from the distal delta generally exceed this norm, as about 50 % are made of FGV (Duke et al. 2008c). The average transport distance from known sources of FGV to Paleoindian sites in the distal ORB delta sample at the time of tool discard is about 64.1 km. Sites are even more distant to viable toolstone sources than those in the proximal delta and materials had to be transported in from the surrounding region (Figure 43).

Most of the FGV in these Paleoindian sites are from one eastern source located ca. 61 km to the southeast of the distal delta (ca. 48 % from FHD). The remaining material derives from eight other sources in lower frequencies. Four more eastern source variants are represented in lower frequencies (ca. 14 % from FHA, ca. 5 % from FHE, ca. 2 % from FHC, and ca. 1 % from CMH). These source areas occur 61 km (FH variants) and 41 km (CMH) to the southeast. Four western source variants are also represented in lower frequencies (ca. 12 % from BLA, ca. 10 % from DCA, ca. 2 % from CH, and ca. 1 % from DCD). These source areas occur 67 km (BLA), 72 km (Deep Creek variants), and 120 km (CH) to the southwest. During this time, there is extensive use of the eastern sources (totaling ca. 69 %) with limited use of western sources (totaling ca. 25 %) but also limited use of seven unknown sources in very low frequencies (totaling ca. 5 %). The general trend appears clear with the majority of toolstone originating from a couple of the nearest available sources of toolstone quality FGV. Material in the Cedar Mountains is closer in distance (ca. 20 km closer) but was not used in significant quantities.

5.13 Archaic materials; Dugway Proving Ground

FGV accounts for a small percentage of the DPG Archaic lithic assemblage, but this figure is not easily calculated. The information from the site records of those

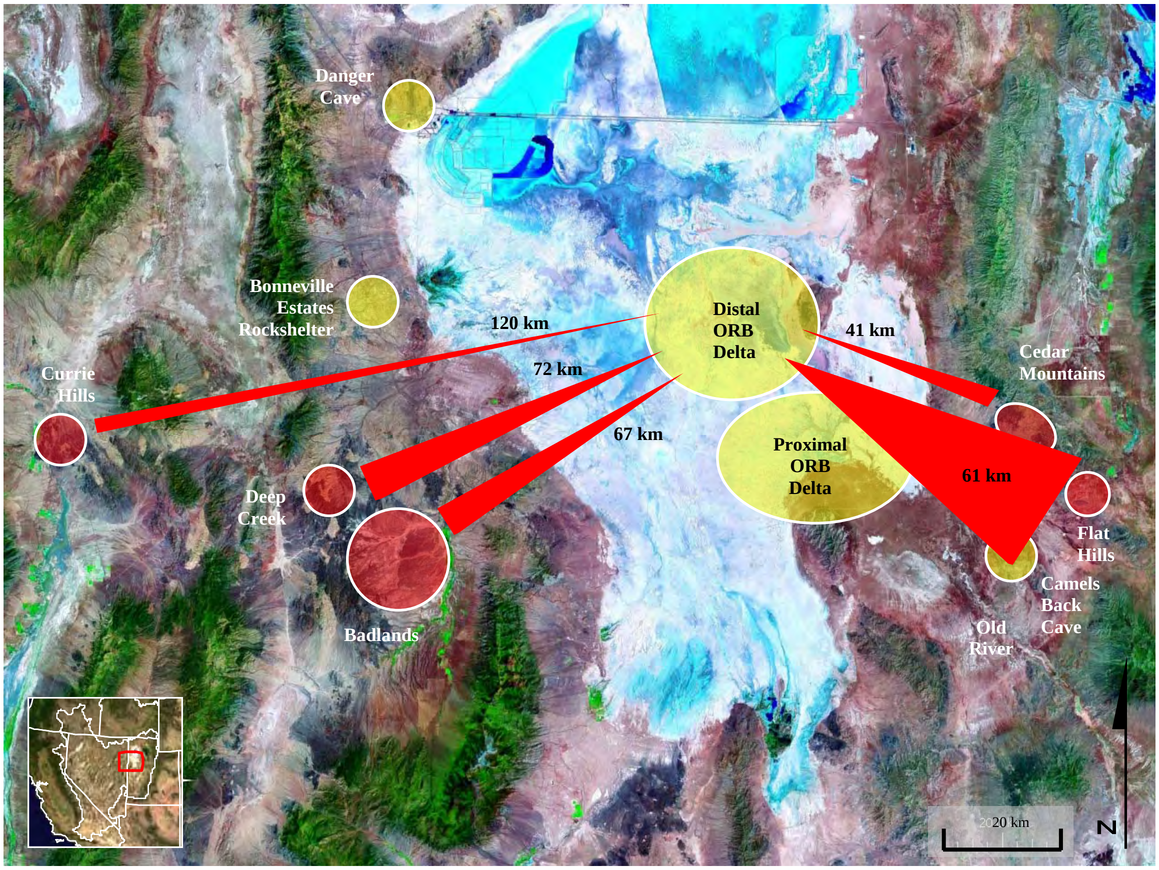

Figure 43. Distance and direction to known FGV sources represented in the distal ORB delta sample. Arrow size indicates frequency: (large) > 15%; (intermediate) 5-15%; (small) < 5% (base image source: http://worldwind.arc.nasa.gov).

sampled indicates FGV is rare in about 37 % of the sites, present in about 43 % of the sites, and common in the remaining 20 % of sites. It appears that FGV use is highly variable in Archaic sites with some individual assemblages containing more than the average amount, but the general picture is consistent with the regional trend with more FGV present in earlier sites and less in later sites.

The average transport distance from known sources of FGV to Archaic sites in the DPG sample at the time of tool discard is about 48 km (ca. 53 km including isolates) (Figure 44). As the samples are spread across a large area, looking at just the sites north and west of Granite Peak, the distance increases to ca. 54 km, while looking at just those

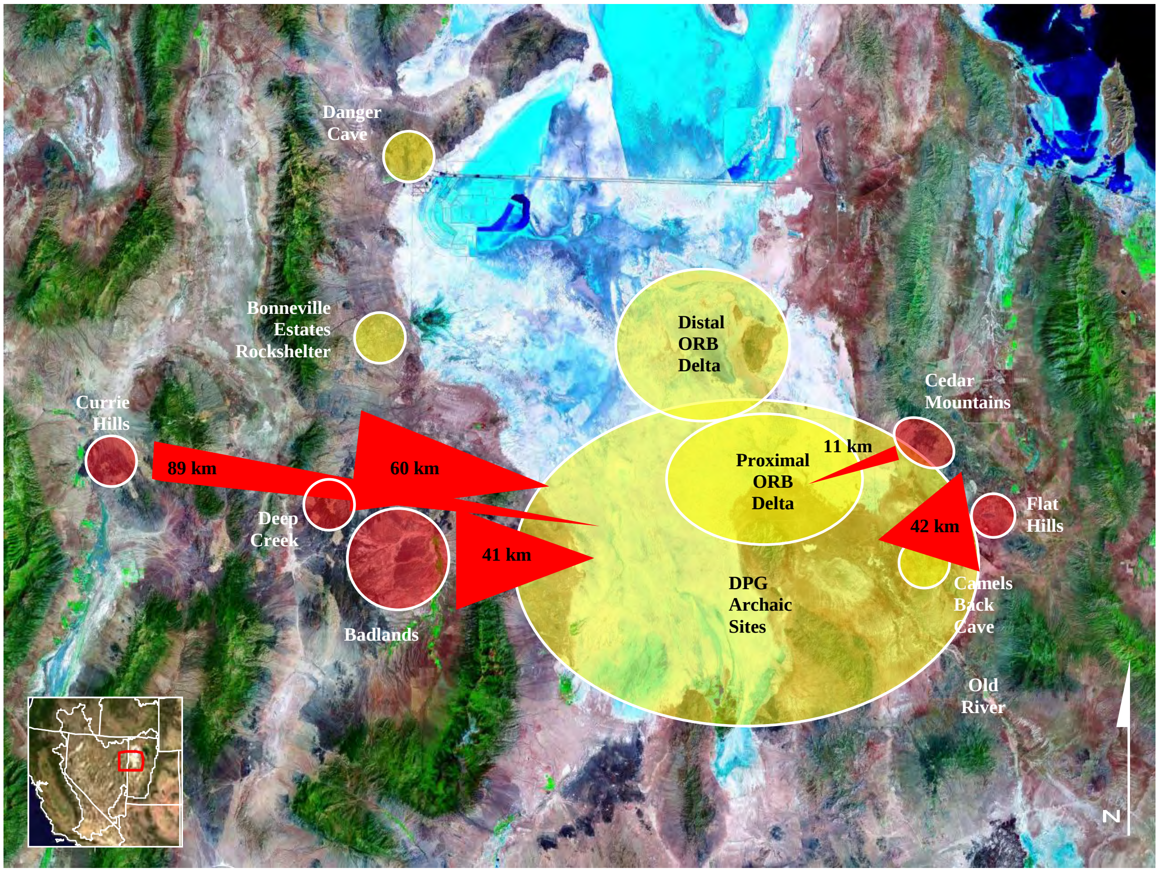

Figure 44. Distance and direction to known FGV sources represented in the sample of DPG Archaic sites. Arrow size indicates frequency: (large) > 15%; (intermediate) 5-15%; (small) < 5% and distances are averages across sites (base image source: http://worldwind.arc.nasa.gov).

sites east of Granite Peak the distance decreases to ca. 31 km. It seems that a trend of more local source use continues, as sites in the western half of the study area more frequently contain FGV from western sources (ca. 84 % western source use), while sites in the eastern half of the study area contain higher frequencies of eastern sources (ca. 88 % eastern source use).

Looking at use during this period as a whole from across the sample, source use is quite diverse with eight known source groups/variants represented, but most of the FGV in these Archaic sites is from western sources (ca. 64 % from DCA and BLA, and CH). The remaining material derives from five eastern sources in lower frequencies (ca. 31 % from FHA, FHD FHC, FHE, and CMB). During this time, there is also limited use of two unknown sources in very low frequencies (totaling ca. 5 %).

5.2 Use in Rockshelter/Cave Assemblages

Analysis of toolstone use in these sheltered sites allows for comparison between occupations of similarly aged open sites in the sample. FGV use will be discussed in reference to the use of other toolstone types, the frequencies of sources represented, and the distance to represented sources. These three sheltered sites, BER, DC, and CBC, offer different views and perspectives of FGV use within varied parts of the region and throughout differing temporal periods.

5.21 Bonneville Estates Rockshelter

FGV accounts for about a third (ca. 32 %) of the BER Paleoindian lithic assemblage (Goebel 2007). Most of this FGV is from a western source occurring within 35 km south of rockshelter (83 % from DCA), while the remaining fraction is from an eastern source located some 120 km southeast of the rockshelter (ca. 17 % from FHD) (Figure 45). Sample size may play into the completeness of this picture but the trend appears consistent with the majority of toolstone originating from the nearest available sources of toolstone-quality FGV. Several other sources of FGV are presently available close to the shelter (e.g., Badlands FGV can be found in the same geographic area as

Deep Creek FGV variants) but for unknown reasons these were not frequently selected for use. It is interesting to note that all the Paleoindian FGV material sourced so far is andesite.

FGV use in the Early Archaic drops off by almost half of its use during the Paleoindian period, to only account for ca. 17 % of the lithic assemblage during this later temporal period (Figure 46). While the amount of general use decreases, the number of sources represented increases and becomes more diverse to include additional western sources (continued reliance on DCA but also some use of CH and limited use of BLA), no eastern source use, but limited use of an unknown source (UNK 5). The use of andesite still dominates the FGV portion of the Early Archaic assemblage, but other FGV rock types are also present including trachyandesite and possibly others.

The average transport distance from known FGV sources to the site at the time of tool discard decreased from 48.3 km for Paleoindian use to 39.5 km for Early Archaic use (18 % reduction). This parallels a reduction of average obsidian transport distance from 161 km during the Paleoindian period to 77 km for the Early Archaic period (52 % reduction). Use of local CCS (within 10 km) increases by 20 % during this temporal transition, from ca. 44 % of the Paleoindian assemblage to include ca. 64 % of the Early Archaic assemblage. The reduction in transport distance and increase in use of more locally available materials may show a trend of reduced mobility through time or may reflect larger cultural changes including changes in technology, land use patterns, environmental flux, or other, non-mobility related factors.

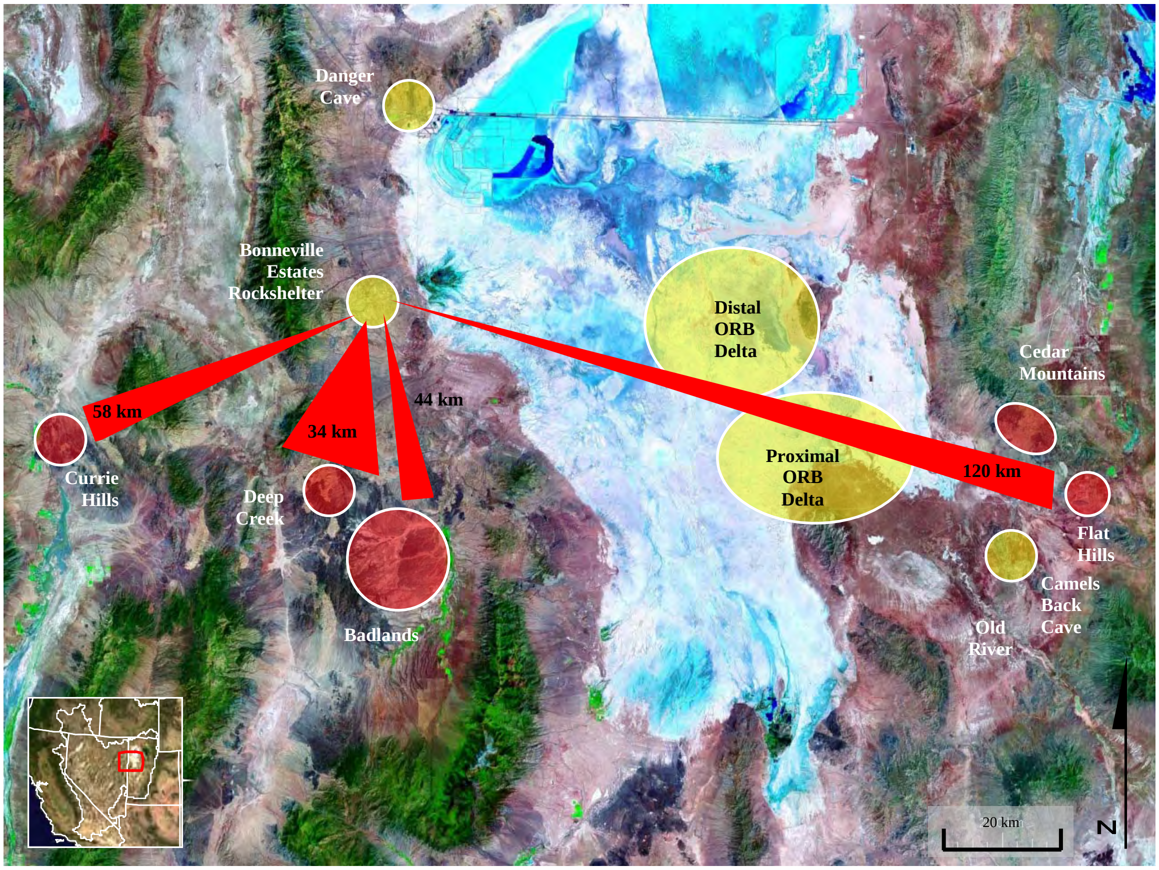

Figure 45. Distance and direction to known FGV sources represented in the BER sample. Arrow size indicates frequency: (large) > 15%; (intermediate) 5-15%; (small) < 5% (base image source: http://worldwind.arc.nasa.gov).

5.22 Danger Cave

Artifact counts by toolstone type from DC are not easily quantified. Accounts of the material culture assert that the use of 'basalt' was "not common but occurred at all levels; there is a slight tendency for the basalt to be more popular in the early history of the site" (Jennings 1957:100). FGV accounts for an unknown amount of the DC Paleoindian lithic assemblage, but it is assumed to compose a significant portion based on the abundant early materials available for sourcing.

The majority of FGV in the Paleoindian-age sample is from western sources (ca. 88 %) that occur between 67 and 78 km south of the site (Figure 47). More than a third

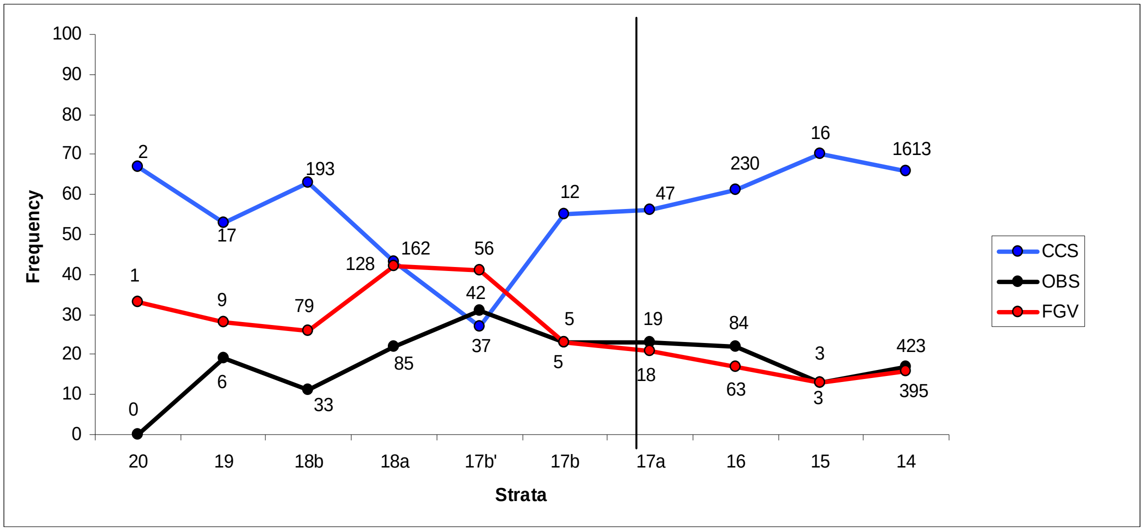

Figure 46. Paleoindian and Early Archaic (left and right of vertical line) CCS, obsidian, and FGV toolstone use at BER (frequency shown on Y-axis and counts shown at points on lines) (Goebel 2007).

originates from BLA (44 %) at ca. 70 km, ca. 18 % from DCA and ca. 12 % from DCD, both at ca. 67 km, and ca. 15 % from CH at ca. 78 km. There is also limited use of the eastern source variant, FHE (ca. 6 %) at 125 km to the southeast and moderate use of two unknown sources (ca. 6 %). The trend of local source use appears clear with the majority of toolstone originating from several of the nearest available sources of toolstone-quality FGV. As is the case at BER, other sources of FGV were available closer to the cave (e.g., Deep Creek FGV variants can be found in the same region as Badlands FGV) but for unknown reasons these were not as frequently selected for use.

FGV use in the Early to Middle Archaic seems to be less than during the Paleoindian period. The overall amount of general use is presumed to decrease, and the number of sources represented also decreases and becomes less diverse to include fewer western sources, continued but less use of one eastern source, and no use of any unknown sources. This period of later use during the Archaic shows some changes in source use but this may be influenced by the items selected for sourcing (all projectile points). Results show continued use of three western sources, with more than ca. 62 % of the FGV originating from DCA. There is also moderate use of BLA at ca. 15 % and CH at ca. 15 %. In total, western sources make up more than 92 % of the Archaic assemblage. Only one tool was made from material deriving from an eastern source (FHE at ca. 8 %) and there was no evidence of unknown source use within this portion of the sample.

The average transport distance from known sources to the site at the time of tool discard was ca. 69 km for Paleoindian and 74 km Early Archaic use. Looking to only projectile points from the Paleoindian strata (n=7), to make a more even comparison (only points were sampled from the later materials), Paleoindian transport distance is reduced to 69.9 km in comparison to 73.6 km for the Early Archaic, thus showing a minor increase in transport distance through time.

5.23 Camels Back Cave

FGV comprises a small constituent of the total lithic assemblage within CBC. Including debitage, flake tools, bifaces, and projectile points (9,667 artifacts within the reported lithic assemblage) its use equates to a meager 4.6 % overall, compared to obsidian at 64.8 %, CCS at 17.6 %, and quartzite at 10.6 % (Elston 2005; Schmitt and Madsen 2005). Pair this small number against the close distance from CBC to the Flat Hills source, just ca. 20 km to the northeast and you have evidence of diminished FGV use within and throughout the Archaic period. Even though FGV use in the Early Archaic is limited compared with the use of other material types, these early occupations account for more than 80 % of the FGV tools at the site. Within the cave’s assemblage,

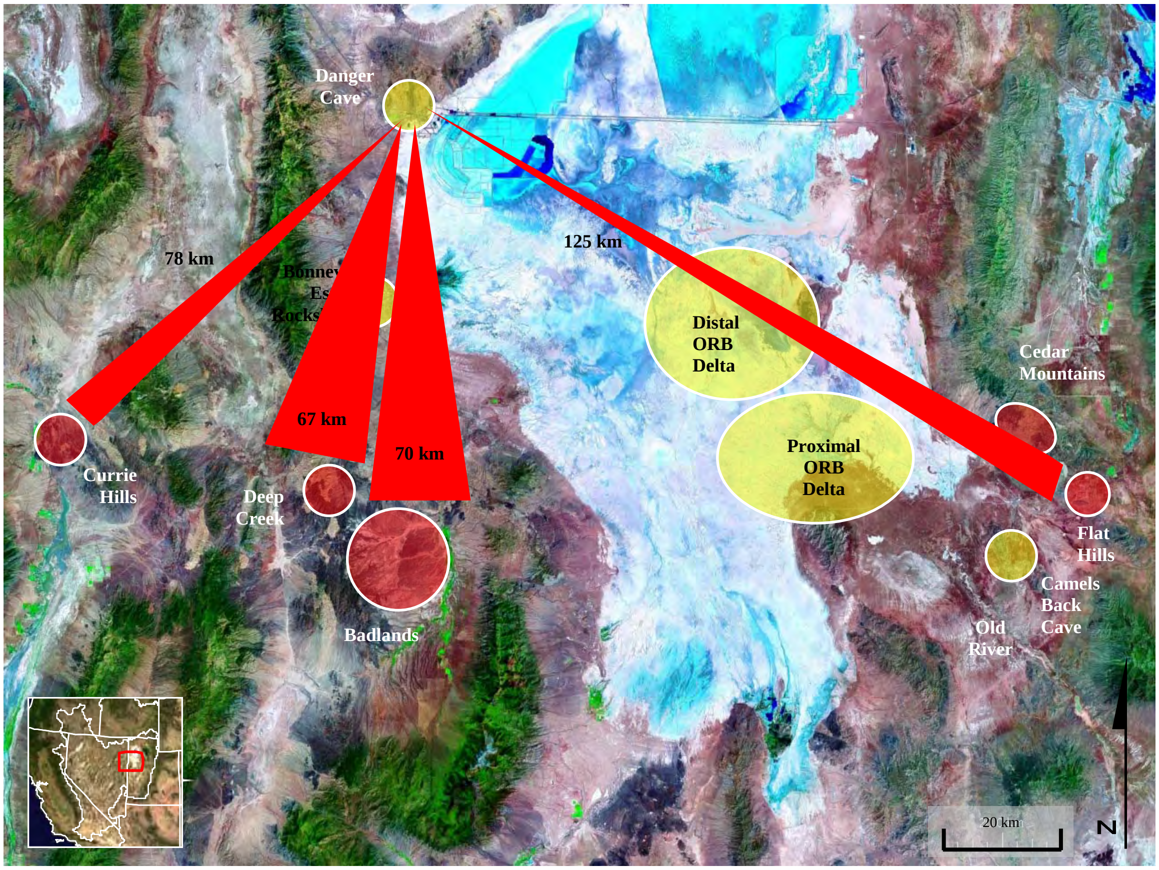

Figure 47. Distance and direction to known FGV sources represented in the DC sample. Arrow size indicates frequency: (large) > 15%; (intermediate) 5-15%; (small) < 5% (base image source: http://worldwind.arc.nasa.gov).

B. Elston noted a “drastic decease in basalt and quartzite use after about 6,200 B.P.” (Elston 2005:135). This reduction in FGV use becomes even more apparent during the last 5,000 radiocarbon years of occupation from the Middle Archaic through Late Prehistoric where there were only five FGV tools recorded (ca. 18 % of all FGV tools).

The majority of FGV in the Early Archaic sample originates from four eastern source variants, FHA (ca. 67 %), FHC (ca. 13 %), FHD (ca. 4 %), and FHE (ca. 4 %) located ca. 20 km northeast of the site (Figure 48). There is also limited use of the two western source variants; BLA (ca. 8 %) and DCA (ca. 4 %) located 97 km and 105 km to the west, respectively. The trend of local source use appears clear with the majority of toolstone originating from several of the nearest available sources of toolstone-quality FGV.

FGV use in the later sample (Middle Archaic through Late Prehistoric period) is less than during the Early Archaic period. The overall amount of general use decreases, and the number of sources represented also decreases and becomes less diverse to include fewer eastern sources and fewer western sources and no use of any unknown sources. This period of later use shows some changes in source use but this may be influenced by small sample size available for sourcing. Results show continued use of FHA (80 %) and BLA (20 %). As is the case at the other sheltered sites, other sources of FGV were available closer to the cave (e.g., various FH variants) but for unknown reasons these were not selected for use.

The average transport distance from known sources to the site at the time of tool discard increased from 30 km for Early Archaic use to 35.4 km for Middle Archaic through Late Prehistoric use. This figure is skewed with a small sample size from the later assemblage. Most of the materials originate from the eastern source area early on (87.5 % from Flat Hills variants) and the remaining materials originate from the western source area (12.5 % from BLA and DCA), while 80 % (n=4) of later materials originated from FHA and 20 % (n=1) from BLA, showing a similar distribution of eastern to western source use, although dramatically reduced overall.

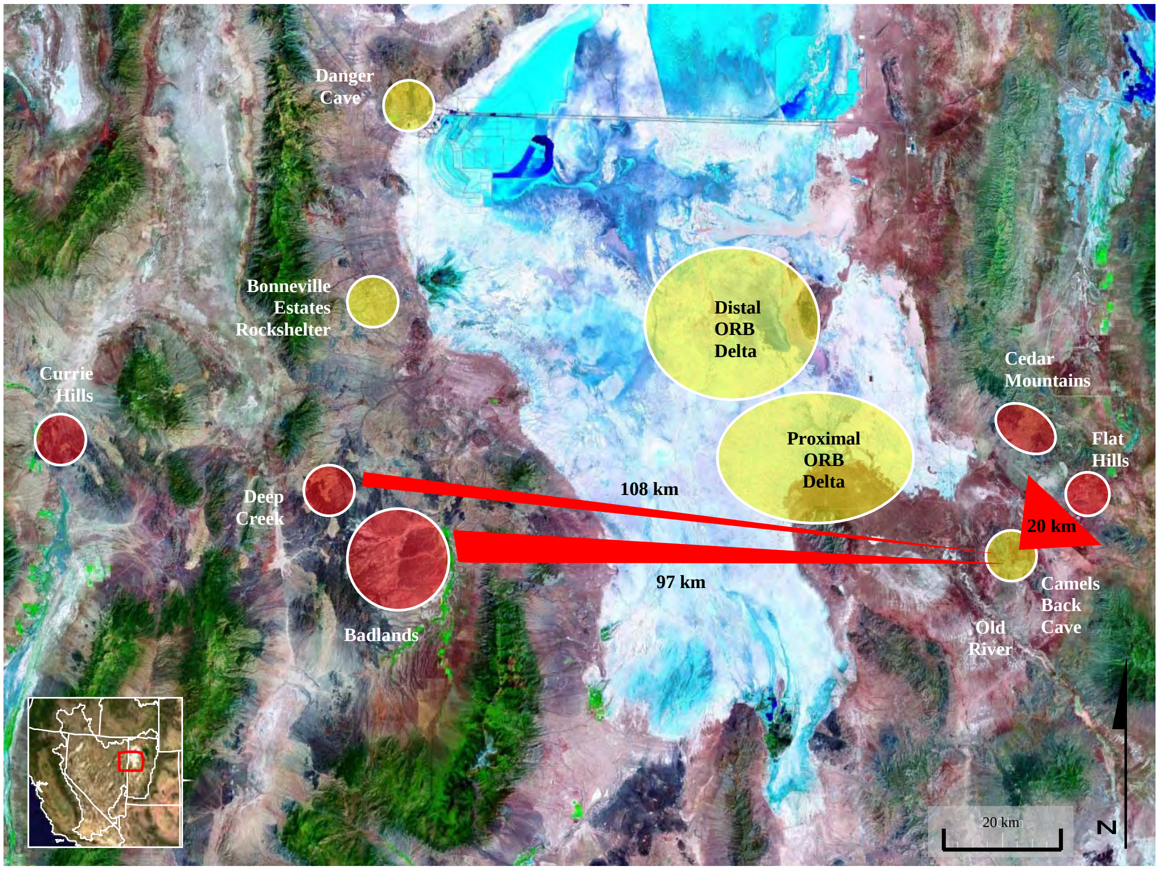

Figure 48. Distance and direction to known FGV sources represented in the CBC sample. Arrow size indicates frequency: (large) > 15%; (intermediate) 5-15%; (small) < 5% (base image source: http://worldwind.arc.nasa.gov).

5.3 Use of Unknown FGV

Just over 3 % of all materials analyzed returned unknown FGV sources (19 of 587 sourced artifacts) (Figure 49). As addressed in Chapter 4, these geochemical results were plotted, interpreted, and classified as 14 different unknowns. Of these, three were identified by multiple artifacts, often shared in different sites across the region, thus allowing for speculation as to the whereabouts of the source locations. The remaining 11 unknowns are unique and were only identified by single artifacts within the region. The location of these numbered unknown sources will likely remain unknown for some time unless the amount of regional sourcing increases dramatically, or the amount of geologic mapping and other field investigations noticeably increase, or they are discovered by chance.

Looking first at the sheltered sites included in this study there were approximately 4 % unknowns present. At Danger Cave, only two artifacts (5.9 % of the Paleoindian sample) were made of unknown source materials (Unknown 4 and B). Unknown B is also found in the proximal ORB Paleoindian sample. The remaining unknown is unique to Danger Cave and has not been identified in any of the other sourced materials from the region. At Bonneville Estates, only one artifact (6.3 % of the Early Archaic/Middle Archaic sample) was made of unknown source material (Unknown 5). This unknown is unique to BER and has not been identified in any of the other sourced materials from the region. No unknowns were identified in the FGV sampled from Camels Back Cave.

In the open sites included in this study there were approximately 4 % unknowns present. In the proximal ORB delta, six artifacts (2 % of the Paleoindian sample) were made of unknown source materials (Unknown 1, 11, A, B, and C). Unknown A is also found in the distal ORB Paleoindian sample and the DPG Archaic sample. Unknown B is also found in the DC Paleoindian sample. Unknown C is found in multiple sites in the proximal ORB Paleoindian sample.

In the distal ORB delta, eight artifacts (5.2 % of the Paleoindian sample) were made of unknown source materials (Unknown A, 2, 6, 7, 8, 9, and 10). Unknown A is also found in the proximal ORB Paleoindian sample and the DPG Archaic sample. In the Archaic sample from DPG, two artifacts (5.1 % of the sample) were made of unknown source materials (Unknown A and 3). Finally, Unknown A is also found in the proximal and distal ORB Paleoindian samples.

Figure 49. Distribution of Unknowns across sites in study area (red dots are sheltered sites, white dots and black circles are surface sites/site clusters), including those at BER, DC, the distal and proximal ORB delta, and in several Archaic sites sampled (base image source: ESRI MODIS from www.geographynetwork.com).

5.4 Variable Use of FGV Through Time and Space

During the latest Pleistocene/early Holocene, there was spatial variability in the FGV sources used across the region and variability in the frequency of sources used by prehistoric populations. Several research objectives were outlined toward the end of

Chapter 1 and these are the same questions that will be addressed below. With the accumulation of much data, both geologic and cultural, we are now in a better position to address them.

The main objective of this study was to better understand the regional sources of FGV toolstone within and around the Bonneville basin and to be able to view the use of these lithic resources in a more meaningful and complete way. This task has been met with great success. There was an immense reduction in the number of unknowns in the sample and a great increase in the understanding of source use across this landscape.

1.) Within the Bonneville basin, is there preferential use of FGV early in prehistory? Are represented FGV geochemical groups (i.e., sources) used differently through time by pre-Archaic and later, Archaic groups?

Without question, there is preferential use of FGV in the earliest periods of occupation in the Bonneville basin of western Utah and eastern Nevada. Sources are used differently by different populations occupying the region at different times over the past 13,000 calendar years. This can be seen in both open sites and sheltered sites and there is preferential use of some materials over others for certain tool types, perhaps specific tasks, and for yet unknown reasons, as evident in the samples analyzed.

2.) How are identified FGV materials moving around the landscape? Does FGV use fit current models of “local vs. extra-local” toolstone use?

Source use in the surface sites in the middle of the basin is markedly different than use in the sheltered sites, as these open sites are located a great distance away from any sources of lithic raw material, with exception of small pebbles of CCS and quartzite sporadically available in the deltaic channel fill, which were infrequently used. In this area, there are no “local” FGV materials. Raw materials are moving long distances to the sites at the center of the basin, but this area still fits the general pattern of more localized source use. In the sample of sheltered sites, these sites occurred toward the edges of the basin in closer proximity to sources of toolstone-quality FGV. Most frequently, across the sample, FGV was selected from the pool of “local” nearest available sources with limited use of other, more distant, “extra-local” sources.

3.) Can varied source use be attributed to any physical properties of the raw materials themselves? Is choice related to mechanical qualities of represented rock types (e.g., basalt, andesite, dacite, rhyolite, etc.) and their flakability, durability, or general availability?

FGV sources and raw materials are not equal. The most important factor differentiating fine-grained volcanic rock types in this context is silica content (e.g., andesite contains less silica than dacite). As a result of physical differences and rock mechanics, various FGV rock types display different patterns of use in artifact classes across the sample (see Tables 19-24). These data are limited by sample size in many cases but can be explored statistically when the numbers allow. For example, there are sufficient samples to compare the use of andesite and dacite in projectile point and biface production during the Paleoindian period in ORB delta sites (Table 25).

Table 19. FGV sources by artifact class represented in the proximal ORB delta sample.

	Artifact Class														
	Projectile Point		Biface		Scraper		Graver/Drill		Flake Tool		Core		Flake		
Source	N	%	N	%	N	%	N	%	N	%	N	%	N	%	Total
Deep Creek A	14	8.3	1	1.9			1	50							16
Deep Creek D															
Badlands A	10	6	6	11.5	5	10							2	22.2	23
Currie Hills	2	1.2	1	1.9	1	2									4
Flat Hills A	70	41.7	17	32.7	18	36	1	50	7	46.7			1	11.1	114
Flat Hills C	2	1.2											2	22.2	
Flat Hills D	50	29.8	25	48.1	24	48			7	46.7	1	100	4	44.4	111
Flat Hills E	9	5.4			1	2									10
Cedar Mountain B	6	3.6	2	3.8					1	6.7					9
Cedar Mountain H															
Unknowns	5	3			1	2									6
Total	168		52		50		2		15		1		9		297

Table 20. FGV sources by artifact class represented in the distal ORB delta sample.

	Artifact Class														
	Projectile Point		Biface		Scraper		Graver/Drill		Flake Tool		Core		Flake		
Source	N	%	N	%	N	%	N	%	N	%	N	%	N	%	Total
Deep Creek A	13	15.5	2	3.8			1	100							16
Deep Creek D			2	3.8											2
Badlands A	9	10.7	9	17.3											18
Currie Hills	2	2.4			1	25							1	14.3	4
Flat Hills A	18	21.4			1	25							2	28.6	21
Flat Hills C	2	2.4	1	1.9											3
Flat Hills D	30	35.7	31	59.6	1	25			5	100	2	100	4	57.1	73
Flat Hills E	4	4.8	4	7.7											8
Cedar Mountain B															
Cedar Mountain H	1	1.2			1	25									2
Unknowns	5	6	3	5.8											8
Total	84		52		4		1		5		2		7		155

Table 21. FGV sources by artifact class represented in the DPG Archaic site sample.

	Artifact Class														
	Projectile Point		Biface		Scraper		Graver/Drill		Flake Tool		Core		Flake		
Source	N	%	N	%	N	%	N	%	N	%	N	%	N	%	Total
Deep Creek A	9	52.9	4	50	1	14.3									14
Deep Creek D															
Badlands A	2	11.8	1	12.5	3	42.9					1	50			7
Currie Hills	2	11.8	1	12.5	1	14.3									4
Flat Hills A	2	11.8	1	12.5					1	25					4
Flat Hills C			1	12.5					1	25					2
Flat Hills D					1	14.3	1	100	2	50					4
Flat Hills E	1	5.9													1
Cedar Mountain B					1	14.3									1
Cedar Mountain H															0
Unknowns	1	5.9									1	50			2
Total	17		8		7		1		4		2				39

Table 22. FGV sources by artifact class represented in the Bonneville Estates Rockshelter sample.

	Artifact Class														
	Projectile Point		Biface		Scraper		Graver/Drill		Flake Tool		Core		Flake		
Source	N	%	N	%	N	%	N	%	N	%	N	%	N	%	Total
Deep Creek A	6	60	5	71.4	1	100			4	100					16
Deep Creek D															
Badlands A	1	10													1
Currie Hills	2	20	1	14.3											3
Flat Hills A															
Flat Hills C															
Flat Hills D	1	10													1
Flat Hills E															
Cedar Mountain B															
Cedar Mountain H															
Unknowns			1	14.3											1
Total	10		7		1				4						22

Table 23. FGV sources by artifact class represented in the Danger Cave sample.

	Artifact Class														
	Projectile Point		Biface		Scraper		Graver/Drill		Flake Tool		Core		Flake		
Source	N	%	N	%	N	%	N	%	N	%	N	%	N	%	Total
Deep Creek A	10	50	4	36.4											14
Deep Creek D	1	5			2	18.2	1	100							4
Badlands A	5	25	4	36.4	5	45.5			3	75					17
Currie Hills	3	15	2	18.2	1	9.1			1	25					7
Flat Hills A															
Flat Hills C															
Flat Hills D															
Flat Hills E	1	5			2	18.2									3
Cedar Mountain B															
Cedar Mountain H															
Unknowns			1	9.1	1	9.1									2
Total	20		11		11		1		4						47

Table 24. FGV sources by artifact class represented in the Camels Back Cave sample.

	Artifact Class														
	Projectile Point		Biface		Scraper		Graver/Drill		Flake Tool		Core		Flake		
Source	N	%	N	%	N	%	N	%	N	%	N	%	N	%	Total
Deep Creek A	1	14.3													1
Deep Creek D															
Badlands A			2	15.4	1	50									3
Currie Hills															
Flat Hills A	5	71.4	8	61.5	1	50			6	85.7					20
Flat Hills C	1	14.3	2	15.4											3
Flat Hills D									1	14.3					1
Flat Hills E			1	7.7											1
Cedar Mountain B															
Cedar Mountain H															
Unknowns															
Total	7		13		2				7						29

Table 25. Chi-square tests for andesite and dacite projectile points and bifaces in the proximal and distal ORB delta samples (note that trachyandesite is included in counts of 'andesite' and trachydacite is included in counts of 'dacite'). Expected counts are printed below observed counts, chi-square contributions are printed below expected counts.

Proximal ORB delta
Chi-Square Test: projectile points, bifaces

	PROJECTILE POINTS	BIFACES	Total
ANDESITE	82 88.09 0.422	34 27.91 1.331	116
DACITE	79 72.91 0.509	17 23.09 1.608	98
Total	161	51	214

χ^2 = 3.870, DF = 1, P-Value = 0.049

Distal ORB delta
Chi-Square Test: projectile points, bifaces

	PROJECTILE POINTS	BIFACES	Total
ANDESITE	55 61.11 0.611	45 38.89 0.960	100
DACITE	22 15.89 2.350	4 10.11 3.694	26
Total	77	49	126

χ^2 = 7.615, DF = 1, P-Value = 0.006

For simplicity and to bolster small sample sizes for assemblages included in this exercise, trachyandesite is included in tallies of andesite and trachydacite is included in tallies of dacite. Differences in andesite and dacite usage in assemblages of the same approximate age in the proximal and distal ORB delta were significant at the 0.05 confidence level for chi-square. For both the proximal and distal ORB delta assemblages, projectile points are made of dacite (higher silica content than andesite) more than expected while they are made on andesite less often than expected for both case. Bifaces in these sites are made of andesite (lower silica content than dacite) more than expected and of dacite less than expected. This simple exercise entertains the idea that amount of silica content (directly tied to FGV rock type) and specific sources (localities) were targeted in the production of specific artifact classes within the study area.

Geologic sources occur at differing distances from sites. Their geochemical and physical makeup provides some with advantages of increased durability and flakability. Geologic formation processes and post-depositional transport dictate size and shape availability to hunter-gatherer groups. Selection for use may have been dictated by many factors including, but not limited to, knapper preference, foraging territories, topographic and hydrologic constraints, and lithic raw material constraints and variability.

5.5 Summary

Addressing toolstone use is a complicated issue. One must consider many factors that contribute to the complex system of hunter-gatherer adaptive behavior. Sourcing results provide the ability to measure the distance a rock moved from its original geologic location. It does not tell whether this piece of stone was directly procured by a mobile or sedentary individual or group, indirectly procured by a mobile or sedentary individual or group in the round of other subsistence related activities, or whether it was acquired through exchange/trade by a mobile or sedentary individual or group, etc. Looking at general source use across the region during the Paleoindian and into the Early Archaic, there appears to be an expansion in the number of sources used through time with more diversity in FGV material types used in later sites. Depending on the site, there seems to be a broadening in range (longer movements between sources and sites) through time and a change in source preferences. This is based on an increased average transport distance of FGV through time, although this does not hold true for BER where there seems to be a reduction in FGV transport distance through time, but this difference is likely due to the small Paleoindian sample studied. In addition, there is a pattern of abundant FGV use early on (Paleoindian/Early Archaic) then a trend of rapidly diminished FGV use through time (post-Early/Middle Archaic).

Chapter 6

Conclusions

Within the Bonneville basin of western Utah and eastern Nevada, there are many sources of FGV rock that were used in the prehistoric production of stone tools. Still, there is a small constituent of geologic sources that have not yet been identified, but these seem to have played a minor role in archaeological tool production in the region. The peak use of these regional FGV sources occurred in the Paleoindian period but extended through the Early Archaic period. FGV use dramatically decreased after the Early Archaic period, eventually being replaced almost entirely by CCS and other raw materials.

When FGV use is prevalent during the Paleoindian and Early Archaic periods, sources seem to be used in similar fashion with closest sources contributing in greatest frequency and more distant sources accounting for lower frequencies. After peak use (post-Paleoindian period) there appears to be an expansion of the number of sources used, as well as an increase in diversity in volcanic rock type represented in the Early Archaic record. It is unclear what caused this boom/expansion in source use; it is possibly due to changes in mobility and land use patterns, an increase in population size with individuals mapping onto additional source materials in conjunction with other activities, or perhaps trade and/or exchange of raw materials between groups. Whatever the reasons, something caused a dramatic shift is reliance on FGV after the surge and its use fell out of fashion and was no longer selected for use in frequencies known from earlier times in prehistory.

6.1 Implications

Previous knowledge of obsidian sources provided the ability to view obsidian toolstone use across this part of the Great Basin. With the mapping and characterization of these 24 FGV sources/source variants in western Utah and eastern Nevada we are now allowed a more complete picture of Paleoindian and Early Archaic hunter-gatherer behavior, especially in regard to toolstone acquisition and use.

The term ‘basalt’ is used extensively in the western USA at large and is prevalent in the literature when describing non-glassy, dark-colored, non-vesicular, volcanic rocks. It is interesting to note that no true basalts were identified in the cultural sample and seem to actually be quite rare in flaked stone tools, as basalts are silica-poor compared with these other types of FGV (e.g., ‘basalt’ used in Sierra Nevada Martis Complex sites as described by Duke 1998 is actually andesite and dacite; Duke personal communication 2008); thus basalt-like materials in this study have been referred to under the more general blanket term, FGV. It would be more appropriate, in light of this research, to continue using this or another alternate term when referencing ‘basalt’-like lithic materials in the future.

6.2 Future Research

Several possibilities for future research were identified along the way that may warrant further investigation. The completion of these tasks or the exploration of these avenues was either beyond the scope of this project or beyond the timeframe or budgetary constraints of this master's thesis project.

First, a number of extensive primary reduction "quarry" sites in the various source areas (Flat Hills, Cedar Mountains, Badlands, and Deep Creek source areas) were identified during field reconnaissance but not recorded in detail. It would be beneficial to formally record at least a sample of these sites to provide analysis of technological organization and to gain a better understanding of quarrying activities at the various source locations. This in itself would be a great thesis project for future student research.

Sources of lithic materials are widespread across the region. Many other sources of FGV have been identified in eastern Nevada (see Jones et al. 2003). It is unclear if some of these materials are represented in small quantities in the Bonneville materials. It is also unclear if some of the Bonneville source materials are found in eastern Nevada archaeological assemblages. Additionally, there may be other sources of FGV found in proximity to the many obsidian sources that are represented in the regional record; it is unknown whether these areas have been investigated for FGV source that may have been transported into the region concurrently with obsidian (Figure 50). A broadening of the study area may provide a more complete picture of FGV use. This could be accomplished by investigating movement of FGV into the region from outlying areas, as well as investigating movement of identified sources of FGV out of the region into outlying areas. With a more complete understanding of toolstone movement within an even larger zone, findings could be incorporated into a more detailed regional picture of

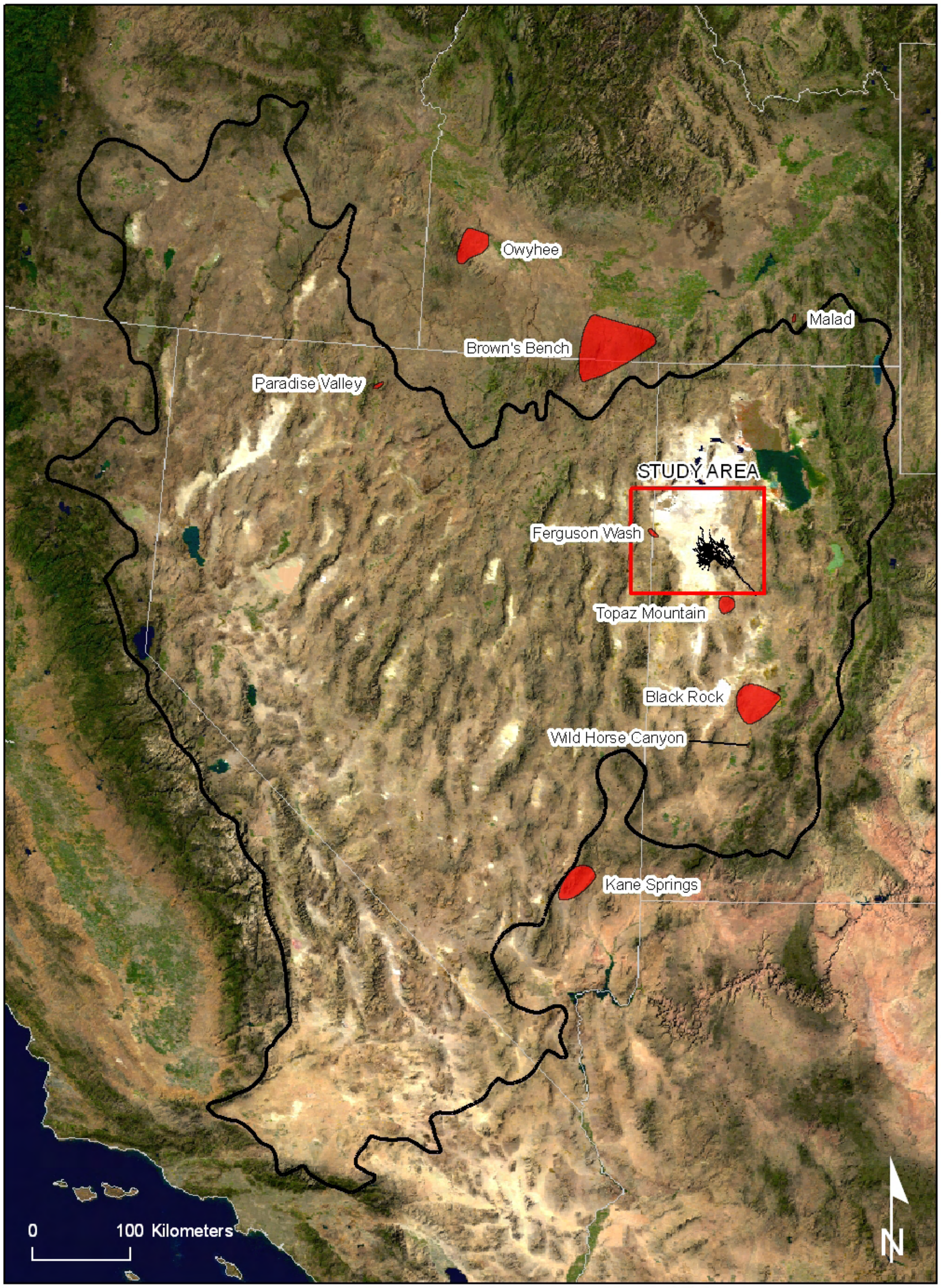

Figure 50. Distribution of obsidian sources represented in sourced materials from Paleoindian sites in the proximal ORB delta (n=161 artifacts). Location of study area shown right of center and black line denotes limits of hydrographic Great Basin (base image source: ESRI MODIS from www.geographynetwork.com).

general toolstone use, perhaps shedding additional light on the established “eastern lithic conveyance zone” (Jones et al. 2003).

6.3 Summary

The main contribution of this study has been its success in identifying geologic sources of toolstone-grade FGV rocks in western Utah and eastern Nevada. A large geochemical database of FGV sources now exists that were previously classified as ‘unknown basalt’. This shift from unknown to known sources has led to a major reduction in the amount of unknown FGV materials, now representing just over 3 % of the regional sample. Also, whole-rock XRF analysis and the plotting of various oxide ratios for major source materials have enabled the identification of the various igneous rock types represented, including andesite, trachyandesite, dacite, and trachydacite.

Next, two previously identified sources, Deep Creek A and Wildcat Mountain, were reexamined and further characterized. Additional information was gathered about both sources, and investigation led to a more complete understanding of these source materials. A primary source location for DCA was identified and the geochemical overlap between Wildcat Mountain and BLA source materials was exposed and clarified.

Finally, there is an ever expanding database of geochemical data for archaeological materials from this portion of the eastern Great Basin (DPG, UTTR, BLM, and other Federal agencies). This growing FGV and obsidian dataset will continue to provide opportunities to address longstanding regional questions of prehistoric resource use, mobility, and land use patterns.

Within the Bonneville basin there was preferential use of FGV early in prehistory with a pattern of abundant FGV use early on (Paleoindian/Early Archaic) then a trend of rapidly diminished FGV use through time (post-Early/Middle Archaic). Paleoindian and later Archaic groups used many of the same FGV sources but these sources were used differently through time. During the Paleoindian period and into the Early Archaic there appears to be an expansion in the number of sources used with more diversity in FGV material types used in later sites. In many of the assemblages studied there is an expansion of range (longer distance between sources and sites) and a change in source preferences through time.

The bulk of FGV in any given assemblage within the study area originated from one or more of the nearest source localities. Raw materials are moving long distances to the sites at the center of the basin, but this central area, although remote still fits the general pattern of more localized source use. FGV use in this part of the eastern Basin has prompted the need to modify what is considered 'local'. If this means materials are being employed in greater frequency between 35 and 75 km of their sources… then FGV in the region fits current models of local toolstone use. Most source materials were used in greatest frequencies at the nearest sites -- with some long distance transport in lower frequencies.

Source selection is a complex issue with many contributing factors, including but not limited to physical and mechanical qualities of the FGV raw materials (e.g., silica content, homogeneity, package size, etc.), access and availability to sources on the landscape, technological and cultural constraints, and individual preference.

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Introduction to Obsidian Characterization Studies

Craig E. Skinner
Northwest Research Obsidian Studies Laboratory
(http://www.obsidianlab.com/info_xrf.html)

INTRODUCTION

Although a variety of physical, optical, petrographic, and chemical attributes are used to characterize volcanic glasses, the use of trace element abundances to "fingerprint" obsidian sources and artifacts has shown the greatest overall success. X-ray fluorescence analytical methods, with their ability to nondestructively and accurately measure trace element concentrations in obsidian, have been widely adopted for this purpose (Harbottle 1982; Rapp 1985; Williams-Thorpe 1995; Glascock et al. 1998; Herz and Garrison 1998; Lambert 1998).

Most geologic sources of obsidian are quite homogeneous in their trace element composition, yet demonstrate adequate intersource variability so that individual sources of glass can be distinguished. Because obsidian can be widely dispersed from its primary geologic source due to a variety of geologic and geomorphic processes, specimens of chemically identical glass are sometimes recovered from outcrops spread over large geographic areas (Hughes 1986; Hughes and Smith 1993). These secondary source boundaries are often not as well documented as primary sources but must be carefully considered in obsidian procurement studies (Shackley 1998; Church 2000). Hughes (1986; 1998) points out that these chemically identical obsidian outcrops must be considered as a single chemical group or chemical type and his terminology is followed here.

From small scale (household and site) to large scale (regional and interregional) levels of analysis, the spatial source patterning of characterized obsidian artifacts is influenced by many different environmental and cultural factors. Interpretation of these patterns can provide valuable information about the prehistoric behavioral and environmental procurement variables responsible for observed artifact distributions. At the site level of analysis, patterns of source use may suggest the presence of specific activity areas, of single tool manufacturing events, or, in special cases, may point to differential access of goods and the existence of non-egalitarian social structures. At the intersite or regional level of investigation, the geographic patterning of artifacts can provide information about seasonal procurement ranges, territorial and ethnic boundaries, the location of trails and travel routes, the curational value of particular sources or formal artifact types, cultural preferences regarding glass quality and colors, the presence of trade and exchange systems, the existence of intergroup interaction, and the exchange of prestige items between elites of different groups (Ericson 1981; Hughes 1978, 1990; Hughes and Bettinger 1984). The effects of environmental influences such as the distance to source, the location of alternative or competing sources of lithic materials, the distribution of raw materials in secondary deposits, or the presence of potential barriers such as mountain ranges, must all be considered. Bias introduced during sampling by certain recovery methods, artifact size, and the use of small numbers of samples may also affect the reconstruction of the spatial patterning of analyzed artifacts.

ANALYTICAL METHODS

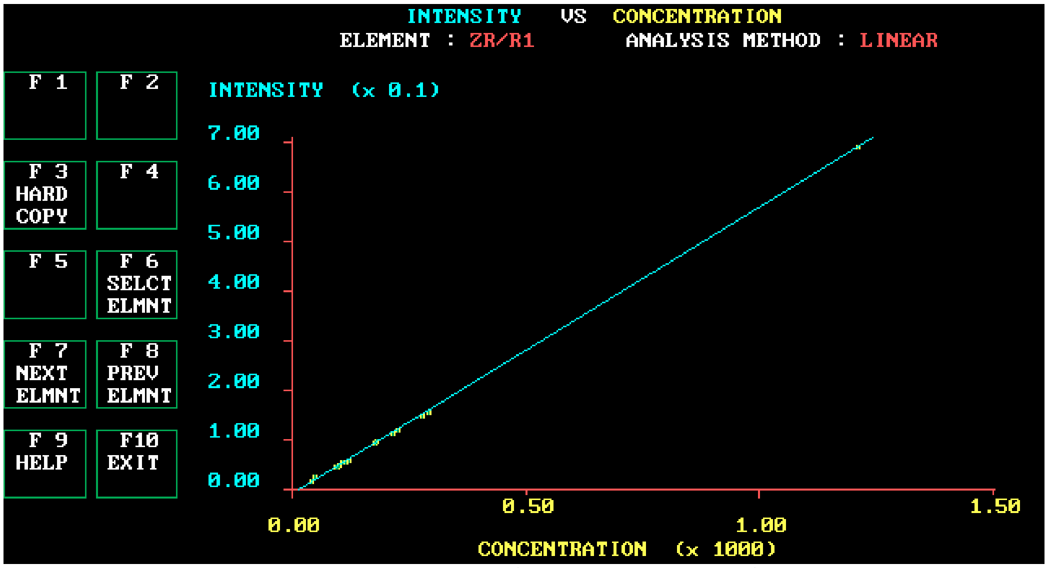
Analysis of samples for different trace element concentrations (Ti, Mn, $Fe_2O_3^T$, Zn, Ga, Rb, Sr, Y, Zr, Nb, and Ba) is completed using a Spectrace 5000 energy dispersive X-ray fluorescence spectrometer. The system is equipped with a Si(Li) detector with a resolution of 155 eV FHWM for 5.9 keV X-rays (at 1000 counts per second) in an area 30 mm2. Signals from the spectrometer are amplified and filtered by a time variant pulse processor and sent to a 100 MHZ Wilkinson type analog-to-digital converter. The X-ray tube employed is a Bremsstrahlung type, with a rhodium target, and 5 mil Be window. The tube is driven by a 50 kV 1 mA high voltage power supply, providing a voltage range of

4 to 50 kV. The principles of X-ray fluorescence analytical methods are reviewed in detail by Norrish and Chappell (1967), Potts and Webb (1992), and Williams (1987). X-ray fluorescence analytical procedures used in the analysis of all obsidian and basalt samples were originally developed by M. Kathleen Davis (BioSystems Analysis and Northwest Research Obsidian Studies Laboratory).

Mid-Z Suite of Elements

For analysis of the mid-Z elements zinc (Zn), gallium (Ga), lead (Pb), thorium (Th), rubidium (Rb), strontium (Sr), yttrium (Y), zirconium (Zr), and niobium (Nb), the X-ray tube is operated at 30 kV, 0.30 mA (pulsed), with a 0.127 mm Pd filter. Analytical lines used are Zn (K-alpha), Pb (L-alpha), Th (L-alpha), Rb (K-alpha), Sr (K-alpha), Y (K-alpha), Zr (K-alpha) and Nb (K-alpha). For small specimens, an alternate method using a collimator may be used. For this procedure, the X-ray tube is operated at 45 kV and 0.60 mA. Samples are typically scanned for 200 seconds live-time in an air path.

Peak intensities for the above elements are calculated as ratios to the Compton scatter peak of rhodium, and converted to parts-per-million (ppm) by weight using linear regressions derived from the analysis of twenty rock standards from the U.S. Geological Survey, the Geologic Survey of Japan, and the National Bureau of Standards. The analyte to Compton scatter peak ratio is employed to correct for variation in sample size, surface irregularities, and variation in the sample matrix.



Linear calibration regression line used for the quantitative analysis of zirconium.

Fe Suite of Elements

For analysis of the elements titanium (Ti), manganese (Mn), and iron ($Fe_2O_3^T$), the X-ray tube is operated at 12 kV, 0.27 mA with a 0.127 mm aluminum filter. Samples are scanned for 200 seconds live-time in a vacuum path. Analytical lines used are Ti (K-alpha), Mn (K-alpha), and Fe (K-alpha). Concentration values (parts per million for titanium and manganese, weight percent for iron) are calculated using linear regressions derived from the analysis of thirteen standards from the U.S. Geological Survey, the Geologic Survey of Japan and the National Bureau of Standards. However, these values are not corrected against the Compton scatter peak or other scatter region, and we recommend against using them for anything other than approximate concentrations. Iron/titanium (Fe/Ti) and iron/manganese (Fe/Mn) peak ratios are supplied for use as corrected values.

A word of caution about titanium, manganese and iron concentration values (i.e., titanium ppm, manganese ppm, and iron weight percent) - as mentioned above, these values are not corrected against the Compton scatter peak or other scatter region, resulting in lower than normal trace element values for small samples that fall below the minimum size requirement. The absence of a spectral reference also means that these values are subject to matrix effects errors. To compensate for these effects, iron-manganese and iron-titanium peak ratios are provided for use as corrected values. To ensure comparability among samples of different sizes, source assignments in all reports are based upon these ratios, and not on the absolute concentration values.

Ba Suite of Elements

For analysis of the elements barium (Ba), lanthanum (La) and cerium (Ce), the X-ray tube is operated at 50 kV, 0.25 mA with a 0.63 mm copper filter in the X-ray path. Analytical lines used are Ba (K-alpha), La (K-alpha), and Ce (K-alpha). Samples are scanned in an air path for 100 to 600 seconds live-time, depending upon trace element concentration.

Trace element intensities are calculated as ratios to the Bremsstrahlung region between 25.0 and 30.98 keV, and converted to parts-per-million by weight using a polynomial fit routine derived from the analysis of sixteen rock standards from the U.S. Geological Survey and the Geologic Survey of Japan. It should be noted that the Bremsstrahlung region corrects for sample mass only and does not account for matrix effects. All samples are scanned as unmodified rock specimens. Reported errors represent counting and fitting error uncertainty only, and do not account for instrumental precision or effects related to the analysis of unmodified obsidian. When the latter effects are considered, relative analytical uncertainty is estimated to be between three and five percent.

FINE-GRAINED VOLCANICS (FGV'S)

Although their geochemical range of variability may be greater than obsidian, artifacts composed of fine-grained volcanic material (FGV's; i.e., basalts, andesites, rhyolites) can often be similarly successfully characterized. The nondestructive analysis of FGV's is limited to dense fine-grained samples free of phenocrysts or other inclusions. Outcrops of FGV's, however, are generally more common and more geographically widespread than those of obsidian and it is likely that in most geographic areas we will *not* be able to assign specific geologic sources to artifacts. For more information about FGV characterization methods and our ongoing Tahoe National Forest region project, click HERE.

PREPARATION

For best results, samples selected for XRF analysis should be no less than 10 mm in diameter and a minimum of 1.5 mm in thickness. Slightly smaller samples (7-10 mm in diameter and 0.5-1.5 mm thick) will show some distortion in element values but may still be reliably characterized (using a collimator) in many cases. In any case, the use of small specimens is not recommended in complex source areas or regions where the source universe is poorly understood.

The surface of the items to be analyzed should be clean and preferably free from labels or residues - a simple wash with tap water and a toothbrush will usually suffice. However, if artifacts already have painted sample numbers, the numbers may be left intact - even when paint is removed, some residue is left behind and it's better if the location of the number is obvious. Interference to the analysis by paint, when it occurs, is usually reflected in elevated levels of titanium, zinc, or lead.

NONDESTRUCTIVE XRF

In traditional X-ray fluorescence trace element studies, samples are powdered and pelletized before analysis (Norrish and Chappell 1967; Potts and Webb 1992). In theory, the irregular surfaces of most obsidian artifacts should induce measurement problems related to shifts in artifact-to-detector reflection geometry (Hughes 1986:35). Early experiments with intact obsidian flakes by Robert N. Jack, and later by Richard Hughes, however, indicate that analytical results from lenticular or biconvex obsidian surfaces are comparable to those from flat surfaces and pressed powder pellets, paving the way for the nondestructive analysis characterization of glass artifacts (Hughes 1986:35-37; Jack 1976). The minimum optimal sample size for analysis has been found to be approximately 10 mm in diameter and 1.5-2.0 mm thick. Later experimental studies conducted by Shackley and Hampel (1993) using samples with flat and slightly irregular surface geometries have corroborated Hughes' initial observations. In a similar experiment, Jackson and Hampel (1993) determined that for accurate results the minimum size of an artifact should be about 10 mm in diameter and 1.5 mm thick. Details about the effects of sample size and surface geometry are discussed in detail by Davis et al. (1998). Agreement between the U. S Geological Survey standard RGM-1 (Glass Mountain obsidian) values and obsidian test samples was good at 1 mm thickness and improved markedly to a thickness of 3 mm.

CORRELATION

The diagnostic trace element values and ratios (these may typically include Ti, Mn, $Fe_2O_3^T$, Zn, Rb, Sr, Y, Zr, Nb, and Ba) used to characterize the samples are compared directly to those for known obsidian sources such as those reported in the literature and with unpublished trace element data collected through analysis of geologic source samples . Artifacts are correlated to a parent obsidian source or chemical source group if diagnostic trace element values fall within about two standard deviations of the analytical uncertainty of the known upper and lower limits of chemical variability recorded for the source. Occasionally, visual attributes are used to corroborate the source assignments although sources are never assigned on the basis of only megascopic characteristics. Diagnostic trace elements, as the term is used here, refer to trace element abundances that show low intrasource variation and uncertainty along with distinguishable intersource variability. In addition, this refers to elements measured by X-ray fluorescence analysis with high precision and low analytical uncertainty. In short, diagnostic elements are those that allow the clearest geochemical distinction between sources. Trace elements generally refer to those elements that occur in abundances of less than about 1000 ppm in a sample. For simplicity in this report, we use the term synonymously with major and minor elements such as iron, titanium, and manganese, which may be present in somewhat larger quantities.

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Appendix B: XRF Data for Geologic Samples

Geologic Samples; Cedar Mountains, Tooele County, Utah

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
1336-1	NA	Cedar Mountain B	95	23	126	522	37	322	22	4298	510	1222	3.97	63.9	30.7
1336-2	NA	Cedar Mountain B	73	34	131	522	39	319	22	4911	530	1361	4.27	65.9	29.0
1336-3	NA	Cedar Mountain B	96	31	130	519	34	326	20	3991	742	1377	3.61	39.9	30.2
1336-4	NA	Cedar Mountain B	80	26	134	511	34	325	22	4143	795	1375	3.83	39.4	30.8
1336-5	NA	Cedar Mountain B	92	30	130	515	36	321	18	3858	651	1373	3.63	45.6	31.3
1296-1	NA	Cedar Mountain I	77	32	163	576	32	271	16	3523	503	1440	3.34	54.6	31.6
1296-2	NA	Cedar Mountain B	78	30	126	502	37	318	19	3950	700	1394	3.62	42.3	30.5
1296-3	NA	Cedar Mountain C	105	22	160	571	41	359	21	4543	636	1470	3.95	50.7	28.9
1296-4	NA	Cedar Mountain A	55	28	147	491	30	271	20	2687	382	1440	2.61	56.8	32.5
1296-5	NA	Cedar Mountain A	50	30	147	476	29	276	18	2976	544	1631	2.84	43.0	31.8
1296-6	NA	Cedar Mountain A	79	27	143	486	32	272	19	3217	491	1511	3.09	51.9	32.1
1296-7	NA	Cedar Mountain A	75	34	149	484	27	274	20	3136	577	1605	3.10	44.2	33.0
1296-8	NA	Cedar Mountain B	75	22	127	489	38	305	17	3636	442	1390	3.36	62.6	30.8
1296-9	NA	Cedar Mountain B	74	30	134	495	34	312	20	4334	554	1391	4.12	60.9	31.6
1296-10	NA	Cedar Mountain B	67	26	132	512	34	313	20	4062	614	1348	3.70	49.4	30.4
1296-11	NA	Cedar Mountain B	68	26	128	499	34	312	17	3668	433	1354	3.40	64.7	30.9
1296-12	NA	Cedar Mountain A	68	53	150	532	27	252	19	3317	387	1403	3.64	77.4	36.5
1296-13	NA	Cedar Mountain A	52	35	154	512	33	276	18	3971	401	1486	3.48	71.6	29.3
1296-14	NA	Cedar Mountain H	76	25	169	526	35	299	19	3844	458	1480	3.19	57.3	27.7
1296-15	NA	Cedar Mountain F	60	29	233	455	27	235	14	3539	500	1457	3.42	56.2	32.2
1296-16	NA	Cedar Mountain G	78	31	152	537	28	212	16	2958	568	1373	2.63	38.2	29.8
1296-17	NA	Cedar Mountain B	85	25	137	527	38	318	19	4392	484	1456	3.74	63.4	28.4
1296-18	NA	Cedar Mountain E	73	35	112	468	36	299	17	4177	486	1406	3.73	63.0	29.8
1296-19	NA	Cedar Mountain B	63	33	132	509	35	315	20	4230	477	1434	3.67	63.2	28.9
1296-20	NA	Cedar Mountain B	83	24	128	496	35	310	13	4289	591	1354	3.93	54.4	30.5
1296-21	NA	Cedar Mountain B	82	27	134	524	38	320	20	4175	643	1415	3.66	46.7	29.2
UR-19	NA	Cedar Mountain A	51	28	160	446	28	244	21	2925	427	1345	2.56	49.6	29.3
UR-20	NA	Cedar Mountain A	58	26	154	488	25	272	15	3477	648	1508	3.21	40.7	30.8
1335-1	NA	Cedar Mountain B	117	23	143	525	37	333	20	4174	501	1438	3.67	60.2	29.3
UR-23	NA	Cedar Mountain B	87	85	128	543	41	328	18	5070	3016	1353	4.49	12.1	29.4
†CMA.1	NA	Cedar Mountain A	56	22	151	480	28	248	20	3532	592	1464	3.51	48.7	33.2
†CMB.1	NA	Cedar Mountain D	ND	7	6	48	8	45	1	656	62	249	0.40	66.0	22.5

†(Duke, personal communication 2006)

All trace element values reported in parts per million. Iron content reported as weight percent oxide. NA = Not Available; ND = Not detected; NM = Not measured; * = Small sample

Appendix B: XRF Data for Geologic Samples

Geologic Samples; Flat Hills, Tooele County, Utah

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	$Fe^{2}O^{3T}$	Fe:Mn	Fe:Ti
1335-2	NA	Flat Hills A	82	28	103	671	20	291	14	4869	473	1609	3.92	68.0	26.9
1335-3	NA	Flat Hills A	101	26	99	653	18	293	16	4188	294	1548	3.48	97.8	27.7
1335-4	NA	Flat Hills A	102	32	111	667	15	299	18	4372	485	1524	3.51	59.4	26.8
1335-5	NA	Flat Hills C	80	20	91	729	16	272	15	4249	327	1562	3.79	95.7	29.7
1335-6	NA	Flat Hills A	87	36	102	652	17	284	13	4848	442	1605	4.02	74.7	27.6
1335-7	NA	Flat Hills A	82	40	100	637	17	284	17	4453	326	1532	3.73	94.4	27.9
1335-8	NA	Flat Hills A	89	25	105	643	15	287	15	4620	310	1578	3.88	103.3	28.0
UR-21	NA	Flat Hills A	97	27	101	658	18	303	13	4180	305	1411	3.58	97.0	28.5
UR-22	NA	Flat Hills A	89	28	96	644	21	298	14	3610	382	1453	2.91	63.0	26.9
UR-24	NA	Flat Hills D	103	23	108	381	37	259	23	3585	583	777	4.48	62.8	41.5
UR-25	NA	Flat Hills A	79	27	105	677	20	315	14	4198	335	1492	3.36	82.9	26.7
UR-26	NA	Flat Hills A	85	27	99	646	16	300	15	3234	265	1374	2.64	83.2	27.4
UR-27	NA	Flat Hills E	47	28	216	297	31	249	22	2696	638	1107	3.32	42.7	40.9
UR-28	NA	Flat Hills A	86	24	73	698	22	275	15	5834	597	1965	4.57	62.5	26.1
UR-29	NA	Flat Hills A	108	22	97	637	17	298	16	4379	511	1487	3.82	61.3	29.1
UR-30	NA	Flat Hills D	61	24	96	346	35	242	21	4332	805	879	5.44	55.0	41.6
UR-35	NA	Flat Hills D	85	30	102	383	37	243	23	3653	913	829	4.47	39.9	40.6
UR-36	NA	Flat Hills E	59	33	218	276	31	249	24	1549	316	976	1.97	52.3	42.5
UR-120	NA	Flat Hills C	76	29	99	739	16	269	15	4593	613	1530	3.83	51.2	27.8
UR-121	NA	Flat Hills C	88	18	101	781	20	277	14	4349	359	1461	3.70	85.1	28.4
UR-122	NA	Flat Hills C	74	23	95	729	18	279	12	3851	329	1470	3.41	85.7	29.6
UR-123	NA	Flat Hills C	92	29	91	738	21	273	13	4802	378	1648	4.06	88.2	28.2
UR-124	NA	Flat Hills C	112	26	103	780	17	286	16	4112	342	1536	3.41	82.2	27.7
UR-125	NA	Flat Hills C	104	21	122	820	19	283	15	4412	367	1585	3.62	81.2	27.4

All trace element values reported in parts per million. Iron content reported as weight percent oxide. NA = Not Available; ND = Not detected; NM = Not measured; * = Small sample

Appendix B: XRF Data for Geologic Samples

Geologic Samples; Deep Creek Area, Elko County, Nevada

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
UR-01	NA	Deep Creek A	104	30	91	347	54	361	22	4079	572	1075	4.46	63.7	36.3
UR-02	NA	Deep Creek A	99	20	98	374	52	389	22	3841	495	1103	3.90	64.6	33.8
UR-04	NA	Deep Creek A	92	25	89	313	45	342	23	4017	598	1365	4.51	61.6	37.3
UR-05	NA	Deep Creek A	75	24	92	340	49	366	23	3846	756	1119	4.15	44.8	35.9
UR-07	NA	Deep Creek A	97	21	93	353	51	360	24	3048	401	1086	3.15	64.9	34.4
UR-09	NA	Deep Creek D	84	26	188	392	31	216	12	3888	535	1065	4.49	68.7	38.4
UR-15	NA	Deep Creek A	101	18	78	346	50	337	20	4216	800	1933	4.61	47.0	36.3
UR-17	NA	Deep Creek A	92	24	93	349	49	358	20	4138	718	1057	4.38	49.9	35.2
UR-32	NA	Deep Creek C	74	16	95	318	47	312	20	3996	531	783	4.36	67.1	36.2
UR-34	NA	Deep Creek A	118	21	91	423	52	364	21	3469	515	1222	3.80	60.5	36.4
UR-100	NA	Deep Creek A	77	20	89	348	50	363	19	4393	568	1043	4.66	67.1	35.3
UR-101	NA	Deep Creek A	62	12	92	360	49	351	19	4207	532	1071	4.37	67.1	34.5
UR-103	NA	Deep Creek A	84	23	87	354	50	357	19	4698	720	1187	4.78	54.1	33.8
UR-104	NA	Deep Creek A	82	18	92	362	47	365	17	4255	656	1141	4.36	54.3	34.1
UR-105	NA	Deep Creek A	100	16	97	372	52	369	17	4137	679	1162	4.11	49.5	33.1
UR-106	NA	Deep Creek A	64	20	89	365	56	364	20	4610	724	1182	4.70	52.9	33.9
UR-107	NA	Deep Creek A	78	21	93	338	47	337	18	3981	490	1087	4.29	71.7	35.8
UR-112	NA	Deep Creek A	84	26	98	364	45	367	20	4747	589	1207	4.72	65.4	33.0
DCA.1	NA	Deep Creek A	69	19	82	338	50	356	19	5128	572	1240	5.38	76.5	34.8
DCB.1	NA	Deep Creek B	69	27	83	314	41	285	19	4306	489	890	4.69	78.4	36.2

All trace element values reported in parts per million. Iron content reported as weight percent oxide. NA = Not Available; ND = Not detected; NM = Not measured; * = Small sample

Appendix B: XRF Data for Geologic Samples

Geologic Samples; Badlands Area, Elko County, Nevada

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
UR-06	NA	Badlands A	106	23	166	429	26	183	14	3691	567	1072	4.77	68.7	42.8
UR-08	NA	Badlands A	87	18	193	458	26	215	19	3975	618	1294	4.74	62.6	39.6
UR-10	NA	Badlands A	102	15	185	507	24	203	17	3714	582	1266	4.87	68.3	43.4
UR-11	NA	Badlands A	94	31	178	489	25	210	18	4371	600	1259	4.86	66.2	36.9
UR-12	NA	Badlands B	95	20	163	496	42	307	21	4978	780	1310	4.51	47.2	30.1
UR-13	NA	Badlands A	77	27	144	439	24	184	15	4751	907	1039	5.69	51.0	39.7
UR-14	NA	Badlands A	88	21	188	462	26	208	17	3678	592	1266	4.97	68.5	44.8
UR-16	NA	Badlands A	58	22	153	572	33	210	15	4474	745	2496	4.63	50.6	34.4
UR-31	NA	Badlands A	105	18	182	503	26	189	15	3983	560	1605	4.67	68.2	38.9
UR-33	NA	Badlands A	81	27	181	514	30	225	20	4315	567	1286	4.51	64.9	34.7
UR-102	NA	Badlands A	81	29	171	518	30	198	15	3890	554	1177	4.83	71.2	41.2
UR-108	NA	Badlands A	92	31	194	484	28	198	19	3461	588	1347	4.28	59.5	41.1
UR-110	NA	Badlands A	95	29	181	458	27	212	15	4183	724	1386	5.04	56.7	40.0
UR-111	NA	Badlands A	94	7	189	482	25	190	16	3754	699	1204	4.93	57.5	43.6
UR-113	NA	Badlands A	97	22	184	465	26	195	17	3651	740	1270	4.45	49.1	40.4

All trace element values reported in parts per million. Iron content reported as weight percent oxide. NA = Not Available; ND = Not detected; NM = Not measured; * = Small sample

Appendix B: XRF Data for Geologic Samples

Geologic Samples; Other Sources, Tooele County, Utah; Elko County, Nevada

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
UR-18	NA	Gold Hill Wash	106	ND	32	868	38	296	54	11951	705	1273	6.21	71.6	17.3
UR-109	NA	Little White Horse Badlands	87	25	181	419	22	165	12	4423	799	1005	5.31	54.0	39.8
UR-126	NA	Rydalch Canyon	88	19	90	334	33	236	19	3148	517	820	3.69	58.6	39.0
UR-130	NA	Rydalch Canyon	102	25	89	302	43	273	18	4152	507	878	4.16	67.2	33.3
UR-131	NA	Rydalch Canyon	64	20	88	307	39	255	15	3979	699	868	4.48	52.3	37.4
UR-132	NA	Wildcat Mountain	81	29	197	489	23	212	14	2426	711	1171	3.48	40.2	47.6
UR-133	NA	Wildcat Mountain	77	24	197	467	23	217	13	2739	589	1280	3.63	50.5	44.0
UR-134	NA	Wildcat Mountain	68	17	201	411	25	216	18	2731	602	1317	3.87	52.7	47.0
†WM-1	NA	Wildcat Mountain	66	31	197	393	24	227	14	2987	623	1315	4.33	56.8	48.0
†WM-2	NA	Wildcat Mountain	69	22	194	406	27	230	14	2311	490	1284	3.34	56.1	48.0
†WM-3	NA	Wildcat Mountain	91	30	217	469	27	236	17	2714	518	1319	3.59	56.9	43.9
†WM-4	NA	Wildcat Mountain	68	21	203	440	26	222	18	2746	531	1457	3.61	55.8	43.7
†WM-5	NA	Wildcat Mountain	74	31	194	436	26	220	16	3491	524	1334	4.17	65.2	39.6
†WM-6	NA	Wildcat Mountain	80	24	204	426	28	224	21	2659	508	1351	3.75	60.5	46.7

†(Duke, personal communication 2006)

All trace element values reported in parts per million. Iron content reported as weight percent oxide. NA = Not Available; ND = Not detected; NM = Not measured; * = Small sample

Appendix C: ALS Chemex Report

Geologic Samples; ALS Chemex Report of Whole Rock XRF Analysis
RE07030548 -
Finalized
CLIENT : "PAGDAV - Page David"
# of SAMPLES : 11
DATE RECEIVED : 2007-03-28 DATE FINALIZED : 2007-04-11
PROJECT : Bonneville FGV Sourcing Study
CERTIFICATE COMMENTS :
PO NUMBER :

SAMPLE DESCRIPTION	ME-XRF06 SiO2 %	ME-XRF06 Al2O3 %	ME-XRF06 Fe2O3 %	ME-XRF06 CaO %	ME-XRF06 MgO %	ME-XRF06 Na2O %	ME-XRF06 K2O %	ME-XRF06 Cr2O3 %	ME-XRF06 TiO2 %	ME-XRF06 MnO %	ME-XRF06 P2O5 %	ME-XRF06 SrO %	ME-XRF06 BaO %	ME-XRF06 LOI %	ME-XRF06 Total %
Wildcat Mnt-UR-133	61.16	16.89	5.4	4.41	1.47	3.21	4.11	0.01	0.54	0.09	0.27	0.05	0.15	2.22	99.97
Deep Creek - A- UR-05	60.81	17.09	6.56	5.82	2.08	3.08	2.69	0.02	0.85	0.09	0.2	0.04	0.13	0.36	99.82
Deep Creek - D- UR-09	60.2	17.84	6.69	4.78	1.94	3.16	3.82	0.01	0.8	0.1	0.28	0.04	0.13	0.02	99.81
Cedar Mnt- B- 1336-3	62.09	16.72	5.75	5.46	1.71	2.78	3.44	0.01	0.73	0.09	0.28	0.05	0.16	0.55	99.82
Cedar Mnt- H- 1296-4	60.92	15.71	5	4.93	1.5	2.24	3.72	0.01	0.7	0.07	0.25	0.05	0.16	3.2	98.45
Badlands- A UR-10	57.56	17.67	7.6	5.15	2.42	2.99	3.92	<0.01	0.79	0.11	0.33	0.05	0.14	-0.28	98.45
Badlands- A UR-14	58.79	17.15	7.33	5	2.39	2.94	3.97	<0.01	0.78	0.11	0.3	0.05	0.14	-0.14	98.8
Flathills- A- 1335-8	65.02	15.99	4.63	3.66	2.04	3.81	3.07	<0.01	0.75	0.04	0.24	0.07	0.18	0.13	99.63
Flathills- C- UR-120	62.22	15.44	5.18	4.05	2.92	3.63	3.07	0.02	0.86	0.06	0.3	0.08	0.19	0.19	98.21
Flathills- D- UR-30	60.06	18.4	6.75	5.65	2.14	3.38	2.37	<0.01	0.73	0.1	0.23	0.04	0.1	-0.16	99.79
Flathills- E- UR-36	66.57	15.64	4.48	3.1	1.34	3.07	4.58	0.01	0.48	0.08	0.16	0.03	0.13	0.18	99.85

Appendix C: ALS Chemex Report

ALS Chemex
EXCELLENCE IN ANALYTICAL CHEMISTRY

ALS USA Inc.
994 Glendale Avenue, Unit 3
Sparks NV 89431-5730
Phone: 775 356 5395 Fax: 775 355 0179 www.alschemex.com

To: **PAGE, DAVID**
2215 RAGGIO PARKWAY
RENO NV 89512

Page: 1
Finalized Date: 11-APR-2007
This copy reported on 12-APR-2007
Account: PAGDAV

CERTIFICATE RE07030548

Project:
P.O. No.:
This report is for 11 Rock samples submitted to our lab in Reno, NV, USA on 28-MAR-2007.
The following have access to data associated with this certificate:

DAVID PAGE		

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
CRU-31	Fine crushing - 70% <2mm
SPL-21	Split sample - riffle splitter
PUL-31	Pulverize split to 85% <75 um

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	INSTRUMENT
ME-XRF06	Whole Rock Package - XRF	XRF
OA-GRA06	LOI for ME-XRF06	WST-SIM

The results of this assay were based solely upon the content of the sample submitted. Any decision to invest should be made only after the potential investment value of the claim 'or deposit has been determined based on the results of assays of multiple samples of geological materials collected by the prospective investor or by a qualified person selected by him/her and based on an evaluation of all engineering data which is available concerning any proposed project.

To: **PAGE, DAVID**
2215 RAGGIO PARKWAY
RENO NV 89512

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

Signature:
Keith Rogers, Executive Manager Vancouver Laboratory

Appendix C: ALS Chemex Report

ALS Chemex

EXCELLENCE IN ANALYTICAL CHEMISTRY

ALS USA Inc.
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To: PAGE, DAVID
2215 RAGGIO PARKWAY
RENO NV 89512

Finalized Date: 11-APR-2007
Account: PAGDAV

CERTIFICATE OF ANALYSIS RE07030548

Sample Description	Method / Analyte / Units / LOR	WEI-21 Recvd Wt. kg 0.02	ME-XRF06 SiO2 % 0.01	ME-XRF06 Al2O3 % 0.01	ME-XRF06 Fe2O3 % 0.01	ME-XRF06 CaO % 0.01	ME-XRF06 MgO % 0.01	ME-XRF06 Na2O % 0.01	ME-XRF06 K2O % 0.01	ME-XRF06 Cr2O3 % 0.01	ME-XRF06 TiO2 % 0.01	ME-XRF06 MnO % 0.01	ME-XRF06 P2O5 % 0.01	ME-XRF06 SrO % 0.01	ME-XRF06 BaO % 0.01	ME-XRF06 LOI % 0.01
Wildcat Mnt-UR-133		0.06	61.16	16.89	5.40	4.41	1.47	3.21	4.11	0.01	0.54	0.09	0.27	0.05	0.15	2.22
Deep Creek - A- UR-05		0.10	60.81	17.09	6.56	5.82	2.08	3.08	2.69	0.02	0.85	0.09	0.20	0.04	0.13	0.36
Deep Creek - D- UR-09		0.10	60.20	17.84	6.69	4.78	1.94	3.16	3.82	0.01	0.80	0.10	0.28	0.04	0.13	0.02
Cedar Mnt- B- 1336-3		0.08	62.09	16.72	5.75	5.46	1.71	2.78	3.44	0.01	0.73	0.09	0.28	0.05	0.16	0.55
Cedar Mnt- H- 1296-4		0.02	60.92	15.71	5.00	4.93	1.50	2.24	3.72	0.01	0.70	0.07	0.25	0.05	0.16	3.20
Badlands- A UR-10		0.18	57.56	17.67	7.60	5.15	2.42	2.99	3.92	<0.01	0.79	0.11	0.33	0.05	0.14	-0.28
Badlands- A UR-14		0.22	58.79	17.15	7.33	5.00	2.39	2.94	3.97	<0.01	0.78	0.11	0.30	0.05	0.14	-0.14
Flathills- A- 1335-8		0.34	65.02	15.99	4.63	3.66	2.04	3.81	3.07	<0.01	0.75	0.04	0.24	0.07	0.18	0.13
Flathills- C- UR-120		0.10	62.22	15.44	5.18	4.05	2.92	3.63	3.07	0.02	0.86	0.06	0.30	0.08	0.19	0.19
Flathills- D- UR-30		0.22	60.06	18.40	6.75	5.65	2.14	3.38	2.37	<0.01	0.73	0.10	0.23	0.04	0.10	-0.16
Flathills- E- UR-36		0.16	66.57	15.64	4.48	3.10	1.34	3.07	4.58	0.01	0.48	0.08	0.16	0.03	0.13	0.18

Appendix C: ALS Chemex Report

ALS Chemex

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994 Glendale Avenue, Unit 3
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Phone: 775 356 5395 Fax: 775 355 0179 www.alschemex.com

To: PAGE, DAVID
2215 RAGGIO PARKWAY
RENO NV 89512

Page: 2 - B
Total # Pages: 2 (A - B)
Finalized Date: 11-APR-2007
Account: PAGDAV

CERTIFICATE OF ANALYSIS RE07030548

ample Description	Method / Analyte / Units / LOR	ME-XRF06 / Total / % / 0.01
Vildcat Mnt-UR-133		99.97
Deep Creek - A- UR-05		99.82
Deep Creek - D- UR-09		99.81
Cedar Mnt- B- 1336-3		99.82
Cedar Mnt- H- 1296-4		98.45
Badlands- A UR-10		98.45
Badlands- A UR-14		98.80
Flathills- A- 1335-8		99.63
Flathills- C- UR-120		98.21
Flathills- D- UR-30		99.79
Flathills- E- UR-36		99.85

Appendix D: XY Scatter Plots of select trace elements for geologic and cultural samples.

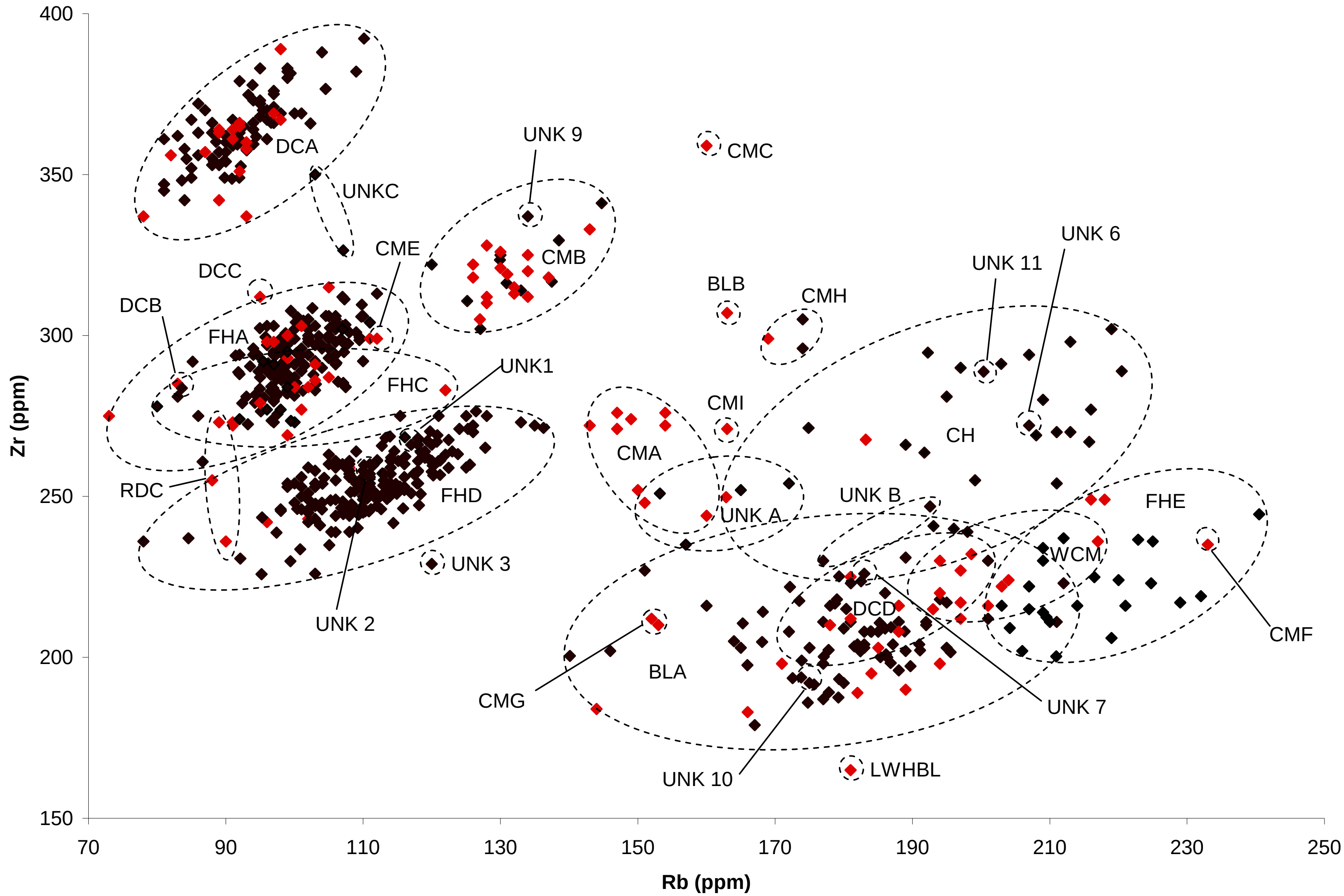

Figure D.1. Plot of Rb/Zr for all samples analyzed (geologic samples in red; cultural samples in black).

* Cedar Mountain D; Gold Hill Wash; Unknown 4, 5, and 8 are not shown as they fall outside plotted area.

Appendix D: XY Scatter Plots of select trace elements for geologic and cultural samples.

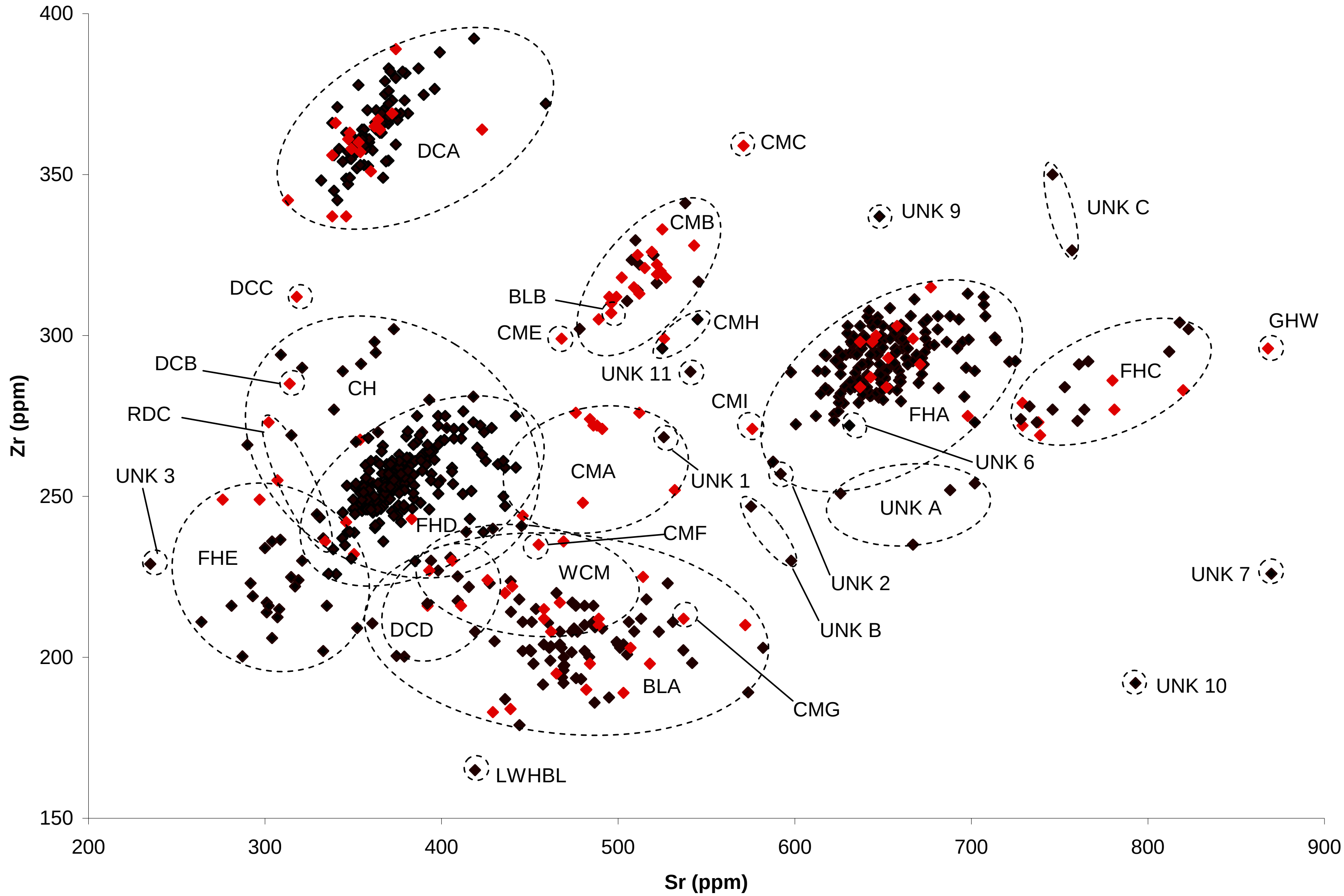

Figure D.2. Plot of Sr/Zr for all samples analyzed (geologic samples in red; cultural samples in black).

* Cedar Mountain D; Gold Hill Wash; Unknown 4, 5, and 8 are not shown as they fall outside plotted area.

Appendix D: XY Scatter Plots of select trace elements for geologic and cultural samples.

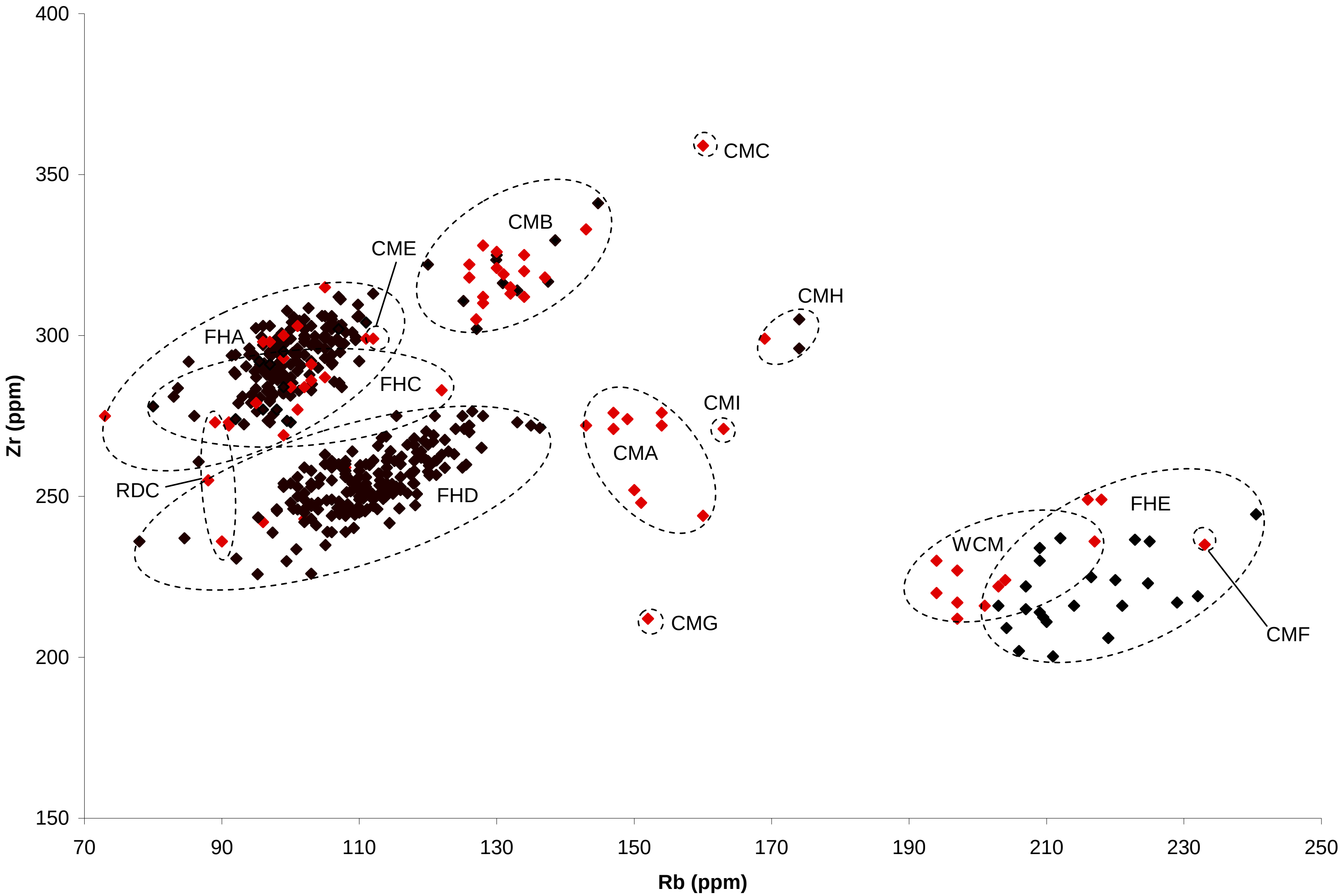

Figure D.3. Plot of Rb/Zr for all eastern samples analyzed (geologic samples in red; cultural samples in black).

* Cedar Mountain D; Gold Hill Wash; Unknown 4, 5, and 8 are not shown as they fall outside plotted area.

Appendix D: XY Scatter Plots of select trace elements for geologic and cultural samples.

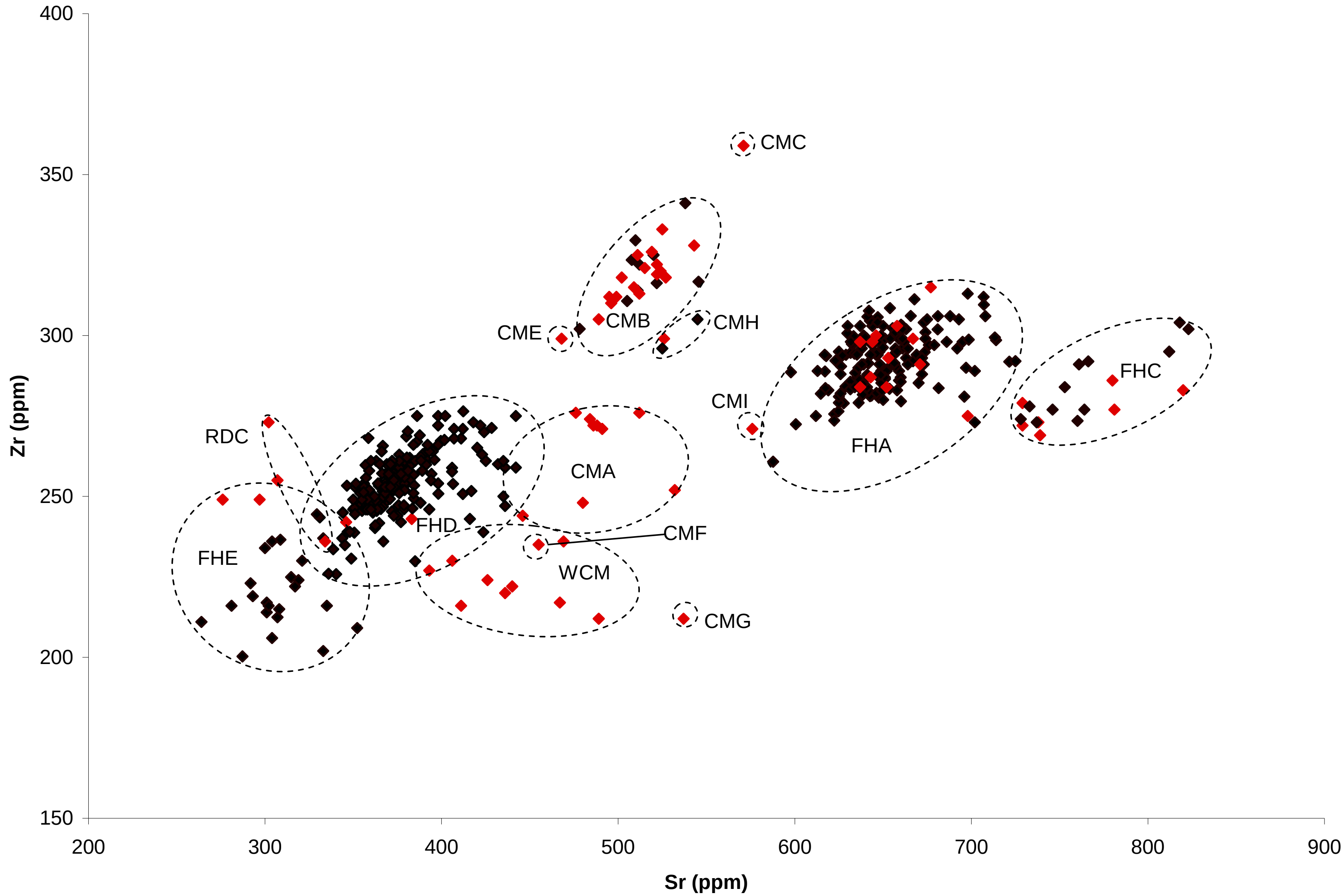

Figure D.4. Plot of Sr/Zr for all eastern samples analyzed (geologic samples in red; cultural samples in black).

* Cedar Mountain D; Gold Hill Wash; Unknown 4, 5, and 8 are not shown as they fall outside plotted area.

Appendix D: XY Scatter Plots of select trace elements for geologic and cultural samples.

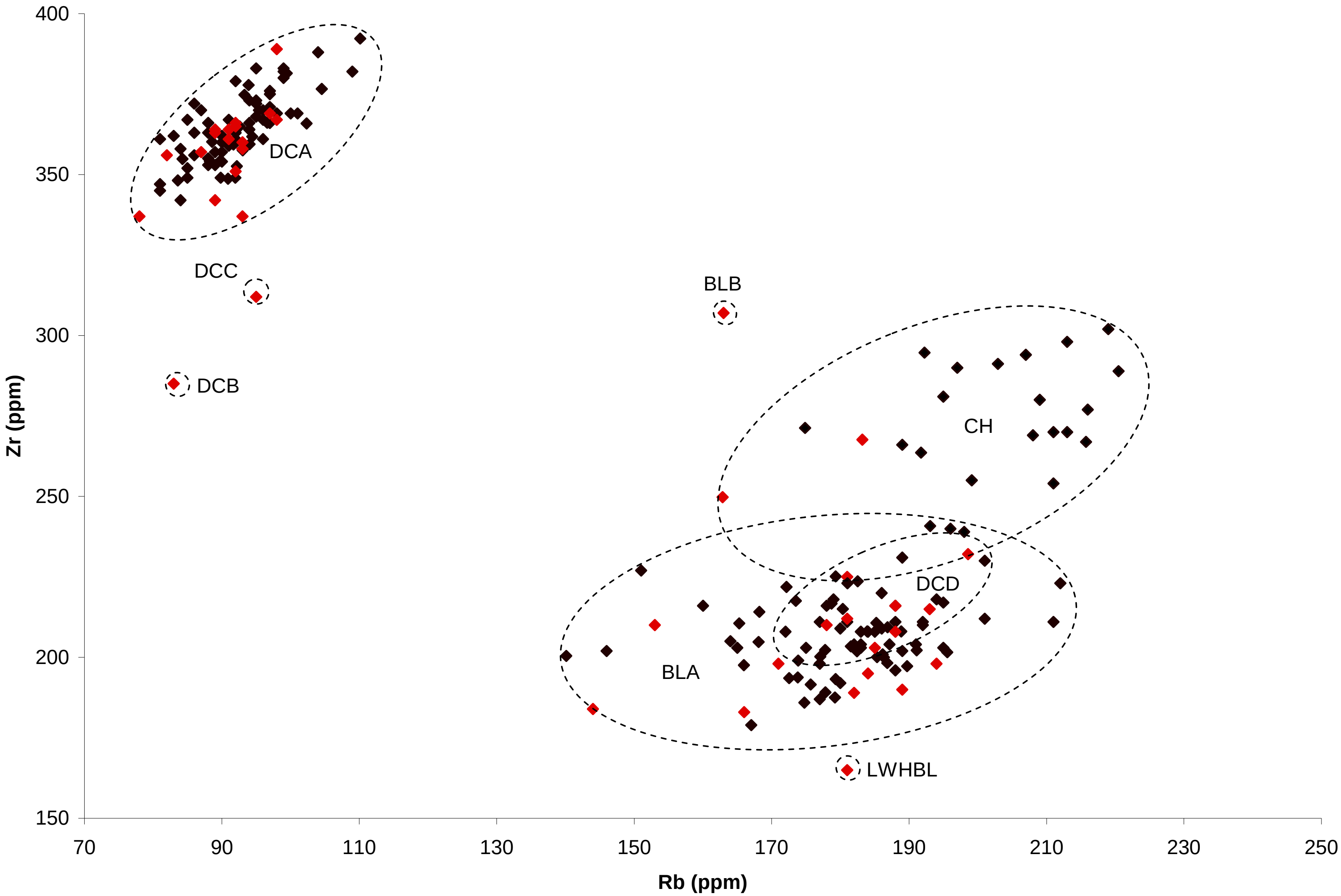

Figure D.5. Plot of Rb/Zr for all <u>western</u> samples analyzed (geologic samples in red; cultural samples in black).

* Cedar Mountain D; Gold Hill Wash; Unknown 4, 5, and 8 are not shown as they fall outside plotted area.

Appendix D: XY Scatter Plots of select trace elements for geologic and cultural samples.

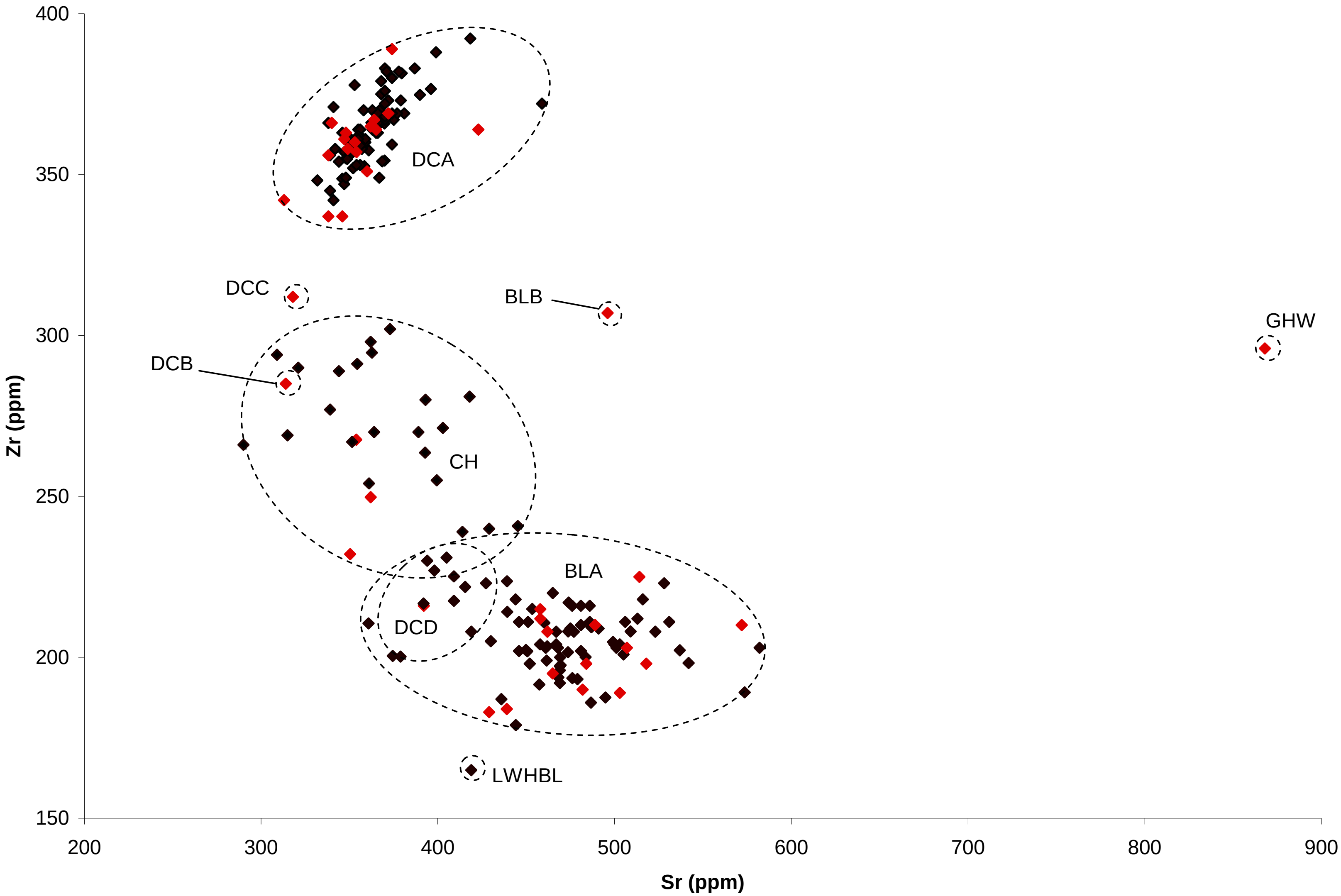

Figure D.6. Plot of Sr/Zr for all <u>western</u> samples analyzed (geologic samples in red; cultural samples in black)

* Cedar Mountain D; Gold Hill Wash; Unknown 4, 5, and 8 are not shown as they fall outside plotted area.

Appendix D: XY Scatter Plots of select trace elements for geologic and cultural samples.

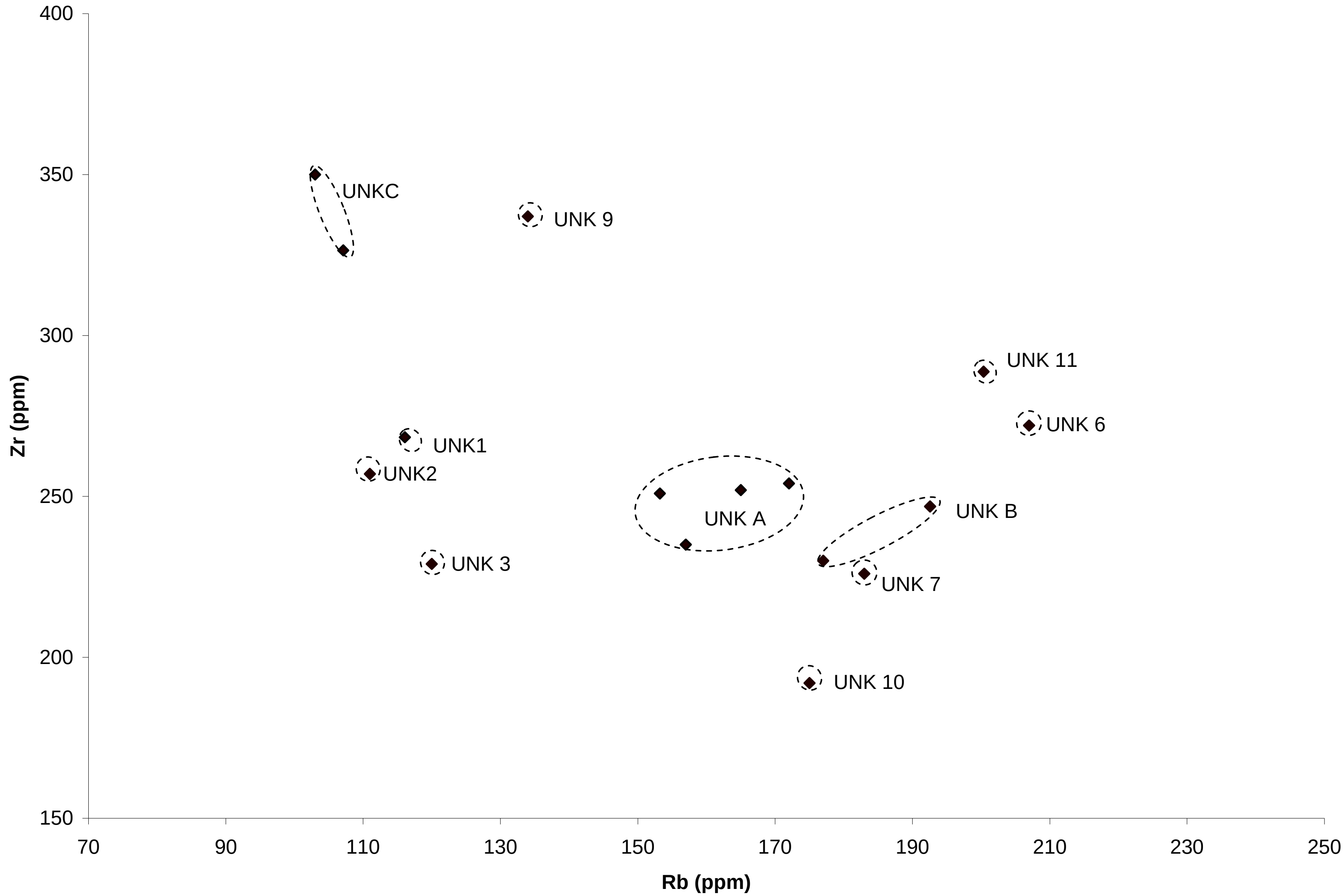

Figure D.7. Plot of Rb/Zr for all unknowns analyzed (shown in black).

* Cedar Mountain D; Gold Hill Wash; Unknown 4, 5, and 8 are not shown as they fall outside plotted area.

Appendix D: XY Scatter Plots of select trace elements for geologic and cultural samples.

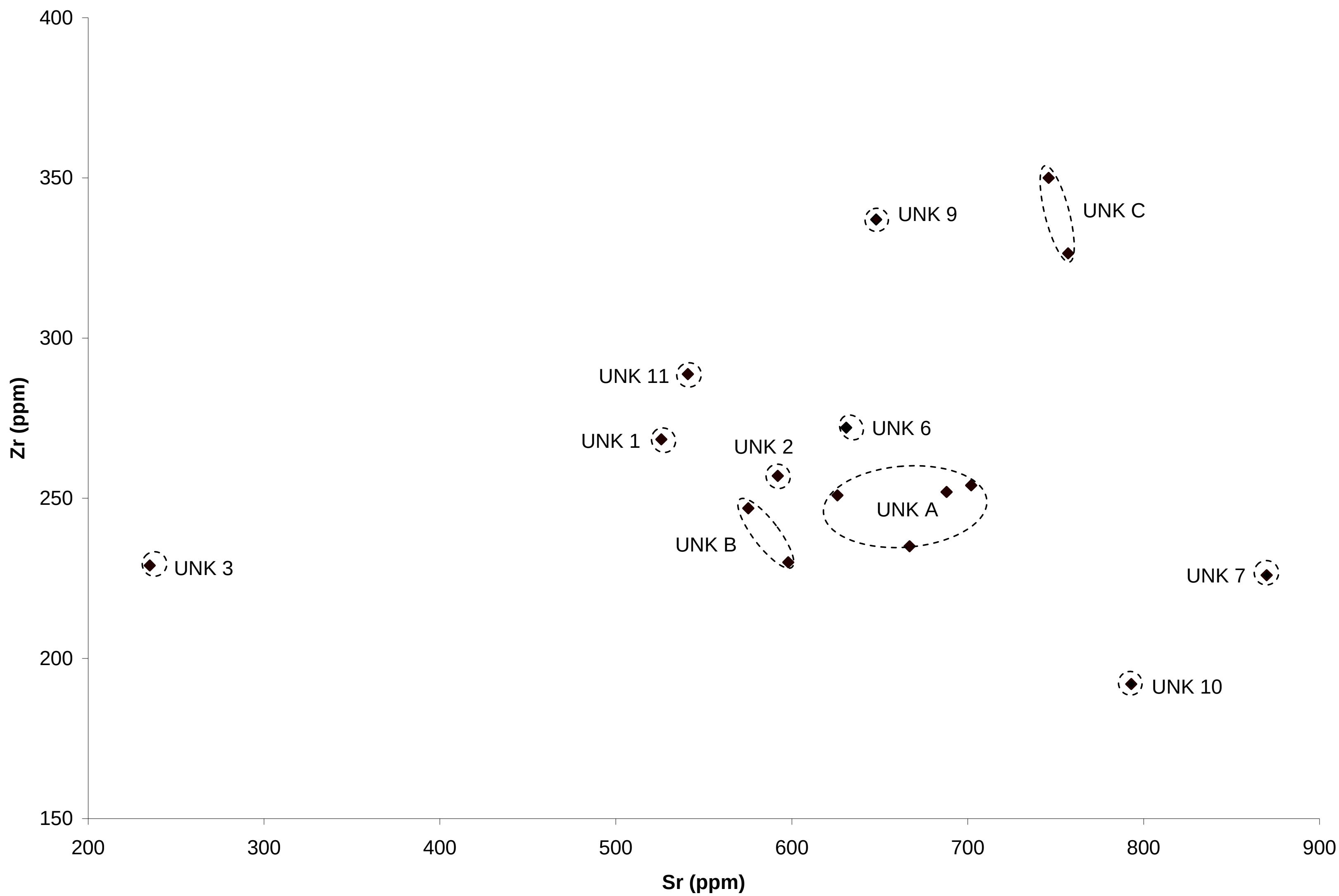

Figure D.8. Plot of Sr/Zr for all unknowns analyzed (shown in black).

* Cedar Mountain D; Gold Hill Wash; Unknown 4, 5, and 8 are not shown as they fall outside plotted area.

Appendix E: XRF Data for Archaeological Specimens

Danger Cave (42To0013), Tooele County, Utah

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	$Fe^{2}O^{3T}$	Fe:Mn	Fe:Ti
19439.1	Biface (midstage)	Deep Creek A	82	24	99	380	51	381	21	4441	732	1088	4.73	52.7	35.4
19439.9	Elko Eared point	Deep Creek A	120	27	92	374	54	359	20	3986	551	1092	4.36	64.7	36.3
19565.2	Gatecliff Split-stem point	Deep Creek A	100	32	90	370	46	354	20	4026	599	1192	4.48	61.2	37.0
22548.2	Windust Stemmed point	Badlands A	82	30	140	374	27	200	16	1799	419	1148	1.88	37.6	35.1
22777	Unhafted knife/biface	Deep Creek A	88	29	91	346	50	349	21	3729	536	1168	4.17	63.8	37.2
22780.11	Modified flake fragment	Badlands A	77	21	187	487	25	209	18	3313	576	1408	4.22	59.9	42.3
23028	Hafted knife	Currie Hills A	70	26	203	354	36	291	22	2360	658	1148	3.20	39.9	45.0
23068.1	Biface (early stage w/ cortex)	Currie Hills A	121	34	199	399	33	255	19	3682	550	1272	4.10	61.1	37.0
23093.3	Gatecliff Split-stem point	Badlands A	92	27	187	458	24	204	15	4078	691	1409	5.16	60.8	42.0
23136.12	Northern Side-Notched Pjp	Deep Creek A	89	21	92	358	51	353	23	4302	536	1167	4.58	69.9	35.4
23137.1	Elko Eared point	Deep Creek A	109	31	93	365	51	365	18	3999	559	1208	4.21	61.7	35.0
23227.3	Biface/beaked scraper	Flat Hills E	88	34	210	307	29	212	24	2467	488	1075	3.23	54.6	43.6
23229.5	Elko Eared point	Deep Creek A	99	22	88	368	51	354	23	4472	650	1207	4.90	61.4	36.4
23242.7	Scraper (on secondary flake)	Flat Hills E	69	28	223	309	31	237	19	2807	544	1121	3.69	55.8	43.7
23294.24	Scraper (on secondary flake)	Badlands A	76	16	176	457	26	192	16	4036	669	1383	5.02	61.2	41.3
23307.6	Biface (midstage)	Deep Creek A	94	25	105	396	51	377	22	3877	492	1130	3.89	64.8	33.4
23310.1	Elko Eared point	Deep Creek A	119	25	102	370	49	366	18	3485	539	1080	3.85	58.6	36.7
23311.2	Pinto point	Deep Creek A	105	16	84	332	49	348	18	4128	585	1208	4.51	62.9	36.3
23311.7	Bilateral/beaked scraper	Badlands A	103	23	166	470	29	198	12	4745	831	1321	5.49	53.7	38.4
23311.8	Biface (midstage)	Badlands A	88	22	182	451	25	202	16	4110	665	1303	5.24	64.2	42.2
23317.5	Scraper/biface? (early stage)	Unknown 4	59	24	101	333	21	108	9	2832	508	885	3.62	58.5	42.4
23318.12	Pinto? point	Badlands A*	63	29	182	462	28	203	20	NM	NM	1385	NM	63.4	42.1
23318.6	Gatecliff Split-stem point	Currie Hills A	89	29	192	363	29	295	21	NM	NM	1192	NM	35.7	48.7
23323	Knife/hafted biface?	Deep Creek A	113	18	97	362	55	366	17	4121	544	1163	4.18	63.0	33.8
23323.6	Scraper	Badlands A	116	22	167	444	31	179	13	4460	912	1090	5.59	49.8	41.5
23323.8	Scraper/biface? (early stage)	Deep Creek D	91	31	181	427	34	223	17	3879	763	1178	4.65	49.6	39.8
23325.1	Biface (early stage)	Badlands A	89	13	174	468	25	194	16	2972	502	1435	3.84	62.7	42.9
23340.4	Large Side-notched point	Currie Hills A	140	27	193	445	35	241	20	4902	635	1179	5.32	68.3	36.0
23341.14	Graver	Deep Creek D	77	26	179	392	28	217	15	4155	731	1203	4.97	55.3	39.6
23342.6	Biface (early stage on flake)	Badlands A	82	9	165	361	30	211	16	3642	570	1228	4.42	63.4	40.2
23343.1	Scraper (on primary flake)	Deep Creek D	92	23	177	379	28	200	15	3893	659	1038	4.74	58.7	40.4
23343.9	Scraper fragment (on flake)	Badlands A	96	21	186	469	30	200	17	3950	852	1398	4.96	47.4	41.6
23374.1	Modified flake	Badlands A	83	22	179	495	27	188	15	3674	605	1309	5.08	68.5	45.8
23374.6	Modified flake /scraper	Currie Hills A	79	24	192	393	32	264	21	3792	695	1338	4.04	47.5	35.5
23374.7	Scraper/graver?	Badlands A	92	29	190	469	25	197	15	3852	707	1321	4.82	55.6	41.5
23390.1	Gatecliff Split-stem point	Badlands A	106	23	173	476	21	194	15	4358	708	1370	5.27	60.5	40.1
23662.4	Elko Eared point	Deep Creek A	97	23	93	361	56	358	22	5073	658	1207	5.28	65.3	34.5
23662.5	Elko Eared point	Deep Creek A	90	25	94	356	47	362	20	4451	607	1180	4.77	64.1	35.6

Appendix E: XRF Data for Archaeological Specimens

Danger Cave (42To0013), Tooele County, Utah

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
23710.6	Elko Eared point	Flat Hills E	76	25	211	287	26	200	21	2059	532	1107	3.00	46.6	48.5
23711.2	Slug/beaked scraper	Currie Hills A	63	34	216	351	31	267	22	3212	749	1156	3.92	42.8	40.5
23711.3	Biface (midstage)	Unknown B	106	31	193	575	38	247	22	3912	611	1661	4.38	58.6	37.2
23730.11	Elko Eared point	Deep Creek A	81	18	92	348	48	349	21	4568	670	1174	4.81	58.6	35.0
23731.4	Modified flake/scraper	Badlands A	106	30	196	474	23	202	17	3766	614	1365	4.69	62.4	41.3
AR3894	Contracting Stemmed point	Deep Creek D	91	21	174	409	28	218	18	3966	694	1258	4.59	54.0	38.4
AR876	Gatecliff Split-stem point	Badlands A	77	25	174	462	27	199	20	3891	742	1391	5.32	58.3	45.2
AR906	Northern Side-notched point	Currie Hills A	97	33	220	344	28	289	25	2549	625	1260	3.51	46.1	45.8
AR910	Biface (midstage)	Badlands A	96	17	178	450	29	202	18	4004	641	1375	4.90	62.3	40.6
RGM-1	NA	RGM-1 Reference Standard	28	29	146	104	29	220	6	1685	290	789	1.88	54.6	37.5

Appendix E: XRF Data for Archaeological Specimens

Bonneville Estates Rockshelter (CrNV-11-4893), Elko County, Nevada

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
2081	Biface	Deep Creek A	92	27	96	369	53	367	20	3903	753	1135	4.16	45.1	35.4
2095	Point fragment	Currie Hills A	85	25	208	315	35	269	19	2272	840	1036	3.05	29.9	44.7
9349	Biface fragment	Deep Creek A	136	30	104	399	58	388	23	3771	471	1132	3.82	66.6	33.7
9984	Stemmed point base	Deep Creek A	97	26	88	365	51	366	22	3689	682	1205	3.96	47.6	35.7
10124	Biface	Deep Creek A	115	21	99	374	52	380	20	4039	566	1164	4.07	58.9	33.6
11014	Northern Side-notched point	Currie Hills A	85	20	211	364	28	270	24	NM	NM	1125	NM	61.8	43.3
11018	Point fragment/preform	Badlands A	94	21	191	503	27	204	16	3822	647	1385	4.88	61.5	42.3
13311	Stemmed point fragment	Flat Hills D	69	20	104	368	35	248	23	3671	661	872	4.69	57.8	42.4
13558	Stemmed point base	Deep Creek A	100	29	100	381	53	369	19	4353	550	1191	4.51	67	34.4
13918	Side scraper	Deep Creek A	101	22	90	359	51	360	19	5261	810	1152	4.52	45.4	28.6
13933	Retouched flake	Deep Creek A	84	19	93	357	56	358	21	4151	796	1161	4.36	44.7	34.9
18478	Biface fragment	Currie Hills A	79	32	207	309	32	294	18	2764	499	1145	3.56	58.7	42.8
18502	Point	Deep Creek A *	92	18	90	352	49	357	19	NM	NM	1058	NM	72.3	34.7
18598	Biface fragment	Deep Creek A *	94	21	90	344	50	354	20	NM	NM	1180	NM	68.1	34.2
19493	Retouched flake	Deep Creek A	119	20	97	368	54	375	17	4366	740	1182	4.63	51	35.2
19551	Retouched flake	Deep Creek A	131	32	95	370	53	383	21	4809	675	1141	5.04	60.8	34.8
19828	Biface fragment	Deep Creek A	102	7	92	365	52	363	21	4345	525	1005	5	70.80	34.8
19892	Northern Side-notched point	Deep Creek A *	99	12	92	355	51	361	25	NM	NM	1082	NM	73.70	34.3
21249	Northern Side-notched point	Deep Creek A *	111	30	83	349	48	362	21	NM	NM	1090	NM	73.60	35.0
22533	Biface fragment	Unknown 5	23	8	39	30	13	60	4	1560	148	172	0	29.80	11.0
22760	Retouched flake	Deep Creek A	90	21	85	375	51	367	22	4564	552	1164	5	72.10	35.4
22993	Northern Side-notched point	Deep Creek A *	98	21	94	363	52	364	21	NM	NM	1188	NM	57.70	34.4
RGM-1	N/A	RGM-1 Reference Standard	19	29	160	108	25	226	10	1748	281	819	2	58.40	37.4

Appendix E: XRF Data for Archaeological Specimens

Camels Back Cave (42To0392), Tooele County, Utah

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
42To0392.46	Side-scraper	Badlands A	107	34	186	465	25	220	16	3825	828	1331	5	45.90	40.5
42To0392.51	Side-scraper	Flat Hills A	78	28	99	648	17	295	16	3838	313	1471	3	88.80	29.2
42To0392.61	Biface	Flat Hills A	91	30	106	648	19	298	14	4342	386	1502	4	79.50	28.6
42To0392.268	Biface	Flat Hills A	99	17	101	637	24	303	20	4497	683	1314	4	47.00	29.0
42To0392.404	Point (dart-sized)	Flat Hills A	92	25	100	651	16	299	14	4261	537	1552	4	54.90	28.1
42To0392.428	Biface	Flat Hills A	84	25	96	644	19	297	14	4345	484	1552	4	63.90	28.9
42To0392.528	Biface	Flat Hills A	98	37	107	707	19	312	16	2833	600	1526	2	34.30	29.4
42To0392.533	Biface	Badlands A	64	26	192	486	27	211	17	4042	680	1349	5	61.10	41.8
42To0392.542	Biface/perforator	Flat Hills E	69	26	212	333	33	237	18	2854	521	1059	4	57.30	42.3
42To0392.546	Biface	Flat Hills C	78	25	98	764	19	277	16	3989	517	1507	3	53.50	28.2
42To0392.577	Utilized flake	Flat Hills A	97	24	97	646	18	294	16	4325	305	1474	4	98.30	28.0
42To0392.595	Northern Side-notch point	Deep Creek A	98	33	99	371	53	382	23	3740	758	1123	4	40.90	33.7
42To0392.604	Point (dart-sized)	Flat Hills A	77	26	98	649	17	289	16	3890	319	1411	3	88.80	29.4
42To0392.613	Utilized flake	Flat Hills A	109	39	103	667	19	292	17	4390	496	1534	4	61.30	28.1
42To0392.618	Utilized flake	Flathills D	84	22	114	377	33	257	25	NM	NM	735	NM	58.90	42.9
42To0392.625	Point (dart-sized; possible Gatecliff split-stem)	Flat Hills A	98	29	100	639	20	291	16	4148	469	1460	4	61.40	28.2
42To0392.628	Utilized flake	Flat Hills A	88	30	106	669	17	294	14	3548	307	1413	3	83.00	29.0
42To0392.667	Elko Corner-notched point	Flat Hills A	114	41	106	695	22	298	16	4349	340	1541	4	89.70	28.3
42To0392.671	Biface fragment	Badlands A	98	24	188	486	25	216	18	4459	721	1431	5	61.80	40.7
42To0392.676	Biface	Flat Hills A	87	39	101	647	18	294	18	3669	308	1517	3	85.20	28.8
42To0392.708	Biface	Flat Hills A	90	29	109	674	16	301	15	4286	359	1495	4	81.50	27.6
42To0392.735	Biface fragment	Flat Hills C	85	27	92	728	18	274	20	4295	577	1678	4	54.30	29.6
42To0392.793	Utilized flake	Flat Hills A	88	19	99	619	17	283	16	3736	464	1484	3	57.40	28.9
42To0392.816	Utilized flake	Flat Hills A	89	31	106	688	20	306	16	4171	282	1536	3	94.10	25.6
42To0392.823	Point	Flat Hills C	100	29	96	746	18	277	12	3975	318	1522	3	85.30	27.5
42To0392.827	Biface	Flat Hills A	103	25	106	673	19	304	14	3709	565	1491	3	45.70	28.3
42To0392.828	Point (dart-sized)	Flat Hills A	86	30	103	644	17	303	17	4362	500	1378	4	58.70	27.3
42To0392.828	Utilized flake	Flat Hills A	105	23	106	663	18	302	18	3785	294	1373	3	91.20	28.6
42To0392.839	Biface	Flat Hills A	105	37	99	625	18	295	15	4194	564	1504	4	54	29.50
RGM-1	N/A	RGM-1 Reference Standard	29	18	163	106	26	223	7	1538	289	764	2	49	36.80

Appendix E: XRF Data for Archaeological Specimens

(Arkush 2000; Hughes 1997); Distal ORB delta, UTTR, Tooele County, Utah

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Ga ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	$Fe^{2}O^{3T}$	Fe:Mn	Fe:Ti
42To745.3.3.2	Parman point	Flat Hills C	104	22	97	761	16	291	12	NM	NM	NM	NM	NM	NM
42To745.3.3.3	Biface (ovate)	Flat Hills D	93	20	102	436	36	259	26	NM	NM	NM	NM	NM	NM
42To747.3.5.2	Biface fragment	Flat Hills D	84	22	102	358	31	246	23	4477	799	NM	5.78	NM	NM
42To747.3.5.5	Crescent	Flat Hills D	86	19	105	432	33	260	23	4643	833	NM	6.03	NM	NM
42To747.3.5.8	Parman point	Flat Hills A	93	20	94	638	12	296	13	5261	410	NM	4.73	NM	NM
42To747.3.5.11	Point fragment	Flat Hills D	97	23	78	367	35	236	19	6149	879	NM	7.31	NM	NM
42To748.3.6.1	Pinto point	Cedar Mountains H	111	19	174	525	42	296	22	NM	NM	NM	NM	NM	NM
42To748.3.6.3	Pinto point	Flat Hills D	97	20	103	370	30	258	23	NM	NM	NM	NM	NM	NM
42To748.3.6.6	Pinto point	Deep Creek A	102	23	86	339	50	356	19	NM	NM	NM	NM	NM	NM
42To748.3.6.8	Haskett point	Flat Hills A	100	26	97	650	14	303	15	NM	NM	NM	NM	NM	NM
42To909.9.3.4	Pinto point	Flat Hills D	87	19	103	363	33	247	23	NM	NM	NM	NM	NM	NM
42To909.9.3.5	Biface fragment	Flat Hills D	94	18	100	356	31	254	25	NM	NM	NM	NM	NM	NM
42To911.9.5.3	Biface fragment	Badlands A	84	17	146	446	23	202	14	NM	NM	NM	NM	NM	NM
42To918.9.9.1	Lake Mohave point	Flat Hills D	82	15	101	351	31	253	23	NM	NM	NM	NM	NM	NM
42To918.9.9.5	Biface fragment	Flat Hills D	88	16	102	361	28	245	20	NM	NM	NM	NM	NM	NM
42To918.9.9.8	Crescent	Cedar Mountains H	9	23	174	545	45	305	22	NM	NM	NM	NM	NM	NM
42To918.9.9.9	Drill	Deep Creek A	100	26	81	339	48	345	19	NM	NM	NM	NM	NM	NM
42To919.9.10.2	Pinto point	Flat Hills D	94	23	101	370	36	256	25	NM	NM	NM	NM	NM	NM
42To919.9.10.3	Lake Mohave point	Flat Hills D	83	20	101	356	31	250	24	NM	NM	NM	NM	NM	NM
42To919.9.10.4	Parman point	Flat Hills A	92	24	97	629	16	294	12	NM	NM	NM	NM	NM	NM
42To924.9.15.2	Uniface	Flat Hills A	90	22	102	639	12	300	8	NM	NM	NM	NM	NM	NM
42To924.9.15.4	Core	Flat Hills D	83	17	100	357	32	248	23	NM	NM	NM	NM	NM	NM

Appendix E: XRF Data for Archaeological Specimens

(Beck and Jones 2002; Hughes 2002); Proximal ORB delta, Tooele County, Utah

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	$Fe^{2}O^{3T}$	Fe:Mn	Fe:Ti
42To1685.1	Drill	Deep Creek A	85	16	81	347	43	347	16	NM	NM	NM	NM	NM	NM
42To1685.11	GBS (square stem)	Flat Hills D	71	17	99	356	31	253	23	4330	1003	NM	6.23	NM	NM
42To1685.16	GBS blade	Deep Creek A	79	18	81	348	47	361	17	5636	842	NM	6.37	NM	NM
42To1685.23	Cougar Mountain point	Cedar Mountain B	71	21	120	512	35	322	15	5052	763	NM	4.93	NM	NM
42To1685.26	GBS blade	Flat Hills D	75	16	99	369	30	254	23	NM	NM	NM	NM	NM	NM
42To1685.38	Pinto	Badlands A	83	18	160	481	23	216	17	NM	NM	NM	NM	NM	NM
42To1685.39	GBS (square stem)	Badlands A	67	13	151	398	28	227	14	NM	NM	NM	NM	NM	NM
42To1685.8	GBS (Stubby)	Flat Hills D	74	21	98	350	29	246	23	4258	1026	NM	6.20	NM	NM
42To1686.13	GBS (contracting stem)	Flat Hills D	83	23	105	376	33	263	22	NM	NM	NM	NM	NM	NM
42To1686.35	GBS (expanding stem)	Unknown C	84	18	103	746	34	350	15	NM	NM	NM	NM	NM	NM
42To1686.36	Lake Mohave point	Flat Hills A	89	17	96	630	16	303	12	NM	NM	NM	NM	NM	NM
42To1686.65	GBS (Stubby)	Deep Creek A	91	23	84	342	46	358	17	NM	NM	NM	NM	NM	NM
42To1687.10	Silver Lake point	Flat Hills D	75	17	102	366	30	249	24	NM	NM	NM	NM	NM	NM
42To1687.9	Lake Mohave point	Flat Hills A	84	20	92	617	13	294	12	NM	NM	NM	NM	NM	NM
42To1862.1	GBS (Stubby)	Deep Creek A	96	15	86	459	52	372	18	NM	NM	NM	NM	NM	NM

Appendix E: XRF Data for Archaeological Specimens

Proximal ORB delta, Tooele County, Utah

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^{2}O^{3T}	Fe:Mn	Fe:Ti
42To1153.14	GBS (long stem)	Flat Hills D	80	35	107	374	36	259	26	3918	870	913	4.82	45.1	40.8
42To1153.16	Modified flake	Flat Hills D	99	31	115	386	35	275	32	3767	672	918	4.74	57.6	41.7
42To1153.18	GBS blade fragment	Deep Creek A	99	27	89	349	51	360	21	4340	697	1200	4.73	55.3	36.2
42To1153.2	Slug scraper	Flat Hills D	85	35	112	392	33	261	27	2633	496	830	3.30	54.8	41.7
42To1153.21	Cougar Mountain point	Flat Hills A	83	23	98	633	18	297	12	4602	514	1514	3.94	62.9	28.6
42To1153.22	Modified flake	Flat Hills D	96	16	85	344	33	237	21	4827	721	838	5.94	66.9	40.7
42To1153.7	Scraper	Flat Hills D	78	26	120	376	30	260	29	3523	1011	912	4.59	37.0	43.2
42To1153.9	GBS blade fragment	Flat Hills A	88	20	107	660	20	303	15	4517	354	1560	3.74	86.9	27.6
42To1182.11	Scraper	Flat Hills A	88	35	94	626	19	290	15	4475	408	1579	3.86	77.9	28.8
42To1182.15	Utilized flake	Flat Hills A	93	21	101	643	15	305	15	4569	400	1575	3.87	79.4	28.2
42To1182.16	Utilized flake	Cedar Mountain B	90	18	130	508	40	323	20	4295	581	1328	3.96	55.8	30.7
42To1182.17	Biface fragment	Cedar Mountain B	101	21	145	538	41	341	23	4324	532	1338	3.89	60.0	30.0
42To1182.3	Lake Mohave point	Flat Hills D	86	14	120	382	30	260	26	3826	804	938	4.88	49.4	42.2
42To1182.7	GBS (long stem)	Flat Hills A	64	20	100	632	19	295	17	4131	541	1539	3.50	53.1	28.2
42To1182.8	GBS (long stem)	Flat Hills A	93	24	98	650	16	296	17	4536	394	1562	3.91	81.8	28.7
42To1182.9	GBS (long stem)	Flat Hills D	82	30	122	406	33	259	28	3709	696	946	4.68	54.8	41.8
42To1354.10	GBS blade fragment	Flat Hills D	92	23	115	363	33	261	31	3656	660	855	4.85	60.0	44.0
42To1354.13	Biface fragment	Flat Hills A	87	17	97	618	14	294	14	4246	340	1434	3.59	87.1	28.2
42To1354.3	Biface fragment	Deep Creek A	99	16	95	358	51	370	24	5123	687	1203	5.09	60.3	33.0
42To1354.5	GBS (long stem)	Flat Hills A	84	22	101	623	21	292	17	4548	430	1467	3.89	74.4	28.5
42To1354.7	GBS (long stem)	Flat Hills A	101	13	98	646	17	294	15	4633	375	1535	3.93	86.3	28.3
42To1354.8	GBS stem fragment	Flat Hills A	85	22	105	666	16	306	14	4366	396	1580	3.55	73.9	27.1
42To1354.9	Cougar Mountain point	Flat Hills C	112	13	95	766	23	292	19	5039	455	1621	4.54	81.6	29.9
42To1358.18	Modified flake	Flat Hills A	89	21	96	642	15	291	15	4401	335	1486	3.71	91.4	28.1
42To1358.19	GBS (long stem)	Flat Hills A	102	20	100	641	17	299	16	4652	383	1537	3.97	85.3	28.4
42To1358.21	GBS (long stem)	Flat Hills A	66	26	92	598	18	289	16	4470	473	1523	3.78	65.7	28.2
42To1358.22	Biface (early stage)	Flat Hills D	69	15	108	355	32	248	25	3584	671	807	4.75	57.7	43.9
42To1358.24	Scraper	Flat Hills A	102	16	106	641	17	292	17	4543	483	1457	3.85	65.4	28.2
42To1358.32	End-scraper	Flat Hills A	86	24	97	641	18	288	17	4174	365	1492	3.63	82.1	29.0
42To1358.36	Modified flake	Flat Hills A	74	16	102	649	18	291	15	4110	270	1476	3.24	99.5	26.3
42To1358.5	Modified flake	Flat Hills A	101	27	110	707	15	310	19	3217	245	1442	2.61	89.0	27.2
42To1358.6	GBS (long stem)	Flat Hills A	72	21	91	627	17	294	15	4872	460	1520	4.16	74.2	28.5
42To1358.7	Cougar Mountain point	Flat Hills A	92	21	95	617	19	289	17	4060	325	1601	3.54	89.9	29.1
42To1358.70	GBS (expanding stem)	Flat Hills A	76	29	100	643	18	281	10	3950	409	1641	3.49	70.2	29.4
42To1358.72	Modified flake	Flat Hills A	74	18	98	622	20	276	16	4489	325	1594	3.74	95.0	27.8
42To1358.9	GBS (long stem)	Flat Hills A	103	16	105	657	22	302	14	4772	492	1510	3.98	66.4	27.8
42To1368.10	Biface	Flat Hills D	62	24	110	378	32	260	25	3403	682	883	4.26	51.0	41.5
42To1368.12	Biface	Flat Hills D	91	24	118	406	35	258	27	3538	632	891	4.47	57.8	41.9
42To1368.13	Biface fragment	Flat Hills A	69	27	98	634	18	286	18	3319	256	1570	2.75	89.8	27.8
42To1368.15	Biface fragment	Flat Hills A *	50	15	106	660	15	286	14	NM	NM	1528	NM	93.1	27.4
42To1368.6	Biface fragment	Flat Hills D	90	17	107	365	37	248	25	4012	771	962	5.03	53.1	41.6
42To1368.7	Scraper/graver	Flat Hills D	70	12	103	359	31	248	29	3804	680	918	4.83	57.9	42.1
42To1368.9	GBS blade fragment	Flat Hills A	83	22	96	647	16	281	15	4426	442	1540	3.71	69.0	28.0
42To1369.1	Biface (late stage)	Flat Hills A	88	14	100	632	18	286	12	4277	423	1520	3.65	70.9	28.5
42To1369.11	GBS (long stem)	Flat Hills A	108	28	97	622	16	274	14	4496	411	1534	3.92	78.3	29.0
42To1369.14	GBS stem fragment	Flat Hills A	85	19	97	660	17	280	17	3612	339	1548		75.3	28.5

Appendix E: XRF Data for Archaeological Specimens

Proximal ORB delta, Tooele County, Utah

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	$Fe^{2}O^{3T}$	Fe:Mn	Fe:Ti
42To1369.2	Biface (late stage)	Flat Hills A	73	24	93	601	15	272	13	4671	487	1540	3.91	66.0	27.9
42To1369.4	GBS (contracting stem)	Unknown C	71	30	107	757	37	326	20	4513	556	1255	4.48	65.8	33.0
42To1369.5	GBS (long stem)	Flat Hills D	84		110	367	33	247	26	3779	753	911	4.99	54.0	43.7
42To1369.7	Scraper/graver	Flat Hills A	99	27	94	636	18	279	16	4349	418	1447	3.65	71.8	28.0
42To1371.102	GBS (square stem)	Flat Hills A	78	31	100	670	18	285	18	4293	317	1482	3.57	92.9	27.7
42To1371.103	Beaked scraper	Flat Hills D	109	20	106	424	31	239	26	3278	786	854	4.22	43.9	42.8
42To1371.25	GBS (square stem)	Flat Hills D	82	27	105	347	32	239	26	3873	686	919	5.08	60.3	43.4
42To1371.32	Pinto point	Deep Creek A *	90	30	84	349	51	355	20	NM	NM	1236	NM	73.5	34.9
42To1371.43	GBS point	Flat Hills D	68	18	109	359	35	246	24	3849	815	906	4.97	49.6	42.8
42To1371.47	Slug scraper	Flat Hills D	89	24	100	366	30	246	25	3438	692	976	4.43	52.3	42.7
42To1371.54	Biface	Flat Hills D	54	35	109	362	29	240	27	3653	685	916	4.64	55.3	42.1
42To1371.56	GBS (contracting stem)	Flat Hills C	82	14	99	760	22	274	18	5214	428	1604	4.54	86.9	29.0
42To1371.59	Parman point	Flat Hills D *	114	26	99	385	27	230	24	NM	NM	872	NM	51.7	42.5
42To1371.68	Pinto point	Flat Hills D	70	34	115	371	31	253	24	3147	534	826	3.80	58.3	40.1
42To1371.7	Biface	Flat Hills D	107	22	128	420	38	265	29	3044	529	893	3.74	58.0	40.8
42To1371.71	GBS (contracting stem)	Flat Hills D	88	16	118	376	35	247	29	3561	831	884	4.41	43.3	41.1
42To1371.79	GBS point	Flat Hills A	80	31	96	656	18	291	11	4566	364	1512	3.85	87.1	28.1
42To1371.8	Biface (late stage)	Flat Hills D	80	31	121	384	32	257	29	3848	679	921	5.03	60.3	43.3
42To1371.89	GBS (Stubby)	Flat Hills A	95	26	97	643	20	281	14	4593	345	1555	3.72	88.9	27.0
42To1371.93	Biface (late stage)	Flat Hills D	80	8	105	363	30	249	23	3819	811	952	4.82	48.5	41.9
42To1371.96	Biface (late stage)	Flat Hills A	94	29	109	714	20	299	16	4458	330	1612	3.57	89.4	26.7
42To1371.97	Beaked scraper	Flat Hills A	120	18	100	642	18	283	14	3924	446	1535	3.36	62.0	28.6
42To1383.1	GBS (long stem)	Cedar Mountain B	66	16	131	522	35	316	18	5386	644	1454	4.80	60.7	29.6
42To1383.10	GBS stem fragment	Flat Hills D *	98	26	108	379	32	247	27	NM	NM	927	NM	53.6	42.7
42To1383.11	GBS (contracting stem)	Flat Hills A *	59	21	103	649	16	288	12	NM	NM	1511	NM	58.9	27.1
42To1383.12	GBS stem fragment	Flat Hills A *	94	17	99	657	18	290	15	NM	NM	1447	NM	91.7	27.3
42To1383.13	GBS (square stem)	Flat Hills D	79	18	119	400	35	267	25	3653	867	918	4.59	43.1	41.6
42To1383.19	Cougar Mountain blade	Flat Hills A	92	19	107	659	17	299	15	4185	638	1562	3.51	45.1	28.0
42To1383.2	GBS stem fragment	Flat Hills E *	75	24	216	315	29	225	20	2955	537	1090	3.61	55.2	40.6
42To1383.20	GBS (long stem)	Flat Hills A	128	28	110	713	20	299	15	3756	444	1520	3.01	56.0	26.8
42To1383.21	Biface fragment (large)	Flat Hills A	84	31	92	628	19	279	14	4203	510	1532	3.64	58.6	28.9
42To1383.4	GBS (long stem)	Flat Hills D	99	19	120	378	35	258	27	3169	557	895	4.00	58.8	41.9
42To1383.8	Debitage (overshot flake)	Flat Hills A	71	15	97	639	19	283	16	4759	342	1504	3.87	93.2	27.1
42To1672.4	Pinto point	Flat Hills D *	78	23	108	356	32	251	28	NM	NM	928	NM	59.0	42.2
42To1672.5	Biface fragment	Flat Hills D *	96	19	121	388	35	261	29	NM	NM	846	NM	59.5	41.2
42To1672.6	GBS (long stem)	Flat Hills D	87	21	107	350	33	246	24	3463	610	898	4.43	59.3	42.4
42To1672.7	Crescent?	Flat Hills D	99	21	107	351	30	244	31	3559	695	915	4.62	54.2	43.0
42To1677.1	Biface (late stage)	Flat Hills D	80	30	108	363	31	246	22	3921	612	909	4.70	62.7	39.8
42To1677.16	GBS blade	Deep Creek A	108	21	93	390	52	375	21	4729	586	1155	5.03	70.0	35.3
42To1677.5	Beaked scraper	Flat Hills D	88	35	114	365	32	242	27	3598	765	897	4.74	50.5	43.7
42To1677.7	GBS (expanding stem)	Flat Hills D	87	21	111	372	31	245	28	3381	612	877	4.38	58.4	42.9
42To1677.8	Biface fragment	Badlands A	84	25	179	479	23	193	15	3864	605	1402	4.83	65.1	41.4
42To1678.2	Biface (mid stage)	Flat Hills D	78	10	97	351	28	239	25	2832	757	946	3.85	41.6	45.1
42To1678.3	Graver	Flat Hills A	90	30	97	629	17	284	15	4470	335	1592	3.81	93.7	28.4
42To1678.6	Biface (late stage)	Flat Hills D	83	24	118	391	39	264	29	3619	631	944	4.53	58.6	41.5
42To1678.7	Biface fragment	Flat Hills A	73	19	104	633	18	300	15	4465	499	1579	3.82	62.9	28.5

Appendix E: XRF Data for Archaeological Specimens

Proximal ORB delta, Tooele County, Utah

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	$Fe^{2}O^{3T}$	Fe:Mn	Fe:Ti
42To1678.8	Biface fragment	Flat Hills D	101	12	114	380	34	269	24	2988	545	957	3.79	57.1	42.2
42To1682.4	Cougar Mountain blade	Flat Hills A	108	29	102	681	18	302	14	4574	510	1539	3.95	63.5	28.8
42To1684.10	GBS (long stem)	Flat Hills A	94	27	97	634	16	294	15	4517	464	1521	3.88	68.7	28.6
42To1684.11	GBS (contracting stem)	Flat Hills A	92	33	97	617	17	284	14	3888	483	1494	3.36	57.3	28.9
42To1684.12	GBS (long stem)	Flat Hills A	75	20	98	634	18	288	16	4390	356	1490	3.78	87.6	28.7
42To1684.13	GBS (long stem)	Flat Hills A	78	24	99	630	18	301	16	4570	552	1553	3.86	57.4	28.2
42To1684.14	Scraper	Flat Hills A	80	24	84	681	20	284	16	4106	507	1505	3.43	55.7	27.9
42To1684.2	GBS stem fragment	Cedar Mountain B	70	29	139	510	35	330	19	4129	611	1392	3.73	50.0	30.1
42To1684.5	Beaked scraper	Flat Hills D	60	20	95	331	34	243	26	3379	716	901	4.35	49.6	42.7
42To1684.7	Biface fragment	Badlands A	112	28	183	439	28	224	15	5205	677	1203	5.66	68.0	36.1
42To1684.8	GBS (long stem)	Flat Hills D	79	26	109	367	30	252	27	3699	646	948	4.82	60.9	43.2
42To1684.9	Scraper/graver	Flat Hills D	84	26	109	364	34	254	26	3916	655	923	5.05	62.9	42.7
42To1685.1	GBS (contracting stem)	Deep Creek A *	119	21	110	418	59	392	22	NM	NM	1224	NM	48.4	31.7
42To1685.19	Scraper	Flat Hills D	117	18	104	351	34	254	26	3504	666	849	4.62	56.5	43.7
42To1685.20	Beaked scraper	Flat Hills A	68	12	98	615	18	282	13	4615	440	1597	3.85	71.8	27.8
42To1685.29	Scraper (end/side)	Badlands A	91	16	168	439	29	214	15	4390	615	1097	4.97	66.0	37.6
42To1685.9	Scraper/graver	Flat Hills A	90	17	95	635	19	294	13	3992	469	1483	3.52	61.7	29.4
42To1686.1	Biface (mid stage)	Currie Hills A	82	15	175	403	33	271	23	4473	571	1376	4.24	60.7	31.5
42To1686.12	Concave scraper	Flat Hills D	83	20	115	365	33	253	28	3751	696	893	4.93	57.7	43.6
42To1686.19	Biface (late stage)	Flat Hills D	67	20	113	366	34	257	24	3575	658	872	4.60	57.1	42.7
42To1686.4	Slug scraper	Flat Hills D	82	15	110	346	31	253	27	3019	654	938	3.83	48.0	42.2
42To1686.41	End scraper	Flat Hills D	96	28	124	389	33	263	22	3747	656	895	4.39	54.6	38.9
42To1686.50	Beaked scraper	Flat Hills D *	109	33	136	428	35	271	29	NM	NM	849	NM	31.8	37.5
42To1686.51	GBS (contracting stem)	Flat Hills D	78	23	120	374	35	257	30	4170	674	916	4.97	60.1	39.6
42To1686.55	Beaked scraper	Flat Hills A	84	20	99	637	18	286	18	4582	408	1539	3.82	77.0	27.8
42To1686.56	Biface fragment	Flat Hills D	81	17	112	368	32	251	24	3270	760	837	4.21	45.2	42.7
42To1686.6	Concave scraper	Flat Hills A	105	29	108	638	16	298	15	4053	314	1608	3.35	88.5	27.6
42To1686.67	GBS (contracting stem)	Flat Hills D	103	28	113	371	35	249	28	3702	728	950	4.62	51.8	41.4
42To1686.69	Lake Mohave point	Deep Creek A	81	9	94	355	51	359	19	4983	577	1210	4.94	69.9	32.9
42To1686.7	GBS blade fragment	Flat Hills D	81	24	104	357	33	256	26	3146	688	931	3.90	46.4	41.2
42To1686.70	GBS (long stem)	Flat Hills E	58	19	204	352	29	209	19	3040	699	1166	3.80	44.4	41.5
42To1687.10	Silver Lake point	Flat Hills D	63	18	117	394	33	257	28	4003	676	927	4.98	60.0	41.2
42To1687.9	GBS (expanding stem)	Flat Hills A	75	15	107	641	17	284	17	4447	433	1512	3.85	73.0	28.8
42To1688.14	Debitage (thinning flake)	Flat Hills D	96	22	122	402	37	268	28	3638	617	876	4.49	59.4	40.9
42To1688.17	Biface fragment (late stage)	Flat Hills D	100	24	120	396	31	261	26	3380	662	943	4.15	51.3	40.8
42To1688.45	Debitage (thinning flake)	Flat Hills D	80	9	104	362	34	241	26	3619	718	897	4.44	50.5	40.7
42To1688.50	Biface (late stage)	Badlands A	127	22	178	574	24	189	13	4672	669	1340	5.73	69.7	40.6
42To1688.55	Lake Mohave point	Badlands A	80	9	191	537	23	202	16	3562	734	1439	4.13	45.9	38.5
42To1688.57	Crescent?	Badlands A	90	23	187	542	24	198	14	4253	810	1430	4.86	48.9	37.9
42To1688.58	GBS (contracting stem)	Flat Hills D	84	18	114	366	33	253	25	3965	812	904	5.00	50.1	41.8
42To1688.8	Debitage (thinning flake)	Flat Hills D	102	29	116	388	32	262	27	3624	650	911	4.60	57.8	42.1
42To1689.8	Pinto point	Flat Hills A	81	26	95	654	18	283	15	4605	426	1605	3.80	73.2	27.5
42To1861.1	Modified flake	Flat Hills A	81	26	97	651	16	286	12	4081	303	1551	3.38	92.2	27.6
42To1861.11	Scraper/graver	Flat Hills A	104	25	107	649	18	285	12	4262	337	1563	3.54	86.8	27.7
42To1861.12	Modified flake	Flat Hills D	74	35	92	349	33	231	18	4264	696	885	5.24	61.3	40.8
42To1861.17	GBS blade	Flat Hills A	105	28	100	631	16	283	14	4680	332	1533	3.77	93.6	26.9

Appendix E: XRF Data for Archaeological Specimens

Proximal ORB delta, Tooele County, Utah

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	$Fe^{2}O^{3T}$	Fe:Mn	Fe:Ti
42To1861.3	Biface (mid stage)	Flat Hills A	97	27	85	721	22	292	17	4874	651	1488	3.75	47.2	25.7
42To1861.5	GBS (long stem)	Cedar Mountain B	76	21	125	505	34	311	22	4281	528	1452	3.78	58.6	29.4
42To1861.6	GBS (long stem)	Flat Hills A	83	30	95	625	18	276	13	4413	353	1534	3.72	86.9	28.1
42To1861.9	GBS blade fragment	Cedar Mountain B	55	24	127	478	37	302	19	4165	589	1502	3.67	51.0	29.3
42To1862.19	Concave scraper	Flat Hills A	79	26	107	668	17	311	14	4564	444	1556	3.78	69.9	27.6
42To1862.2	GBS (Stubby)	Deep Creek A *	74	28	90	367	52	349	23	NM	NM	1273	NM	70.5	33.5
42To1862.4	Utilized flake	Flat Hills D	104	21	111	384	32	249	24	3803	765	904	4.75	50.6	41.4
42To1862.5	End-scraper	Flat Hills E	87	22	225	292	33	223	21	2579	552	1101	3.42	50.9	44.1
42To1872.1	Cody knife?	Badlands A	82	22	168	499	34	205	15	4898	681	1316	6.12	73.1	41.4
42To1872.11	GBS blade fragment	Flat Hills A	99	24	110	641	16	306	13	4533	477	1559	3.83	66.0	28.2
42To1872.17	GBS (square stem)	Flat Hills A	84	16	96	640	17	300	17	4346	496	1551	3.95	65.4	30.3
42To1872.28	GBS (long stem)	Flat Hills A	90	18	100	647	20	306	14	4516	365	1525	3.96	89.5	29.2
42To1872.29	Lake Mohave point	Flat Hills D	66	19	113	358	34	268	28	3947	709	889	5.03	57.8	42.3
42To1872.3	Concave scraper	Flat Hills D	108	17	121	386	37	267	27	3891	703	919	5.09	58.9	43.3
42To1872.4	Silver Lake point	Badlands A	90	17	184	474	28	208	21	4366	800	1436	5.40	54.9	41.0
42To1872.42	GBS (contracting stem)	Flat Hills A	83	27	99	632	18	297	14	4460	345	1578	3.88	92.8	29.0
42To1872.46	GBS (long stem)	Badlands A	66	24	185	460	26	211	20	4248	828	1402	5.34	52.5	41.7
42To1872.47	GBS (square stem)	Flat Hills A *	91	32	100	647	20	304	14	NM	NM	1524	NM	72.1	28.5
42To1872.49	GBS (square stem)	Flat Hills D	93	13	113	367	34	266	30	3531	675	848	4.60	55.6	43.2
42To1872.57	GBS blade	Flat Hills D	95	31	111	357	35	260	27	3601	898	870	4.64	42.1	42.7
42To1872.59	Scraper	Flat Hills A	74	24	95	655	18	302	14	3836	538	1448	3.39	51.7	29.5
42To1872.6	Biface (late stage)	Flat Hills A	82	25	99	632	20	298	14	3927	322	1593	3.41	87.6	29.0
42To1872.64	Biface fragment (late stage)	Flat Hills A	87	34	103	654	18	309	14	4236	491	1484	3.65	61.0	28.7
42To1872.7	Modified flake	Flat Hills D	84	22	118	380	35	254	28	3425	742	825	4.43	48.7	42.9
42To1872.8	GBS (long stemmed)	Flat Hills D *	112	27	114	380	39	262	28	NM	NM	955	NM	58.8	40.6
42To1873.1	Lake Mohave point	Deep Creek A	99	17	94	353	50	378	19	4629	732	1210	4.93	54.8	35.3
42To1873.28	Debitage (thinning flake)	Badlands A	110	22	189	509	26	208	15	3952	740	1296	5.37	59.1	45.0
42To1873.29	Debitage (thinning flake)	Badlands A	99	26	180	453	24	215	21	3846	670	1412	4.87	59.2	42.0
42To1873.30	Slug scraper	Flat Hills D	78	17	121	388	34	269	30	3128	629	908	4.08	53.1	43.3
42To1873.5	Modified flake/graver	Flat Hills D	70	24	109	382	33	255	25	2900	635	917	4.36	56.1	49.8
42To1878.14	Cougar Mountain point	Unknown 1	79	34	116	526	36	268	28	3520	692	948	4.72	55.6	44.4
42To1878.3	GBS (long stem)	Flat Hills A	85	24	99	642	22	308	15	4189	434	1531	3.67	69.7	29.2
42To1878.5	Biface (mid stage)	Badlands A	71	18	179	409	33	225	18	3669	592	1168	4.57	63.1	41.3
42To1878.7	Biface (late stage)	Flat Hills D	83	19	98	355	30	246	25	3865	831	827	5.08	49.7	43.6
42To1920.15	GBS (contracting stem)	Flat Hills D *	40	32	101	339	29	234	26	NM	NM	950	NM	41.4	40.8
42To1920.16	Beaked scraper	Badlands A	90	14	172	415	30	222	20	5806	735	1241	5.48	70.4	31.8
42To1920.2	Core fragment	Flat Hills D	82	21	120	381	37	270	30	3389	665	870	4.44	54.5	43.5
42To1920.22	Biface fragment (late stage)	Flat Hills D	109	21	125	412	33	271	26	3731	612	955	4.34	44.1	41.1
42To1920.23	GBS (expanding stem)	Flat Hills A	93	26	107	674	19	295	13	3753	285	1555	3.08	88.4	27.8
42To1920.26	Biface fragment (mid stage)	Flat Hills D	84	24	126	391	35	260	25	3620	791	900	4.57	51.2	41.2
42To1920.27	GBS blade fragment	Badlands A	92	27	185	484	26	200	18	4195	597	1538	4.69	54.9	39.5
42To1920.29	Biface fragment (mid stage)	Flat Hills D	81	28	105	345	31	235	25	3856	716	907	4.73	48.4	41.3
42To1920.33	GBS (square stem)	Flat Hills D	75	16	109	375	35	244	27	3742	626	921	4.70	59.9	40.6
42To1920.38	GBS stem fragment	Flat Hills D *	95	34	115	406	34	254	24	NM	NM	919	NM	49.2	39.5
42To1920.4	Beaked/slug scraper	Flat Hills D	104	24	126	412	32	276	29	3762	780	970	4.79	50.1	42.2
42To1921.2	GBS blade fragment	Badlands A	90	16	186	505	28	201	16	3971	893	1377	4.76	60.3	40.3

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CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	$Fe^{2}O^{3T}$	Fe:Mn	Fe:Ti
42To1921.8	Biface (late stage)	Flat Hills A	103	27	103	639	19	285	16	4312	343	1556	3.77	97.1	23.6
42To1924.10	Biface (mid stage)	Flat Hills D	77	22	95	340	38	226	24	4409	672	976	5.39	66.5	41.7
42To1924.101	GBS (Stubby)	Flat Hills A *	95	17	101	649	17	283	12	NM	NM	1588	NM	99.3	28.1
42To1924.102	GBS (expanding stem)	Flat Hills A	77	28	99	646	16	282	15	4545	525	1537	3.87	60.3	28.4
42To1924.103	GBS (long stem)	Flat Hills D	88	20	113	384	33	253	26	3165	528	962	3.82	59.3	40.1
42To1924.107	Modified flake	Flat Hills D	83	40	118	412	35	251	30	2936	671	894	4.12	50.2	46.5
42To1924.127	Circular scraper	Unknown A	101	24	153	626	35	251	19	5721	662	1445	6.02	74.0	34.9
42To1924.129	Beaked scraper	Flat Hills D *	87	24	116	383	33	246	26	NM	NM	886	NM	60.8	41.8
42To1924.13	Lake Mohave point	Flat Hills A	77	29	95	625	16	279	15	4776	345	1602	3.90	95.8	28.2
42To1924.141	End scraper	Flat Hills D	93	24	110	361	31	245	29	3470	654	877	4.39	54.8	42.0
42To1924.16	Scraper	Flat Hills D	96	23	111	379	33	246	26	3491	714	877	4.39	58.9	42.7
42To1924.167	GBS (Stubby)	Flat Hills A	88	21	98	647	19	287	15	4333	339	1448	3.68	89.5	28.3
42To1924.19	End/side-scraper	Badlands A	91	25	175	487	26	186	17	4497	799	1283	5.87	52.3	42.9
42To1924.23	Biface (late stage)	Cedar Mountain B	88	27	137	545	38	317	18	4161	536	1291	3.66	56.1	29.3
42To1924.28	Beaked scraper	Flat Hills D	76	29	114	367	32	250	28	3917	837	897	4.74	46.1	40.1
42To1924.39	GBS (square stem)	Flat Hills A	105	27	94	639	19	282	15	4539	394	1549	3.74	78.1	27.5
42To1924.53	Biface fragment (late stage)	Flat Hills D	106	29	115	393	37	264	27	3711	723	924	4.46	50.3	39.9
42To1924.54	Scraper	Flat Hills D	94	31	115	398	32	251	31	3474	661	939	4.14	51.2	39.6
42To1924.55	GBS (long stem)	Flat Hills D	66	17	113	364	33	246	28	3837	670	891	4.86	59.2	42.0
42To1924.78	GBS (Stubby)	Flat Hills A	89	27	87	588	15	261	16	4624	368	1598	3.94	88.3	28.4
42To1924.90	End-scraper	Flat Hills D	74	25	114	417	36	252	30	3930	678	904	4.75	57.1	40.1
42To2945.17	Pinto point	Unknown 11	71	33	200	541	41	289	18	5340	839	1473	4.93	47.8	30.7
DPGIF526	Pinto point	Flat Hills A *	83	31	98	656	19	291	14	NM	NM	1614	NM	90.0	27.3
DPGIF876	Pinto point	Flat Hills A	89	27	107	699	16	299	15	4621	331	1601	3.83	95.6	27.6
DPGIF1932	Pinto point	Flat Hills E *	72	25	240	329	30	244	19	NM	NM	1109	NM	31.1	40.2
RGM-1	NA	RGM-1 Reference Standard	56	32	156	111	23	220	8	1650	300	785	1.88	52.8	38.2

Appendix E: XRF Data for Archaeological Specimens

Proximal ORB delta, Tooele County, Utah

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	$Fe^{2}O^{3T}$	Fe:Mn	Fe:Ti
04DM03.01	GBS - Classic	Flat Hills D	98	26	118	411	32	268	28	3877	851	852	4.84	46.2	41.4
04DM03.02	Biface	Badlands A	62	20	172	467	23	208	17	4061	624	1397	4.86	63.5	39.7
42To0385.3	GBS	Flat Hills D	102	27	121	398	35	275	29	3625	748	899	4.43	48.3	40.6
42To0567.6	Pinto Point	Flat Hills A	76	28	105	651	17	299	16	4103	478	1494	3.43	59.1	27.9
42To0867.2	Pinto Point	Flat Hills D	88	28	110	344	27	245	27	3586	785	925	4.52	46.9	41.8
42To1170.2	Uniface	Flat Hills A	82	40	107	661	15	303	17	4063	530	1450	3.33	51.7	27.4
42To1493.01	Pinto Point	Flat Hills A	100	127	104	697	17	290	17	4428	2278	1598	3.3	11.8	24.9
42To1573.41	Biface	Flat Hills A	92	33	99	659	20	286	18	4387	479	1568	3.67	62.9	27.9
42To1573.48	GBS Base	Deep Creek A	64	22	85	352	50	352	17	4534	677	1242	4.59	55.3	33.6
42To1573.54	Biface Fragment	Flat Hills D	81	25	116	371	31	260	26	3876	642	884	4.74	60.2	40.5
42To1684.16	Prismatic Blade Flake	Flat Hills D	70	21	110	370	31	253	28	3828	623	870	4.71	61.6	40.8
42To1684.19	GBS	Cedar Mountain B	89	33	133	511	38	314	18	4530	636	1412	3.89	50.1	28.6
42To1791.03	Scraper	Currie Hills A	102	23	198	414	29	239	21	3764	581	1162	4.38	61.7	38.6
42To1860.08	Debitage	Flat Hills C	110	33	107	823	19	302	17	4763	378	1616	4.08	88.8	28.5
42To1860.15	Snapped Blade	Flat Hills C	98	25	99	812	23	295	18	5090	549	1623	4.48	66.6	29.3
42To1872.66	Biface Fragment	Flat Hills A	97	30	110	708	18	306	15	4541	344	1503	3.93	94.2	28.8
42To1872.69	Scraper	Flat Hills A	90	28	105	661	16	296	13	4695	338	1548		96.8	28.2
42To1872.70	GBS	Flat Hills A	86	17	102	643	17	294	15	4531	332	1459	3.81	94.7	28
42To1872.71	GBS	Flat Hills A *	53	31	97	648	17	291	15	NM	NM	1464	NM	105.7	29.7
42To1874.6	GBS	Flat Hills D	77	26	111	369	37	260	31	3888	677	901	4.96	59.7	42.3
42To1875.24	GBS	Flat Hills A	85	23	96	655	19	291	13	4874	345	1535	4.12	98.2	28.1
42To1875.25	GBS	Currie Hills A	61	24	216	339	34	277	22	3276	564	1126	4.13	59.9	41.8
42To2141.02	Pinto Point Fragment	Flat Hills A	98	36	105	681	20	306	16	4339	659	1572	3.71	46.1	28.5
42To2145.05	Pinto Point	Flat Hills E *	65	43	232	293	34	219	21	NM	NM	1021	NM	42.8	44.5
42To2145.22	Pinto Point	Flat Hills E	58	145	209	301	31	214	24	2923	2270	1055	3.66	13.1	41.5
42To2146.10	Pinto Point	Flat Hills E	73	56	209	321	34	230	18	3287	929	1143	4.03	35.4	40.7
42To2152.39	Pinto Point	Badlands A	100	95	177	436	27	187	17	4479	1358	1146	5.16	30.9	38.2
42To2152.82	Pinto Point	Flat Hills D	84	48	116	378	33	256	28	3824	880	921	4.95	45.7	42.9
42To2467.4	Scraper	Flat Hills A	99	38	102	674	19	299	14	4342	645	1520	3.44	43.7	26.4
42To2551.13	GBS	Flat Hills A	105	29	106	675	17	305	14	5019	346	1600	4.07	96.8	27
42To2551.15	GBS	Flat Hills D	72	34	109	365	29	254	24	3739	656	895	4.71	58.5	41.7
42To2551.17	GBS	Flat Hills A	114	21	83	696	21	281	12	5930	592	1461	4.92	67.7	27.6
42To2551.24	GBS	Flat Hills E	68	33	225	304	29	236	20	3167	573	1179	3.89	55.7	40.9
42To2551.25	GBS	Flat Hills D	106	21	120	379	31	261	27	3504	864	887	4.4	41.5	41.7
42To2551.62	GBS	Unknown B	94	28	177	598	32	230	18	5605	657	1137	5.63	69.7	33.3
42To2552.1	GBS	Flat Hills D	96	32	117	398	34	266	27	3971	695	899	4.96	58.2	41.4
42To2552.12	GBS	Currie Hills A	69	27	209	393	29	280	22	3379	623	1214	4.34	56.9	42.6
42To2552.2	Scraper	Flat Hills D	85	24	112	358	34	249	24	2666	730	870	3.72	41.7	46.3
42To2553.3	GBS	Flat Hills D	98	32	128	402	32	275	29	3561	593	891	4.32	59.6	40.3
42To2554.19	GBS	Flat Hills A	100	26	105	657	14	296	16	4532	322	1566	3.66	93.9	27
42To2554.20	Scraper	Badlands A	104	20	183	468	27	203	17	3856	615	1312	4.75	63	40.8
42To2554.29	Scraper	Flat Hills A	97	29	99	663	19	293	17	4281	417	1522	3.61	71.2	28.1
42To2554.51	Uniface	Flat Hills A	83	27	107	662	19	298	18	3881	302	1418	3.21	88	27.6
42To2554.9	GBS	Flat Hills D	80	21	119	382	33	262	25	3592	659	850	4.65	57.6	42.9
42To2555.16	GBS	Deep Creek A	78	21	96	359	50	361	18	4338	608	1187	4.45	59.9	34.1
42To2555.17	GBS	Badlands A	88	23	180	491	25	209	18	4366	683	1372	5.22	62.2	39.6
42To2555.18	GBS	Flat Hills E	80	37	220	319	31	224	21	3057	567	1124	3.81	55.2	41.4

Appendix E: XRF Data for Archaeological Specimens

Proximal ORB delta, Tooele County, Utah

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
42To2555.21	GBS	Deep Creek A	84	21	97	366	49	366	19	4898	618	1205	5.21	68.7	35.3
42To2555.7	GBS	Flat Hills D	65	23	106	350	31	249	30	3193	687	922	4.14	49.3	43.1
42To2556.1	Biface Fragment	Flat Hills A	113	40	112	698	16	313	17	4011	397	1522	3.21	66.8	26.7
42To2556.33	GBS	Flat Hills A	90	33	98	661	18	299	18	4797	440	1615	4.05	75.5	28.1
42To2556.35	Biface	Flat Hills D	91	32	133	418	34	273	29	3160	694	875	3.85	45.4	40.5
42To2556.46	GBS	Flat Hills A	98	30	97	636	18	290	15	4590	337	1535	3.87	94.6	28.1
42To2556.48	GBS	Flat Hills D	76	25	118	407	35	268	30	3173	551	921	3.9	58.1	40.9
42To2556.52	GBS	Flat Hills A	97	32	96	652	18	289	14	4772	434	1507	4.1	77.4	28.6
42To2556.6	Unifacially Modified Flake	Flat Hills A	88	21	101	692	17	296	15	3259	299	1522	2.98	83	30.6
42To2558.3	GBS	Flat Hills A	98	29	99	626	19	288	12	4561	413	1595	3.83	76.2	28
42To2558.6	GBS	Deep Creek A *	82	28	91	356	51	359	22	NM	NM	1141	NM	68.7	36.2
42To2559.72	GBS	Flat Hills A	83	31	95	641	17	287	17	4424	521	1540	3.88	61	29.2
42To2559.73	GBS	Flat Hills A	61	17	97	702	22	273	15	5531	540	1304	5.07	76.6	30.4
42To2559.89	GBS	Badlands A	74	19	195	501	25	203	21	4198	668	1473	5.23	63.8	41.3
42To2559.90	GBS	Flat Hills D	75	28	125	442	37	259	27	3811	745	921	5	54.7	43.5
42To2559.99	Biface	Flat Hills A	88	30	100	673	15	291	18	4377	326	1533	3.74	94.8	28.5
DPGIF.576	Pinto Point	Flat Hills A	95	38	94	656	19	294	17	4003	314	1403	3.54	93.4	29.5
DPGIF.1169	GBS Midsection	Flat Hills A	68	21	97	638	18	291	16	4480	337	1554	3.75	91.7	27.9
DPGIF.1184	GBS Base	Flat Hills A	103	31	92	672	16	288	15	4477	489	1547	3.85	64.7	28.7
DPGIF.1185	GBS Midsection	Flat Hills A	85	29	101	659	19	289	18	4223	562	1489	3.81	55.6	30.1
DPGIF.1188	GBS Midsection	Flat Hills A	99	27	108	657	15	301	16	4019	528	1591	3.41	53.1	28.4
DPGIF.1398	GBS	Flat Hills A	119	26	103	658	18	283	11	4515	474	1544	3.93	68	29
DPGIF.1400	Cody Knife	Flat Hills A	91	28	105	672	17	293	16	4011	342	1442	3.49	84.1	29
DPGIF.1561	GBS	Flat Hills D	90	30	126	398	34	272	30	3181	565	824	3.93	57.1	41.1
DPGIF.1562	Biface	Flat Hills D	84	34	104	388	36	248	25	3795	673	804	4.68	56.7	40.9
DPGIF.1564	Pinto Point	Flat Hills E	75	27	207	308	27	215	21	2664	911	997	3.3	29.7	41.2
RGM-1	NA	RGM-1 Reference Standard	29	18	94	106	26	223	7	1538	289	764	1.68	49.2	36.8

Appendix E: XRF Data for Archaeological Specimens

Archaic surface sites; Dugway Proving Ground, Tooele County, Utah

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
42To0567.288	Biface Fragment	Flat Hills C	66	36	99	753	19	284	14	4525	492	1575	3.87	64.6	28.5
42To0567.348	Modified Flake	Flat Hills A	71	27	101	613	18	289	11	3166	288	1489	2.84	82	30
42To0890.1	Uniface	Flat Hills D	111	32	109	366	32	264	28	3369	1217	892	4.33	29	42.7
42To0898.4	Utilized Flake	Flat Hills D	55	36	114	375	36	254	26	3628	872	891	4.41	41.2	40.3
42To1186.67	Non Diagnostic Point	Flat Hills E	87	23	210	264	28	211	21	2185	481	1100	2.94	50.5	44.8
42To1406.122	Chopper	Badlands A	97	19	188	506	23	211	15	3462	602	1271	4.51	61.2	43.2
42To1407.1	Elko Corner-Notched Point	Deep Creek A	93	23	86	366	52	363	24	4379	536	1160	4.54	69.3	34.4
42To1456.104	Rosegate Point	Deep Creek A	121	23	91	370	53	367	21	4647	580	1112	4.81	67.6	34.4
42To1456.70	Drill	Flat Hills D	98	26	111	368	37	251	23	3469	573	825	4.16	59.4	39.8
42To1457.16	Side-notched Point	Badlands A *	110	31	180	469	23	192	16	NM	NM	1353	NM	47.7	40.9
42To1459.10	Preform	Deep Creek A *	105	17	89	354	52	353	18	NM	NM	1163	NM	74.4	34.2
42To1459.154	Desert Side-Notched Point	Deep Creek A *	80	18	84	341	50	342	19	NM	NM	1003	NM	74	35.4
42To1459.17	Core	Unknown 3	28	21	120	235	39	229	18	4231	122	234	2.21	155.7	17.6
42To1459.45	Core	Badlands A *	79	16	177	452	24	198	16	NM	NM	1290	NM	65.8	41.3
42To1477.02	Biface	Flat Hills A	101	33	93	625	18	281	14	4265	349	1601	3.52	83.3	27.5
42To1778.08	Large Side Notch Point Base	Deep Creek A	60	46	97	341	50	371	21	5092	804	1057	4.71	47.7	30.8
42To1778.14	Scraper	Currie Hills A	89	21	196	429	31	240	18	3892	596	1149	4.42	60.6	37.7
42To1782.01	Elko Corner-Notched Point	Currie Hills A	72	21	195	418	30	281	19	3527	874	1236	4.31	40.2	40.6
42To1784.03	Stage IV Biface Fragment	Deep Creek A	113	22	97	370	53	376	23	4378	752	1152	4.56	49.4	34.6
42To1795.05	Large Triangular Point	Deep Creek A	81	23	109	378	54	382	21	4189	536	1182	4.14	63.3	32.9
42To1800.01	Scraper	Deep Creek A	71	26	88	346	50	363	24	3540	735	1119	3.6	40.2	33.9
42To1800.02	Scraper	Badlands A	79	23	181	446	27	211	18	3258	908	1242	4.08	36.6	41.5
42To1803.06	Large Side Notch Point	Unknown A	94	25	157	667	28	235	22	5090	921	1236	5.38	47.4	35.1
42To1803.08	Scraper	Badlands A	75	30	164	430	26	205	20	3682	930	1355	4.49	39.3	40.5
42To1804.09	Utilized Flake	Flat Hills D	81	34	103	368	34	254	26	4062	645	900	5.03	63.5	41
42To1804.22	Stage III Biface Fragment	Deep Creek A	93	17	96	367	51	370	20	4240	800	1192	4.61	47	36.1
42To1804.23	Scraper	Badlands A	99	60	178	476	25	216	16	4228	1162	1283	5.06	35.4	39.7
42To1804.3	Biface Fragment	Currie Hills A	81	27	197	321	32	290	23	2582	533	1154	3.53	54.4	45.4
42To1808.09	Large Corner-notched Point	Deep Creek A	67	32	87	363	53	370	25	4453	733	1197	4.68	52	34.9
42To2065.04	Northern Side-Notched Point	Badlands A	69	37	189	481	27	202	19	4195	619	1337	4.83	63.7	38.2
42To2113.10	Elko Corner-Notched Point	Currie Hills A	75	27	213	389	29	270	21	3243	540	1381	3.98	60.4	40.8
42To2146.18	Stage III Biface Fragment	Deep Creek A	113	20	99	387	52	383	19	4807	889	1214	4.73	43.3	32.7
42To2149.06	Projectile Point	Flat Hills A	90	36	100	660	17	287	13	4248	394	1546	3.52	73.8	27.7
42To2175.02	Scraper	Cedar Mountain B	76	33	130	520	39	325	19	4550	775	1473	4.04	42.6	29.5
42To2311.06	Bifacially Modified Flake	Flat Hills C	96	22	111	818	21	304	16	5011	558	1656	4.32	63.3	28.7
DPGIF.546	Large Corner-notched Point	Deep Creek A	93	21	94	372	50	373	26	4373	740	1159	4.62	50.9	35.1
DPGIF.553	Large Corner-notched Point	Deep Creek A	96	40	94	338	48	366	25	4734	618	1129	4.77	63	33.5
DPGIF.560	Elko Eared Point	Deep Creek A	105	32	94	355	51	364	21	4880	714	1171	5.08	57.9	34.5
DPGIF.1344	Elko Corner-notched Point	Flat Hills A	96	29	98	702	18	289	19	4524	404	1554	4.11	83.5	30.2
RGM-1	NA	RGM-1 Reference Standard	29	18	94	106	26	223	7	1538	289	764	1.68	49.2	36.8

Appendix E: XRF Data for Archaeological Specimens

(Duke); Distal ORB delta, UTTR, Tooele County, Utah

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	$Fe^{2}O^{3T}$	Fe:Mn	Fe:Ti
[nworsl 2006-77]															
42To0910.3	Biface	Unknown A	75	27	165	688	30	252	22	4672	907	1092	5.47	49.0	38.8
42To0910.4	Biface	Unknown A	109	18	172	702	29	254	25	4555	882	1151	5.13	47.3	37.4
42To0910.5	Cougar Mountain point	Flat Hills D	83	25	108	359	32	258	27	3412	836	866	4.70	45.8	45.6
42To0910.9	Biface	Flat Hills D	74	27	114	373	38	259	30	3370	657	816	4.37	54.3	43.0
42To0910.11	GBS (square stem)	Badlands A	70	32	195	474	27	217	23	4194	747	1275	5.20	56.6	41.1
42To0910.18	Biface	Badlands A	96	32	212	528	26	223	22	3162	622	1418	3.84	50.5	40.4
42To0910.24	Biface	Badlands A	105	23	165	461	25	203	17	4326	656	1237	5.25	65.2	40.3
42To0910.28	Biface	Flat Hills D	91	22	120	384	31	266	26	3040	837	798	4.17	40.7	45.5
42To0910.31	GBS (contracting stem)	Unknown 9	102	37	134	648	35	337	19	4040	546	1375	3.75	56.4	31.0
42To0910.32	Biface	Badlands A	97	12	183	523	25	208	15	3577	795	1311	4.76	48.8	44.1
42To0910.33	Core	Flat Hills D	75	29	110	389	32	258	30	3391	697	878	4.76	55.7	46.5
42To0910.35	GBS (square stem)	Flat Hills D	92	33	108	360	35	261	28	3528	846	838	4.77	45.9	44.8
42To0910.36	Biface	Flat Hills D	75	25	107	365	34	260	28	3485	824	826	4.67	46.2	44.4
42To0910.40	GBS (square stem)	Flat Hills D	63	19	106	394	32	255	27	3165	662	848	4.51	55.6	47.2
42To0910.41	Biface	Flat Hills D	93	17	125	442	34	275	29	3098	639	843	4.06	52.0	43.5
42To0910.42	Biface	Deep Creek A	98	19	95	370	53	368	21	4321	598	1069	4.48	61.3	34.5
42To0910.44	Pinto point	Flat Hills D	92	22	106	376	37	259	24	3446	681	901	4.78	57.2	46.0
42To0910.47	GBS (expanding stem)	Flat Hills D	98	16	112	372	29	261	26	3641	791	879	4.53	46.7	41.3
42To0910.48	Pinto point	Flat Hills D	97	27	118	379	32	254	26	3253	589	869	4.19	58.2	42.7
42To0910.56	GBS (irregular stem)	Flat Hills D	104	26	102	377	33	242	29	4406	979	863	5.64	46.8	42.4
42To0910.78	GBS (contracting stem)	Badlands A	95	21	188	469	23	196	16	4191	664	1362	5.02	61.7	39.8
42To0910.85	Biface	Flat Hills D	94	24	123	395	34	264	28	3386	636	900	4.39	56.5	43.1
42To0910.88	Biface	Badlands A	82	24	183	500	27	204	18	4477	853	1353	5.42	51.6	40.1
42To0910.92	Biface	Flat Hills D	106	25	126	424	35	270	29	3178	589	925	4.07	56.6	42.5
42To0910.93	Pinto point	Flat Hills E	71	28	206	333	25	202	22	2516	500	1078	3.27	53.8	43.2
42To0910.98	Silver Lake point	Flat Hills D	72	16	103	416	33	243	29	3061	589	895	4.16	57.8	45.1
42To0910.99	Biface	Flat Hills D	84	20	112	436	33	247	28	3315	842	894	4.53	43.9	45.3
42To0910.100	Biface	Flat Hills D	104	23	120	435	34	261	27	3192	747	875	4.01	43.9	41.7
42To0910.101	Biface	Flat Hills D	95	32	122	423	35	263	28	3039	581	864	3.99	56.3	43.6
42To0913.10	Biface	Badlands A	102	23	192	481	28	210	14	3819	775	1281	4.58	48.1	39.8
42To0913.21	GBS (expanding stem)	Flat Hills D	87	23	110	378	33	252	25	3803	813	865	4.86	48.7	42.4
42To2826.6	Biface	Flat Hills D	55	26	116	379	34	252	25	2980	849	856	4.16	40.0	46.3
42To2832.3	Biface	Badlands A	91	18	182	467	28	204	15	4253	833	1306	5.15	50.3	40.2
42To2832.4	GBS (irregular stem)	Flat Hills A	88	22	97	650	16	280	19	4343	462	1516	3.67	65.2	28.2
42To2832.13	Biface	Flat Hills D	73	22	110	435	36	250	28	3566	673	845	4.68	56.8	43.5
42To2832.14	Biface	Flat Hills D	96	26	111	373	34	252	27	3000	654	851	3.91	48.9	43.3
42To2832.15	Biface	Flat Hills E	63	32	229	301	29	217	19	2450	532	1066	3.38	52.2	45.9
42To2833.10	Biface	Flat Hills D	76	16	111	398	34	254	26	3247	642	837	4.59	58.5	46.9

Appendix E: XRF Data for Archaeological Specimens

(Duke); Distal ORB delta, UTTR, Tooele County, Utah

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
42To2833.12	Biface	Flat Hills D	102	19	114	425	35	261	27	3213	642	899	4.31	54.9	44.5
42To2833.13	GBS (irregular stem)	Flat Hills A	106	23	102	686	17	298	13	4488	469	1559	3.65	64.1	27.2
42To2835.2	GBS (irregular stem)	Badlands A	99	15	184	477	25	208	18	4575	779	1323	5.32	55.6	38.6
42To2835.8	Pinto point	Flat Hills D	93	26	118	364	31	254	29	3555	628	892	4.37	56.8	40.8
42To2835.12	GBS (expanding stem)	Flat Hills D	103	28	135	422	35	272	27	2699	695	854	3.19	37.7	39.4
42To2835.25	Pinto point	Flat Hills A	94	29	102	654	19	299	14	4416	571	1502	3.94	56.5	29.7
42To2835.26	Biface	Flat Hills D	90	25	106	376	34	261	30	3509	649	883	4.60	57.9	43.5
42To2836.9	GBS (irregular stem)	Flat Hills A	72	23	105	649	14	300	15	4167	309	1558		90.6	27.1
42To2836.13	Biface	Unknown 2	84	28	111	592	34	257	26	3172	669	916	4.25	51.9	44.4
42To2837.2	Lake Mohave point	Flat Hills D	64	19	112	362	29	250	29	3644	659	888	4.73	58.5	43.0
42To2837.7	Biface	Flat Hills D	89	15	116	372	34	260	28	3575	867	864	4.73	44.5	43.9
42To2838.1	Biface	Deep Creek D	68	33	201	394	26	230	22	2597	589	1106	3.62	50.5	46.3
42To2838.2	GBS (expanding stem)	Deep Creek A	99	22	92	356	51	364	21	4057	514	1221	4.00	63.9	32.8
42To2838.3	Biface	Deep Creek D	102	24	189	405	30	231	19	4269	656	1260	4.94	61.4	38.4
42To2838.8	GBS (expanding stem)	Flat Hills D	95	23	121	372	30	261	30	4011	746	933	5.08	55.5	42.0
42To2838.11	Biface	Flat Hills D	110	22	110	373	28	256	25	3463	716	901	4.63	52.8	44.3
42To2838.17	Biface	Flat Hills D	82	23	113	373	37	257	24	3710	745	951	4.77	52.2	42.6
42To2838.18	GBS (irregular stem)	Flat Hills D	80	31	111	369	35	253	27	3657	684	876	4.76	56.8	43.1
42To2839.8	Biface	Flat Hills C	80	25	80	733	20	278	18	6131	585	1244	5.35	74.5	29.0
42To2839.13	GBS (expanding stem)	Flat Hills D	100	26	108	371	35	260	29	3569	847	859	4.84	46.5	44.9
42To2840.3	Biface	Deep Creek A	95	13	92	352	53	360	16	4699	634	1122	5.09	65.4	35.9
42To2840.10	GBS (irregular stem)	Flat Hills E	78	26	209	300	37	234	21	2562	566	1086	3.50	50.7	45.4
42To2843.3	GBS (irregular stem)	Deep Creek A	111	27	95	379	54	373	21	4383	665	1186	4.80	58.9	36.4
42To2843.7	Biface	Flat Hills D	85	18	119	393	36	264	31	3296	778	873	4.26	44.7	42.9
42To2843.11	GBS (expanding stem)	Flat Hills D	75	22	118	385	33	261	28	3663	694	871	4.88	57.3	44.2
42To2843.15	Parman point	Flat Hills D *	96	28	108	370	33	257	31	NM	NM	886	NM	48.1	44.0
42To2843.16	Pinto point	Badlands A	91	20	175	582	25	203	16	3388	523	1221	3.99	62.6	39.1
42To2843.19	GBS (expanding stem)	Unknown 8	149	29	155	342	28	138	14	3337	3598	472	4.22	9.5	42.0
42To2843.22	GBS (contracting stem)	Badlands A	103	22	211	531	28	211	20	3937	619	1299	4.80	63.3	40.4
42To2843.26	Biface	Flat Hills E *	63	29	214	281	29	216	19	NM	NM	1005	NM	52.6	50.8
42To2844.4	GBS (square stem)	Flat Hills D	64	15	108	379	35	256	26	3828	884	883	4.96	45.7	43.0
42To2844.5	Biface	Badlands A	94	28	194	516	24	218	17	4207	664	1356	4.98	61.1	39.2
42To2844.8	Biface	Flat Hills D	85	23	116	373	37	253	24	3512	896	897	4.84	44.0	45.7
42To2845.4	GBS (expanding stem)	Deep Creek A	109	34	101	366	50	369	23	4476	632	1168	4.54	58.7	33.7
42To2846.1	GBS (expanding stem)	Unknown 10	101	46	175	793	26	192	13	3623	901	1363	3.48	31.6	32.0
42To2846.8	Biface	Flat Hills D	72	29	116	368	32	253	31	3595	612	934	4.42	59.1	40.8
42To2846.12	Pinto point	Flat Hills D	87	25	111	373	35	256	25	3729	679	897	4.79	57.5	42.6

Appendix E: XRF Data for Archaeological Specimens

(Duke); Distal ORB delta, UTTR, Tooele County, Utah

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
42To2846.14	Biface	Flat Hills D	92	22	118	392	32	266	27	3748	663	921	4.73	58.3	41.9
ISO.09.15.03	Lake Mohave point	Flat Hills A	80	28	100	651	16	287	16	4365	353	1450	3.79	88.3	28.9
ISO.09.37.14	GBS (expanding stem)	Badlands A	64	31	185	419	29	208	17	4508	736	1079	5.17	57.1	38.0
ISO.9.101.37	Biface	Flat Hills D	80	13	109	398	35	254	30	3138	564	910	3.99	57.9	42.2
RGM-1	NA	RGM-1 Reference Standard	26	25	153	107	24	221	9	1733	285	797	1.83	54.3	35.6
[nworsl 2006-05]															
42To0909.122	GBS (expanding stem)	Currie Hills A	102	31	219	373	30	302	22	3022	698	1241	4.13	48.3	45.3
42To0922/ 923.143	GBS (contracting stem)	Deep Creek A	101	36	92	368	52	379	21	5224	681	1227	5.54	66.2	35.2
ISO.05.512.4	GBS (irregular stem)	Deep Creek A	98	34	95	370	48	372	18	4514	778	1174	4.82	50.5	35.5
ISO.05.512.14	Parman point	Badlands A	88	24	179	444	32	218	14	5199	833	1160	5.88	57.3	37.5
42To0745.03.03.02	GBS (square stem)	Flat Hills A	77	26	102	693	20	305	20	4108	300	1609	3.47	95.6	28.2
42To0747.03.05.08	Pinto point	Flat Hills A	92	26	99	626	17	282	15	4423	431	NM	3.75	71.4	28.3
42To0919.09.10.06	Pinto point	Flat Hills E *	61	24	221	335	30	216	19	NM	NM	NM	NM	55.9	39.9
42To1043.41.70.0	GBS (Stubby)	Flat Hills A	95	25	104	664	17	296	14	5195	435	NM	4.32	81.3	27.7
ISO.04.30.01	Pinto point	Flat Hills D	74	19	102	354	33	251	28	3502	519	NM	3.91	61.8	37.1
ISO.03.17.02	Pinto point	Deep Creek A	128	21	98	377	55	369	27	4590	749	NM	4.75	51.7	34.4
ISO.04.25.03	Lake Mohave point	Flat Hills A	106	41	104	676	16	297	15	4550	343	1526	3.89	93.5	28.5
ISO.04.31.01	GBS (square stem)	Flat Hills A	83	18	103	679	21	297	13	4287	525	NM	3.52	55.1	27.4
ISO.08.20.09	Pinto point	Deep Creek A	109	20	98	374	52	369	21	4809	610	NM	4.99	66.7	34.5
ISO.03.13.10	GBS (expanding stem)	Flat Hills A	58	26	97	658	20	295	16	4047	358	NM	3.46	79.6	28.5
ISO.0.1331b	GBS (Stubby)	Flat Hills A	99	22	100	659	16	302	17	4351	332	NM	3.64	90.5	27.9
ISO.0.134.1	GBS (irregular stem)	Flat Hills A	105	21	110	725	17	292	15	4599	541	1478	3.82	57.9	27.7
ISO.0.174.1	Silver Lake point	Flat Hills A	78	32	106	664	14	291	16	4553	355	NM	3.80	88.4	27.8
ISO.0.215.3	Pinto point	Badlands A	122	22	201	513	27	212	15	4535	740	NM	5.38	59.1	39.3
ISO.0.262.1	Pinto point	Deep Creek A	134	25	85	348	49	349	19	4929	794	1225	5.08	52.1	34.2
ISO.0.270.0	Parman point	Flat Hills C	69	36	100	737	20	273	16	4700	382	1602	4.24	91.1	30.0
ISO.08.33.02	Lake Mohave point	Unknown 7	90	23	183	870	33	226	16	4002	581	1149	4.85	68.2	40.2
ISO.08.33.05	Pinto point	Unknown 6	82	23	207	631	33	272	19	3214	554	NM	3.99	59.0	41.3
RGM-1	NA	RGM-1 Reference Standard	39	27	158	108	25	225	8	1740	428	814	1.92	37.6	37.1
[nworsl 17 sites wendover?]															
42To1008.6.38.0	Debitage	Flat Hills D	89	21	118	381	34	258	27	3169	706	862	3.97	46.0	41.6
42To1013.11.29.0	Biface	Flat Hills D	96	21	110	357	33	246	26	4070	742	915	5.17	56.8	42.1
42To1013.11.39.0	GBS point	Badlands A	87	20	186	475	24	209	20	4328	711	1476	5.21	59.6	39.9

Appendix E: XRF Data for Archaeological Specimens

(Duke); Distal ORB delta, UTTR, Tooele County, Utah

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	$Fe^{2}O^{3T}$	Fe:Mn	Fe:Ti
42To1013.11.50.0	GBS point	Deep Creek A	73	22	88	356	51	353	20	4290	573	1179	4.48	64.0	34.7
42To1016.14.22.0	GBS point	Flat Hills D	88	23	117	384	29	251	28	3772	614	916	4.90	65.0	43.0
42To1016.14.24.0	GBS point	Flat Hills D	75	20	101	358	35	246	30	3790	660	924	4.97	61.4	43.5
42To1016.14.17.0	Biface	Flat Hills D	90	24	109	393	32	246	25	3793	662	940	5.00	61.5	43.6
42To1016.14.15.0	Biface	Flat Hills D	80	20	106	375	35	244	27	3162	642	837	4.45	56.6	46.6
42To1016.14.13.0	Debitage	Flat Hills D	75	25	113	373	32	255	25	3810	789	907	4.81	49.7	41.9
42To1016.14.8.0	Biface	Flat Hills D	79	24	104	360	33	246	27	3812	757	904	4.79	51.5	41.6
42To1016.14.16.0	Flake tool	Flat Hills D	91	23	103	336	31	226	28	4331	654	957	5.29	65.8	40.5
42To1020.18.26.0	Debitage	Flat Hills A	63	24	86	612	17	275	13	3809	305	1615	3.32	89.9	29.1
42To1021.19.11.0	Debitage	Flat Hills D	86	24	109	359	31	252	28	3908	630	872	5.01	64.9	42.5
42To1028.26.15.0	GBS point	Flat Hills D	84	23	108	373	34	244	29	4117	696	972	5.26	61.5	42.3
42To1028.26.22.0	Debitage	Flat Hills D	94	23	110	355	33	249	24	3789	638	942	5.03	64.3	44.0
42To1028.26.25.0	Debitage	Currie Hills A	59	31	211	361	34	254	24	2280	403	1065	2.97	60.8	43.3
42To1028.26.29.0	Biface	Flat Hills E	66	27	203	302	30	216	20	2943	613	1116	3.62	48.4	40.8
42To1028.26.32.0	Debitage	Flat Hills A	95	28	99	634	19	284	17	4356	308	1564	3.70	99.0	28.3
42To1044.42.67.0	Flake tool	Flat Hills D	77	23	113	376	31	251	27	3832	661	898	4.97	61.3	43.0
42To1044.42.72.0	GBS point	Flat Hills D	68	20	108	348	32	239	27	3496	584	899	4.54	63.5	43.1
42To1044.42.70.0	Flake tool	Flat Hills D	88	28	124	407	34	271	28	3683	600	899	4.62	62.8	41.6
42To1046.44.32.0	Pinto point	Deep Creek A	79	23	90	355	51	362	20	4761	585	1246	5.12	71.3	35.7
42To1046.44.31.0	Flake tool	Flat Hills D	74	24	107	344	31	245	24	3128	568	912	4.38	63.0	46.4
42To1046.44.25.0	Biface	Flat Hills E	60	25	207	317	30	222	23	2959	548	1220	3.73	55.9	41.9
42To1046.44.19.0	Crescent	Currie Hills A	52	23	189	290	28	266	20	2597	455	1087	3.53	63.8	45.1
42To1046.44.17.0	Pinto point	Deep Creek A	79	25	89	347	48	357	21	5218	711	1256	5.41	61.9	34.4
42To1046.44.26.0	GBS point	Deep Creek A	78	23	88	348	47	355	19	4996	582	1271	5.22	73.2	34.7
42To1054.52.21.0	GBS point	Flat Hills A	102	29	102	661	18	302	16	4387	418	1706	3.66	72.0	27.8
42To1054.52.26.0	Biface	Badlands A	82	18	177	451	23	211	17	4205	633	1502	5.25	67.6	41.4
42To1054.52.27.0	Flake tool	Flat Hills D	80	27	103	371	33	253	25	3601	654	900	4.82	60.1	44.4
RGM-1	NA	RGM-1 Reference Standard	39	17	150	99	24	218	11	1708	261	850	1.95	63.1	38.3

Appendix E: XRF Data for Archaeological Specimens

Unknowns, Tooele County, Utah

CATALOG NUMBER	ARTIFACT TYPE	GEOCHEMICAL SOURCE	Zn ppm	Pb ppm	Rb ppm	Sr ppm	Y ppm	Zr ppm	Nb ppm	Ti ppm	Mn ppm	Ba ppm	Fe^2O^{3T}	Fe:Mn	Fe:Ti
42To1878.14	Cougar Mountain point	Unknown 1	79	34	116	526	36	268	28	3520	692	948	4.72	55.6	44.4
42To2836.13	Biface	Unknown 2	84	28	111	592	34	257	26	3172	669	916	4.25	51.9	44.4
42To1459.17	Core	Unknown 3	28	21	120	235	39	229	18	4231	122	234	2.21	155.7	17.6
23317.5	Scraper/biface? (early stage)	Unknown 4	59	24	101	333	21	108	9	2832	508	885	3.62	58.5	42.4
22533	Biface fragment	Unknown 5	23	8	39	30	13	60	4	1560	148	172	0	29.80	11.0
ISO.08.33.05	Pinto point	Unknown 6	82	23	207	631	33	272	19	3214	554	NM	3.99	59.0	41.3
ISO.08.33.02	Lake Mohave point	Unknown 7	90	23	183	870	33	226	16	4002	581	1149	4.85	68.2	40.2
42To2843.19	GBS (expanding stem)	Unknown 8	149	29	155	342	28	138	14	3337	3598	472	4.22	9.5	42.0
42To0910.31	GBS (contracting stem)	Unknown 9	102	37	134	648	35	337	19	4040	546	1375	3.75	56.4	31.0
42To2846.1	GBS (expanding stem)	Unknown 10	101	46	175	793	26	192	13	3623	901	1363	3.48	31.6	32.0
42To2945.17	Pinto point	Unknown 11	71	33	200	541	41	289	18	5340	839	1473	4.93	47.8	30.7
42To0910.3	Biface	Unknown A	75	27	165	688	30	252	22	4672	907	1092	5.47	49.0	38.8
42To0910.4	Biface	Unknown A	109	18	172	702	29	254	25	4555	882	1151	5.13	47.3	37.4
42To1924.127	Circular scraper	Unknown A	101	24	153	626	35	251	19	5721	662	1445	6.02	74.0	34.9
42To1803.06	Large Side Notch Point	Unknown A	94	25	157	667	28	235	22	5090	921	1236	5.38	47.4	35.1
23711.3	Biface (midstage)	Unknown B	106	31	193	575	38	247	22	3912	611	1661	4.38	58.6	37.2
42To2551.62	Great Basin Stemmed Point	Unknown B	94	28	177	598	32	230	18	5605	657	1137	5.63	69.7	33.3
42To1369.4	GBS (contracting stem)	Unknown C	71	30	107	757	37	326	20	4513	556	1255	4.48	65.8	33.0
42To1686.35	GBS (expanding stem)	Unknown C	84	18	103	746	34	350	15	NM	NM	NM	NM	NM	NM

Appendix F: Attribute Data for Surface Sites.

SITE/ ISOLATE NO.	UT PROJECT REFERENCE	PRIMARY LANDFORM	SITE AREA	PROJ. POINTS	POINT TYPES	KNIFE/ BIFACE	SCRAPER	GRAVER/ DRILL	FLAKE TOOL	CORE	DEBITAGE	AFFILIATION
PROXIMAL ORB												
42To385	U-84-MA-1063m	SL	5225	2	MS	1	1	-	-	2	<100	PA
42To567	U-02-DA-0385m(e)	DN	371953	8	PNERO*	32	5	1	28	12	>500	EA/MA/FR/LP
42To867	U-96-DH-0045m	DN	66937	1	P	4	-	-	-	-	~100	EA
42To1153	U-99-DU-0211m	SA CH	78333	13	KCS	4	5	3	5	-	~200	PA
42To1170	U-99-DU-0211m	GR CH	4773	-	-	-	2	-	-	-	<100	PA
42To1182	U-99-DU-0211m	GR/SA CH	159970	17	KCMS*	2	3	1	5	1	>500	PA/MA
42To1354	U-00-DU-0186m	GR CH	2089	5	CS	6	1	-	-	1	27	PA
42To1358	U-00-DU-0186m	GR/SA CH	201972	17	CS*	36	10	3	10	7	>500	PA/MA/FR
42To1368	U-01-DU-0303m	GR CH	9257	1	C	7	2	-	5	-	20	PA
42To1369	U-00-DU-0186m	GR CH	12172	6	CBS	8	-	-	1	-	~200	PA
42To1371	U-01-DU-0303m	GR CH	43933	16	BLPAS	34	4	1	44	4	~100	PA
42To1383	U-00-DU-0186m	SA CH	83483	12	CSP	12	-	-	1	-	~125	PA/EA
42To1493	U-00-DA-0514m	DN	749	1	P	1	2	1	-	1	6	EA
42To1573	U-01-DU-0239m	PL	17167	11	S*	28	2	1	17	7	>500	PA/FR
42To1672	U-01-DU-0303m	GR CH	8048	6	SP	2	-	-	-	-	27	PA/EA
42To1677	U-01-DU-0303m	SA CH	16922	3	CP	5	2	3	1	-	25	PA/EA
42To1678	U-01-DU-0303m	SA CH	14301	3	PA	7	1	1	-	-	38	PA/EA
42To1682	U-01-DU-0303m	GR CH	308	2	S	3	1	-	1	-	5	PA
42To1684	U-01-DU-0303m	GR CH	11808	8	CBA	3	2	-	2	-	~50	PA
42To1685	U-01-DU-0303m	GR CH	33233	15	CBLASP	15	4	-	4	1	>500	PA/EA
42To1686	U-01-DU-0303m	GR CH	19109	30	CBLMPS	16	14	3	7	-	~500	PA/EA
42To1687	U-01-DU-0303m	GR CH	1157	8	BLM	1	1	-	-	-	8	PA
42To1688	U-01-DU-0303m	GR CH	16121	16	BLAS	12	3	2	29	-	~200	PA
42To1689	U-01-DU-0303m	SA CH	16520	4	SP	2	-	1	2	-	~150	PA/EA
42To1791	U-01-DA-0277m	DN	283	-	-	1	2	-	-	-	<100	UNK
42To1860	U-01-DU-0303m/U-03-DU-0449m	GR CH	4242	1	S	-	3	-	3	-	~100	PA
42To1861	U-01-DU-0303m	GR CH	25837	8	CBLS	5	2	-	4	-	~50	PA
42To1862	U-01-DU-0303m	GR CH	13543	10	BS	2	4	-	3	-	~70	PA
42To1872	U-01-DU-0303m	GR CH	41792	23	CBLMAS	14	3	1	21	1	~100	PA
42To1873	U-01-DU-0303m	GR CH	16829	16	BLMPA	17	1	1	4	1	~40	PA

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PROJECTILE POINT CODES: HASKETT (K); COUGAR MNT (C); DUGWAY STUBBY (B); SILVER LAKE (L); LAKE MOJAVE (M); PINTO (P); PARMAN (A); STEMMED (S); POSSIBLE FLUTED (T); CODY KNIFE (I); NORTHERN (N); HUMBOLDT (H); ELKO (E); GATECLIFF (F); GYPSUM (G); ROSEGATE (R); COTTONWOOD (C); DSN (D); OTHER (O); UTTR "CRESCENTS" CODED AS SCRAPERS
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Appendix F: Attribute Data for Surface Sites.

SITE/ ISOLATE NO.	UT PROJECT REFERENCE	PRIMARY LANDFORM	SITE AREA	PROJ. POINTS	POINT TYPES	KNIFE/ BIFACE	SCRAPER	GRAVER/ DRILL	FLAKE TOOL	CORE	DEBITAGE	AFFILIATION
42To1874	U-01-DU-0303m	GR CH	4744	3	CB	1	1	-	-	-	16	PA
42To1875	U-01-DU-0303m	GR CH	10932	10	CBS	5	-	1	-	-	~50	PA
42To1878	U-01-DU-0303m	GR CH	2043	7	CLM	2	-	1	5	-	14	PA
42To1920	U-01-DU-0303m	GR CH	24001	4	CS	13	6	1	20	1	~70	PA
42To1921	U-01-DU-0303m	GR CH	2587	6	BLS	3	-	-	3	1	26	PA
42To1924	U-01-DU-0303m	GR CH	99462	15	CBMS	45	8	-	98	1	~150	PA
42To2141	U-03-DA-0514m	VB	9938	5	P	-	-	1	1	-	<100	EA
42To2145	U-03-DA-0570m	VB	23111	12	PO	11	-	1	6	4	~100	EA
42To2146	U-03-DA-0570m	VB	63026	20	PO	12	-	1	7	2	>500	EA
42To2152	U-03-DA-0570m	VB	83933	9	PO	54	3	1	15	5	>500	EA
42To2467	U-05-DA-0208m	AF	3241	2	S*	1	2	-	2	2	25	PA/FR
42To2551	U-05-DU-0498m	IN CH	47757	21	CBS	17	1	1	18	1	~125	PA
42To2552	U-05-DU-0498m	IN CH	30749	5	S	1	1	-	6	-	~125	PA
42To2553	U-05-DU-0498m	IN CH	3146	5	ST	-	-	-	3	-	13	PA
42To2554	U-05-DU-0498m	IN CH	52087	18	BS	19	3	-	11	-	~100	PA
42To2555	U-05-DU-0498m	IN CH	23335	12	BS	5	2	-	10	-	28	PA
42To2556	U-05-DU-0498m	IN CH	22070	22	BS	10	4	3	12	-	~125	PA
42To2558	U-05-DU-0498m	IN CH	9204	7	BS	2	-	-	1	-	~150	PA
42To2559	U-05-DU-0498m	IN CH	90672	37	CBLPS	28	2	4	33	2	~450	PA/EA
42To2945	U-06-DA-1367m	IN CH	40757	16	PS	4	5	2	12	-	>500	PA/EA
04DM03†	U-04-DU-ORB	GR/SA CH	UNK	1	S	1						PA
DPG ARCHAIC												
42To567	U-02-DA-0385m(e)	DN	371953	8	PNERO	32	5	1	28	12	>500	EA/MA/FR/LP
42To890	U-96-DH-0045m	AF	2546	-	-	1	1	-	2	-	49	UNK
42To898	U-96-DU-0393m	DN	1821	2	RC	1	1	-	2	-	<500	FR/LP
42To1186	U-99-DU-0612m	DN	78000	15	RO	22	1	2	12	3	<500	FR
42To1406	U-00-DU-0187m	SP	155053	45	ENRD	43	-	3	10	5	>500	FR/LP
42To1407	U-00-DU-0187m	SP	240288	15	ERDO	17	4	1	1	10	>500	FR/LP
42To1456	U-00-DU-0239m	DN	7263	20	PHERCO	26	4	1	-	3	>500	EA/MA/FR

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PROJECTILE POINT CODES: HASKETT (K); COUGAR MNT (C); DUGWAY STUBBY (B); SILVER LAKE (L); LAKE MOJAVE (M); PINTO (P); PARMAN (A); STEMMED (S); POSSIBLE FLUTED (T); CODY KNIFE (I); NORTHERN (N); HUMBOLDT (H); ELKO (E); GATECLIFF (F); GYPSUM (G); ROSEGATE (R); COTTONWOOD (C); DSN (D); OTHER (O); UTTR "CRESCENTS" CODED AS SCRAPERS
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SITE/ ISOLATE NO.	UT PROJECT REFERENCE	PRIMARY LANDFORM	SITE AREA	PROJ. POINTS	POINT TYPES	KNIFE/ BIFACE	SCRAPER	GRAVER/ DRILL	FLAKE TOOL	CORE	DEBITAGE	AFFILIATION
42To1457	U-00-DU-0239m	DN	4703	3	NRO	3	1	-	-	3	<100	EA/FR
42To1459	U-01-DU-0209m(e)	DN	56253	35	SNEDCO	37	2	2	14	8	>500	AR/FR
42To1477	U-00-DA-0514m	DN	5106	1	N	1	1	-	-	-	<500	AR
42To1778	U-01-DA-0277m	DN	50543	5	NER	4	-	-	-	1	<500	MA/FR
42To1782	U-01-DA-0277m	DN	1219	1	E	-	-	-	-	-	~125	AR
42To1784	U-01-DA-0277m	DN	82	1	R	2	1	-	-	1	-	FR
42To1795	U-01-DA-0277m	DN	40337	6	RDO	1	1	-	1	-	<500	FR/LP
42To1800	U-01-DA-0277m	DN	5835	-	-	-	2	-	-	-	<100	UNK
42To1803	U-01-DA-0277m	DN	29306	3	PSE	2	2	1	-	-	<500	AR/LA
42To1804	U-01-DA-0277m	DN	43537	14	PNHERCO	5	2	-	3	-	<500	EA/MA/FR/LP
42To1808	U-01-DA-0277m	DN	42682	7	FERO	3	1	1	-	1	<500	AR/FR
42To2065	U-03-DU-0311m	VB	722	6	NHERO	4	1	-	1	-	67	AR/FR
42To2113	U-03-DU-0413m	SP	44016	5	ER	5	-	-	3	1	>500	LA/FR
42To2146	U-03-DA-0570m	VB	63026	20	PO	12	-	1	7	2	>500	AR
42To2149	U-03-DA-0570m	VB	9538	2	NO	5	1	-	2	-	60	MA
42To2175	U-03-DA-0570m	VB	19277	2	EO	1	2	-	1	3	<100	AR
42To2311	U-04-DA-0406m	AF	27609	1	O	31	2	-	11	3	>500	AR
DISTAL ORB												
42To0745	U-92-WC-555m	PL/SL	97500	3	SP	1	-	-	-	-	~200	PA/EA
42To0747	U-92-WC-555m	PL	110000	6	P	19	7	-	-	-	<400	PA?/EA
42To0748	U-92-WC-555m	PL	87500	4	P	6	2	-	-	-	<2000	PA?/EA
42To0909	U-05-FF-0512m	PL	200070	81	SPHEO*	147	1	4	7	-	>500	PA/AR
42To0910	U-06-FF-0732m	SL	19200	1	S	-	1	-	-	1	50	PA/AR
42To0911	U-05-FF-0512m	PL/CH	25672	4	SO	9	-	-	3	2	<500	PA/EA
42To0913	U-06-FF-0732m	PL	2700	7	SNE*	1	-	-	-	-	<100	PA/MA
42To0918	U-96-WC-0506m	SL	14000	17	SP	26	-	3	-	1	~300	PA/EA
42To0919	U-96-WC-0506m	PL	43200	5	SP	19	-	-	-	2	~300	PA/EA
42To0922	U-06-FF-0732m	PL/DN	99518	29	SERO*	71	14	-	34	4	>500	PA/LA
42To0924	U-05-FF-0512m	PL	11338	15	S	24	5	1	14	-	~100	PA

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PROJECTILE POINT CODES: HASKETT (K); COUGAR MNT (C); DUGWAY STUBBY (B); SILVER LAKE (L); LAKE MOJAVE (M); PINTO (P); PARMAN (A); STEMMED (S); POSSIBLE FLUTED (T); CODY KNIFE (I); NORTHERN (N); HUMBOLDT (H); ELKO (E); GATECLIFF (F); GYPSUM (G); ROSEGATE (R); COTTONWOOD (C); DSN (D); OTHER (O); UTTR "CRESCENTS" CODED AS SCRAPERS
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42To1008	U-98-HD-0376m	PL	3770	2	S	7	4	2	-	-	~60	PA/AR?
42To1013	U-98-HD-0376m	PL	94250	8	SO	6	2	3	1		>300	PA
42To1016	U-98-HD-0376m	PL	31415	1	S	2	-	-	-	1	~50	PA
42To1020	U-98-HD-0376m	PL	19800	3	SO*	4	-	-	-	1	>100	PA/LP
42To1021	U-98-HD-0376m	PL	45550	4	SPO	2	2	-	-	-	~100	PA/EA
42To1028	U-98-HD-0376m	PL	11290	4	SO	4	-	-	-	-	~250	PA
42To1043	U-98-HD-0376m	PL	68650	40	SPHEO*	34	8	6	2	5	>500	PA/EA/MA
42To1044	U-98-HD-0376m	PL	67400	21	SPHO*	16	6	1	2	4	~250	PA/EA/MA
42To1046	U-98-HD-0376m	PL	28560	9	SPNHO*	4	-	-	-	1	~200	PA/EA
42To1054	U-98-HD-0376m	PL	8000	1	S	4	1	-	-	-	~20	PA
42To2826	U-06-FF-0732m	SL	1361	2	S*	1	-	-	3	-	32	PA
42To2832	U-06-FF-0732m	DN/PL	18005	6	SEO*	9	-	-	1	-	83	PA/MA
42To2833	U-06-FF-0732m	DN/PL/CH	15705	8	SP	7	-	-	2	-	51	PA/EA
42To2835	U-06-FF-0732m	DN/PL	77603	15	SP	13	4	-	6	2	481	PA/EA
42To2836	U-06-FF-0732m	DN/PL	29510	4	SP	8	-	-	2	1	91	PA/EA
42To2837	U-06-FF-0732m	DN/SL	10969	2	MP	6	-	-	2		45	PA/EA
42To2838	U-06-FF-0732m	DN/SL	15366	3	S	14	-	-	2	1	29	PA
42To2839	U-06-FF-0732m	SL	20776	7	SP	15	-	-	-	-	83	PA/EA
42To2840	U-06-FF-0732m	PL	7313	2	S	9	1	-	-	-	33	PA
42To2843	U-06-FF-0732m	PL	146251	9	SP	9	4	-	6	2	254	PA/EA
42To2844	U-06-FF-0732m	PL	21459	3	S	8	2	-			51	PA
42To2845	U-06-FF-0732m	PL/CH	5488	2	SP	1	-	-	2	1	29	PA/EA
42To2846	U-06-FF-0732m	PL	2731	3	SP	9	1	-	-	-	48	PA/EA

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